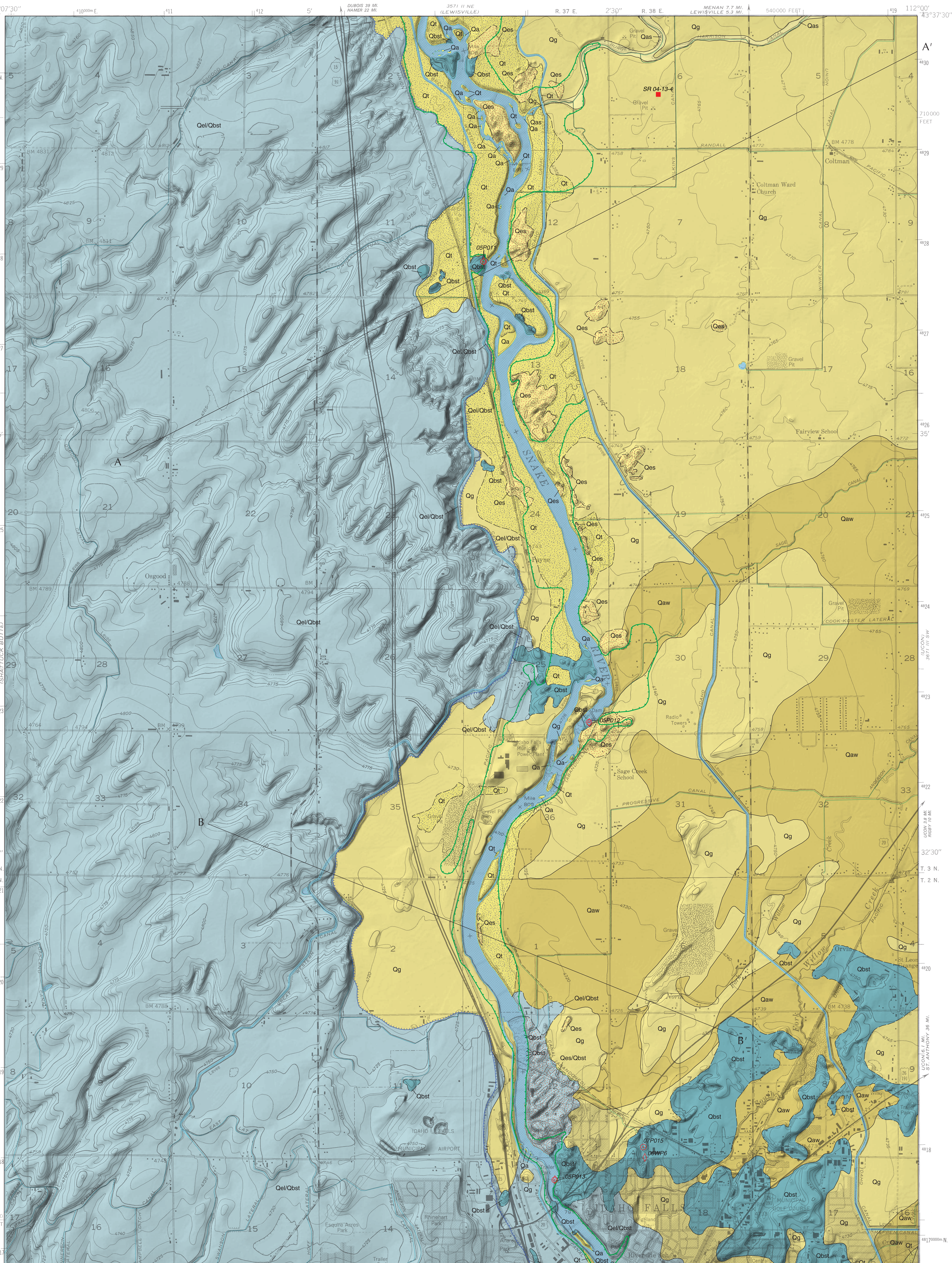
GEOLOGIC MAP OF THE IDAHO FALLS NORTH QUADRANGLE, BONNEVILLE COUNTY, IDAHO

William M. Phillips and John A. Welhan

2011



Base map scanned from USGS film positive, 1979.

Culture and drainage by multiplex methods from aerial photographs taken 1946. Topography by plane-table methods 1948.

Photorevised 1979.

Shaded elevation from 10 m DEM.

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

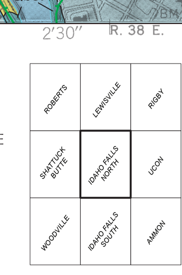
10,000-foot grid ticks based on Idaho coordinate system, central zone.

1000-meter Universal Transverse Mercator grid ticks, zone 12.

UTM Grid and 1979 Magnetic North Declination at Center of Map

SCALE 1:24,000

Contour interval 5 feet



ADJOINING QUADRANGLES

QUADRANGLE LOCATION

Field work conducted 2006-2007.

This geologic map was funded in part by the U.S. Geological Survey National Cooperative Geologic Mapping Program.

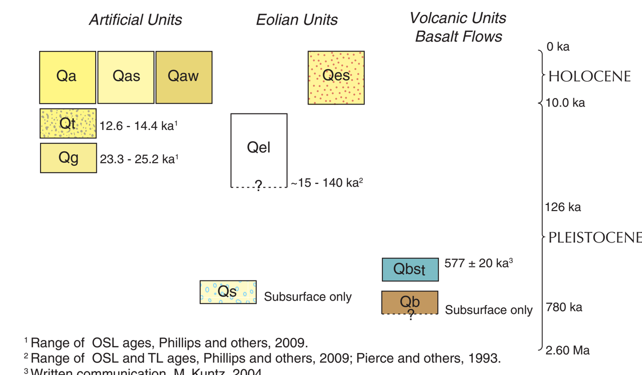
Digital cartography by Collette Gantenbein and Jane S. Freed at the Idaho Geological Survey's Digital Mapping Lab.

Reviewed by John D. Kauffman, Idaho Geological Survey.

Map version 2-4-2011.

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

CORRELATION OF MAP UNITS



[1] Range of OSL ages, Phillips and others, 2009.
[2] Range of OSL and TL ages, Phillips and others, 2009; Pierce and others, 1993.
[3] Written communication, M. Kuntz, 2004.

Geologic time scale from Walker, J.D., and Geissman, J.W., compilers, 2009, Geologic Time Scale: Geological Society of America, doi: 10.1130/2009.CTS004R2C.

INTRODUCTION

This map depicts bedrock and surficial geological units in the Idaho Falls North quadrangle. The map area sits on the edge of the eastern Snake River Plain, a major crustal downwarp associated with the Yellowstone Hotspot. The oldest bedrock units are late Miocene to Pliocene rhyolitic volcanic rocks of the Heise volcanic field (Morgan and McIntosh, 2005). These units were erupted as hotspot volcanism progressed through the region. They crop out in the foothills of the Blackfoot Mountains east of quadrangle and underlie the area. Subsequent subsidence and basaltic volcanism created the lava plains dotted with shield volcanoes characteristic of the eastern Snake River Plain. The Snake River drainage developed during this time and was influenced by both regional subsidence and lava flows. In the eastern Snake River Plain, the Snake River flows between the rhyolitic uplands of the Blackfoot Mountains on the east and basaltic shield volcanoes on the west. The basalt of Shattuck Butte was erupted in the middle Pleistocene from a shield volcano west of the map area. This unit underlies much of the city of Idaho Falls in the shallow subsurface and is exposed along the Snake River. The headwaters of the Snake River in the Yellowstone-Grand Teton area were glaciated at least twice during the Pleistocene, between ~140-160 ka and ~13-25 ka. During these periods, the Snake River was a braided stream with a much greater discharge than the present-day river. A broad outwash plain composed of gravel and sand was built during the last (Pinedale) glaciation (Scott, 1982). Waning discharge near the end of the Pinedale glaciation caused incision into the outwash plain, forming fill-cut terraces. At some point during the middle to late Pleistocene, the Snake River also cut a narrow bedrock channel through Shattuck Butte lava flows to form the falls and cascades for which Idaho Falls is named. In addition, flows adjacent to the Snake River were scoured and streamlined by steam action. The outwash plain was a source of eolian sediments during glaciations. Deposits of fine sand, silt, and clay (loess) were deposited by strong winds and are as much as 20 m (66 ft) thick on Shattuck Butte flows. During the Holocene, the Snake River became a meandering stream confined to a relatively narrow flood plain. Sand derived from Holocene Snake River sediments were deposited in small dunes on the eastern side of the river. In 1976, small portions of the map area adjacent to the Snake River were flooded when the Teton Dam catastrophically failed. This flood was about 100 times larger than any historic Snake River flood, hence it provides perspective on the effects of exceptionally large prehistoric events (Scott, 1977).

SOURCE OF MAP INFORMATION

Mapping is based upon soil maps (Miles, 1981), regional geologic maps (Scott, 1982; Rember and Bennett, 1979), a masters thesis Allison, 2001), mapping of extent of Teton Dam flood (Ray and Matthai, 1976), field work conducted in 2005, geochemical and paleomagnetic analysis of basalts, optically stimulated luminescence dating of sediments, and compilation of hundreds of water well records (available from the Idaho Department of Water Resources at http://www.idwr.idaho.gov/).

DESCRIPTION OF MAP UNITS

ALLUVIAL UNITS

Qa **Alluvium of Snake River (Holocene)**—Gravel, sand, and silt of the modern Snake River floodplain. Thickness generally <3 m (<10 ft). Gravel clast lithology same as unit *Qg* and *Qt*. Consists of gravel-rich point-bar deposits of the main channel and low terraces composed of finer-grain overbank deposits overlain by the Harston, Heiseton and Xeric torrifluvent soils (Miles, 1981).

Qas **Alluvium of sidestreams of South Fork Snake River (Holocene)**—Gravel, sand, and silt of small streams meandering across glacial outwash deposits (unit *Qg*). Thickness <3 m (10 ft). Deposits restricted to relic channels presently occupied by the Burgess and Harrison canals; these channels are tributary to the South Fork of the Snake River and formerly flowed during spring floods.

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 1.5-3 m (5-10 ft). Paesl and Paul soils are developed on this unit (Miles, 1981). Discharge is much diminished in Willow Creek because of irrigation water diversion and development of Ririe Dam. Willow Creek presently reaches the Snake River through two incised channels that flow through Idaho Falls. Former flow paths are indicated by the map pattern of Willow Creek alluvium. One path reached the Snake River along the relic channel presently occupied by Sage Canal (sec. 30, T. 3 N., R. 38 E.). Another prominent incised channel begins in the SE-corner of the map area (sec. 16, T. 2 N., R. 38 E.) and flows to the Snake in the adjacent Idaho Falls South quadrangle.

Qt **Alluvium of Snake River terraces (late Pleistocene)**—One or more terrace tread surfaces along the Snake River separated by low scarps from the floodplain (*Qa*) and outwash plain (*Qg*) units. The terraces are largely erosional surfaces cut into underlying outwash alluvium rather than depositional features. Exposures in gravel pits suggest that terrace alluvium consists of thin (<1.5 m; <5 ft)) planar-bedded gravel with the same clast lithologies as *Qg*. Separated from unit *Qg* in the southern part of the map area by a low scarp that diminishes in height to the north. Terrace deposits cannot be separated reliably from unit *Qg* in well logs or with soil development data. Terrace surfaces are generally covered by 0.5-1.5 m (1.6-5 ft) of loess-derived soils of Bannock and Bock associations with a Bk horizon developed at 30-70 cm (1-2 feet, Miles, 1981). The glacial chronology in the Yellowstone-Grand Teton headwaters area (Licciardi and Pierce, 2008) and OSL ages of unit *Qg* (Table 3; Phillips and others, 2009) suggest that stream incision and deposition of the unit coincided with waning discharge during termination of glaciation at about 13-14 ka.

Qg **Alluvium of Snake River outwash (late Pleistocene)**—Well-rounded, thickly planar- to cross-bedded gravel, separated locally by thin, cross-bedded sand beds. Gravel is dominantly pebble to cobble sized, clast-supported, locally normallygraded and imbricated. Gravel framework is filled by subrounded fine to medium sand. Gravel clasts are dominated by very hard, pink, purple, and gray quartzite with lesser sandstone, granitic rocks, rhyolite, porphyritic igneous rocks, basalt, and limestone. Grains in sand beds are composed of subangular black obsidian, quartzite, quartz and feldspar phenocrysts, muscovite, and fragments of basalt and rhyolite. Sand beds are locally black because of high obsidian content. Capped by 0.5-1.5 m (1.6-10 ft of loess-derived soils of the Bannock and Bock soil associations with a Bk horizon developed at 30-70 cm (1-2.3 ft; Miles, 1981). Based on water well logs, unit is <3-12 m (<10-39 ft) thick in the Idaho Falls North quadrangle. The unit is part of the braided-stream outwash plain deposited during the Pinedale glaciation by meltwaters from the Snake River headwaters (Scott, 1982). OSL ages between 25.2 ka and 12.6 ka (Table 3; Phillips and others, 2009) are consistent with cosmogenic surface exposure ages of moraines in the Yellowstone headwaters (Licciardi and Pierce, 2008). Unit is important sand and gravel resource and is widely mined in the map area.

EOLIAN UNITS

Qes **Dune sand (Holocene)**—Fine to medium sand, well sorted, and loose. Sand composed of quartzite grains, quartz phenocrysts, mafic and feldspathic lithics, and black obsidian. Consists of small active and stabilized dunes and sheet sands along the eastern side of the Snake River, indicating sand source is likely Holocene alluvium. Many dunes formed in lee of basalt bedrock knobs, and trend northeast, parallel to prevailing winds. Thickness ranges from 3 to 6 m (10 to 20 ft). Undated in the map area. OSL ages from the nearby parabolic and hairpin dune field south and east of the map area are between about 3 ka to as young as 80-140 years (Rittenour and Pearce, 2009; Rittenour, 2009). Soils of the Wolverine series are developed on this unit (Miles, 1981).

Qel **Loess (Pleistocene)**—Massive light gray to pale brown, silt, clayey silt, and very fine to fine sand. Calcareous except in near-surface soil horizons. Thickness is greatest over flows of basalt of Shattuck Butte where loess is as much as 20 m (66 ft) thick. Units *Qg* and *Qt* have much thinner loess caps, generally <1.5 m (<5 ft). Landforms on the loess overlying basalt of Shattuck Butte have a northeast orientation parallel to present-day prevailing winds.

Loess in the eastern Snake River Plain contains at least three buried soil horizons indicating multiple periods of accumulation that are correlated with regional glaciations (Pierce and others, 1982; Pierce and others, 2003; Forman and others, 1993) i.e. Pinedale (ca. 25-14 ka), early Wisconsinian (ca. 65-70 ka) and Bull Lake (160-130 ka). In the Mickelson soil pit in NE 1/4 NW 1/4 sec. 4, T. 3 N., R. 38 E. (just outside the map area in the adjacent Lewisville quadrangle) loess below a buried soil has an OSL age of 75.3 ka and is capped by loess that accumulated between about 24-16 ka (Phillips and others, 2009). Significant loess accumulations are not present on Holocene basalt flows of the eastern Snake River Plain (Kuntz and others, 1986). Pancheri and Polatis soils (Miles, 1981) are developed on the unit.

Qs **Sedimentary interbed (middle to early Pleistocene?)**—Widespread subsurface unit separating basalt of Shattuck Butte from older flows. Composed of fine-grained sediment, possibly loess or lake sediment, with lesser gravel and sand. Thickness ranges from <3 m to 15 m (<10 to 49 ft). Not exposed in map area and known only from water well logs. Undated.

VOLCANIC UNITS

Qel/Qbst, Qbst, Qes/Qbst **Basalt of Shattuck Butte (middle Pleistocene)**—Medium gray olivine- and plagioclase-phyric basalt. Shown as *Qel/Qbst* where covered by loess; shown as *Qes/Qbst* where covered by dune sand. Textures vary from glomercrystic with olivine and plagioclase clusters as much as 5 mm, to equigranular and fine-grained. Olivine generally abundant with individual phenocrysts in length as much as 1 mm. Many vesicles are filled with a soft, white, non-carbonate mineraloid; carbonate and silica coatings also common. Generally poorly exposed because of loess and fluvial sediment cover, or obscured by urban development. Adjacent to the Snake River, flows eroded by stream action as indicated by streamlined forms, potholes, and lack of thick loess cover. Many eroded surfaces are above the highest historic flood stages of the Snake River, including the 1976 Teton Dam flood. Basalt flows are best exposed along the Snake River and in nearby irrigation canals. On the basis of paleomagnetism (Table 2), isolated exposures of basalt from the northern edge of the map area to the Highway 20 bridge over the Snake River (sec. 13, T. 2 N., R. 37 N.) are correlated with the Shattuck Butte eruptive center about 8 km (5 miles) west of the map area. These flows have a distinctive excursional paleomagentic declination unique to the region. Basalt was also mapped on the basis of Polatis- and Pancheri-Rock outcrop complexes indicating thin soil cover over basalt (Miles, 1981). East of the Snake River, basalt likely correlative to *Qbst* is present over most of the map area in the subsurface with a base defined by an underlying sedimentary interbed (unit *Qs*). Thickness of this basalt ranges from 33 to 45 m (108 to 148 ft). Water well logs suggest that basalt likely correlative with *Qbst* is more than 75 m (246 ft) thick west of the Snake River. Dated at Shattuck Butte at 577 ± 20 ka by $^{40}Ar/^{39}Ar$ (M. Kuntz, written communication, November, 2004). Paleomagnetic properties suggest correlation with the Emperor-Big Lost reversal excursion event, dated at 565 ± 14 ka (Champion and others, 1988) and 549 ± 6 ka (Lanphere, 2000).

Qb **Basalt (early Pleistocene?)**—Widespread subsurface basalt beneath unit *Qs* known only from water well records. Not exposed in the map area. Undated.

SYMBOLS

Contact: dashed where approximately located.

Terrace scarp; ticks on lower side.

Extent of the 1976 Teton Dam flood; tic on side of flooding.

05P012 Geochemical sample location (see Table 1).

05P013 Paleomagnetic sample location (see Table 2).

SR 04-13-4 OSL sample location (see Table 3).

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ACKNOWLEDGMENTS

We thank the many property owners who permitted us to perform geologic mapping on their property. Mel Kuntz (USGS) supplied an unpublished $^{40}Ar/^{39}Ar$ date for basalt of Shattuck Butte. Glenn Hoffmann (NRCS) facilitated the sampling of loess. Tammy Rittenour (Utah State) performed OSL sampling and dating. Cherry Kersey (University of Idaho) assisted with paleomagnetic analyses.

Table 1. Major oxide and trace element chemistry of basalt samples collected in the Idaho Falls North quadrangle.

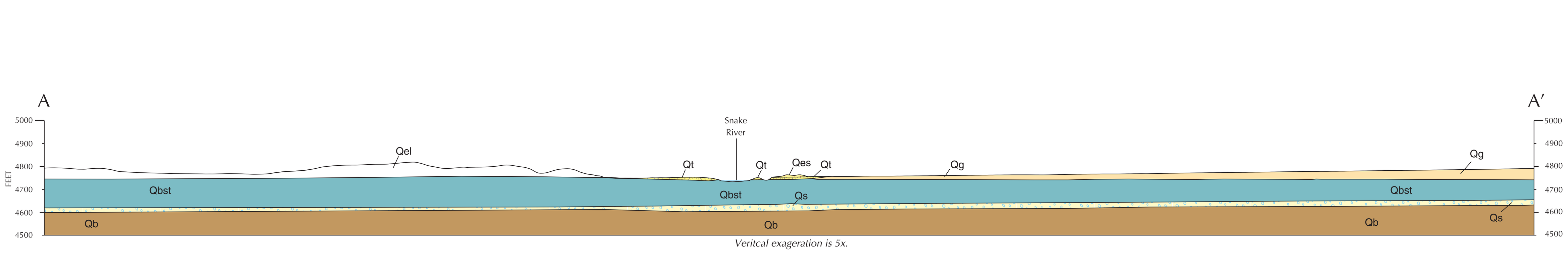
Sample number	Latitude	Longitude	Unit name	Map unit	Major elements in weight percent (unnormalized)											Trace elements in parts per million																	
					SiO_2	TiO_2	Al_2O_3	FeO*	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th	Nd
05P010**	43.60250	-112.15194	basalt of Shattuck Butte	Qbst	44.14	2.881	13.81	13.23	0.201	7.01	11.15	2.30	0.44	0.843	1.96	50	175	29	283	518	5	341	324	45	34.1	19	22	142	7	43	90	2	47
05P011	43.60056	-112.05944	basalt of Shattuck Butte	Qbst	43.91	2.756	14.17	12.80	0.197	6.72	11.34	2.46	0.57	0.833	1.26	53	132	28	272	546	8	337	320	43	34.7	20	30	136	7	46	91	2	45
05P012	43.55472	-112.04500	basalt of Shattuck Butte	Qbst	45.98	2.784	14.03	13.03	0.238	6.57	9.98	2.42	0.74	0.769	0.43	54	180	29	280	855	15	328	314	45	33.2	21	27	138	6	45	87	3	44
05P013	43.50917	-112.04972	basalt of Shattuck Butte	Qbst	44.60	2.859	14.19	12.85	0.223	6.08	11.15	2.50	0.56	0.840	1.24	43	141	29	283	606	8	345	327	45	34.8	22	21	139	8	46	83	2	44
06WP6	43.5114	-112.0374	basalt of Shattuck Butte	Qbst	47.14	2.935	14.51	13.30	0.204	6.93	9.43	2.55	0.74	0.799	-0.36	55	173	27	295	516	15	316	311	41	23.7	21	24	147	7	40	85	2	48

*Total Fe expressed as FeO.
**Sample from vent of basalt of Shattuck Butte in the Shattuck Butte 7.5' quandrangle.
LOI loss on ignition.
Sample 06WP6 is from the same locality as paleomagnetism sample 07P015 (Table 2).
All analyses by XRF and performed at Washington State University GeoAnaltyical laboratory, Pullman, Washington.

Table 2. Paleomagnetic data for basalt Idaho Falls North quadrangle.

Site number	Unit	Latitude	Longitude	n	D	I	α_{95}	k	Polarity	Demag level (mT)
05P010*	Qbst	43.60250	-112.15194	4	76.1	67.8	17.5	28.4	E	40
05P011	Qbst	43.60056	-112.05944	8	87.5	71.5	5.3	109	E	40
05P012	Qbst	43.55472	-112.04500	8	95.7	67.7	9.5	34.8	E	40
05P013	Qbst	43.50917	-112.04972	8	84.8	75.6	3.7	224	E	40
07P015	Qbst	43.51244	-112.03758	4	70.6	79.2	2.82	1066	E	60

n = number of oriented cores.
D = site mean declination of characteristic remnant magnetism.
I = site mean inclination of characteristic remnant magnetism.
α_{95} = confidence limit for the mean direction at the 95% level.
k = precision parameter.
E = excursional polarity.
*Sample from vent of basalt of Shattuck Butte in the Shattuck Butte 7.5' quadrangle.



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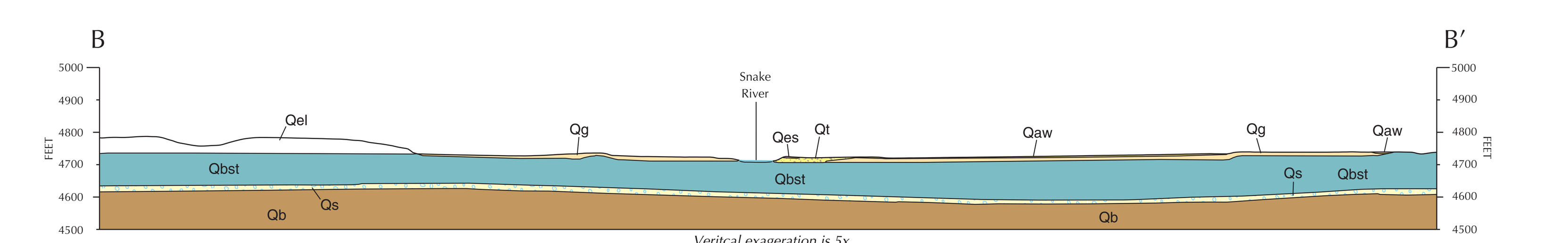

Veritcal exagerration is 5x.

Table 3. Optically stimulated luminescence (OSL) ages.

Sample Number	Latitude	Longitude	Unit Name	Depth (m)	Grain Size (μm)	H_2O* (%)	U (ppm)	Th (ppm)	K_2O (%)	Rb_2O (ppm)	Cosmic (Gy/ka)	Dose Rate (Gy/ka)	USU Number	Number of Aliquots	Equivalent Dose (Gy)	OSL Age (ka)
SR-04-13-4	43.61721	-112.03550	Qg?	1.8	90-150	3.6	1.5 ± 0.1	4.2 ± 0.4	1.13 ± 0.03	39.2 ± 1.6	0.21 ± 0.2	1.74 ± 0.07	USU-105	33	21.84 ± 0.49	12.57 ± 0.68

**in situ* water content of sample.
OSL analysis by Tammy Rittenour at the Luminescence Laboratory, Utah State University; errors are 1σ.
Age error includes random and systematic errors calculated in quadrature.
Gy = absorption of 1 joule of radiation energy by 1kg of matter.
Cosmic = dose rate from cosmic radiation.
H_20, U, Th, K_2O, and Rb_2O are used to compute the dose rate from in situ radioactive decay.

$$\text{OSL age (ka)} = \frac{\text{Equivalent Dose (Gy)}}{\text{Dose rate (Gy/ka)}}$$

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