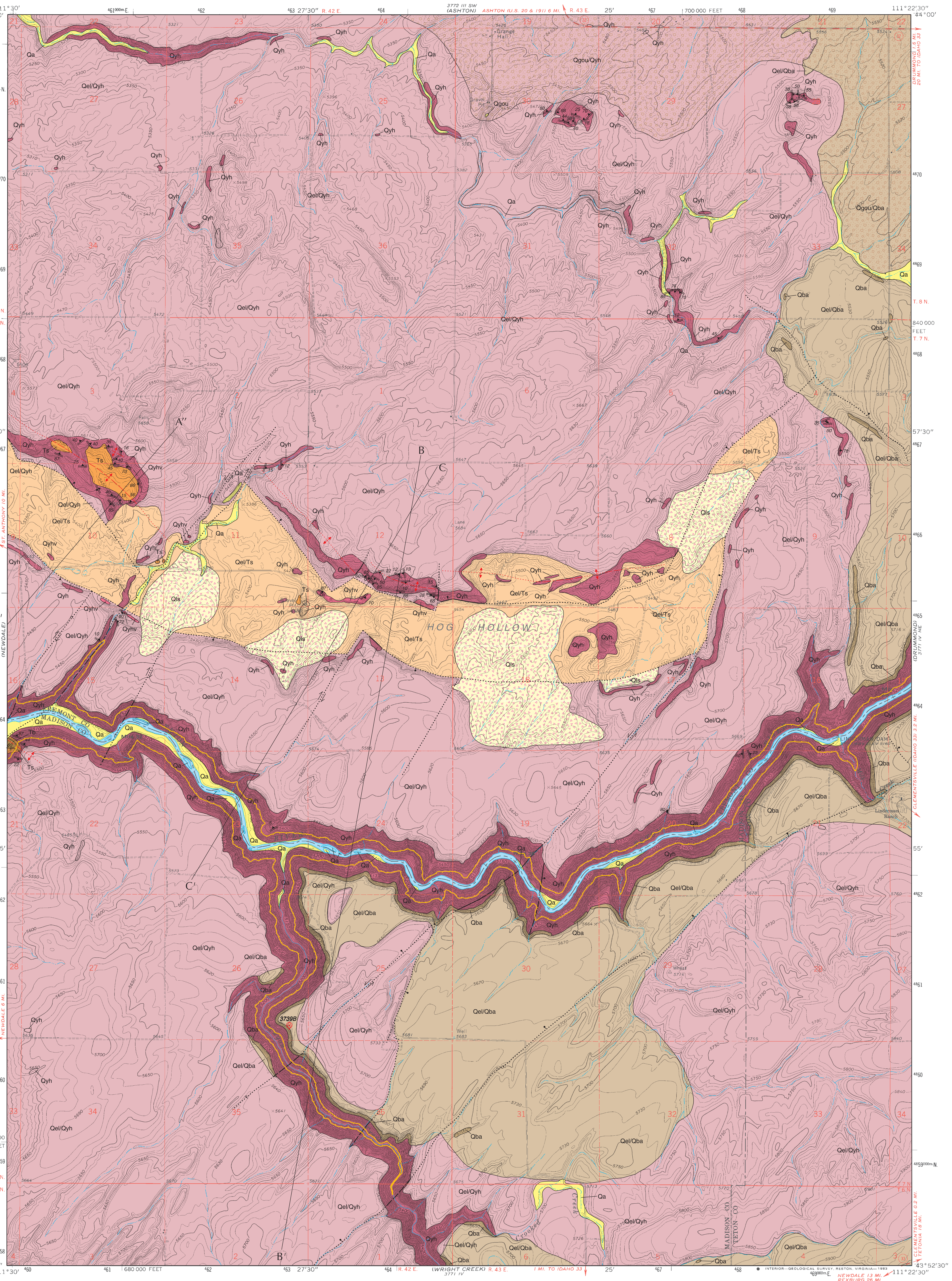
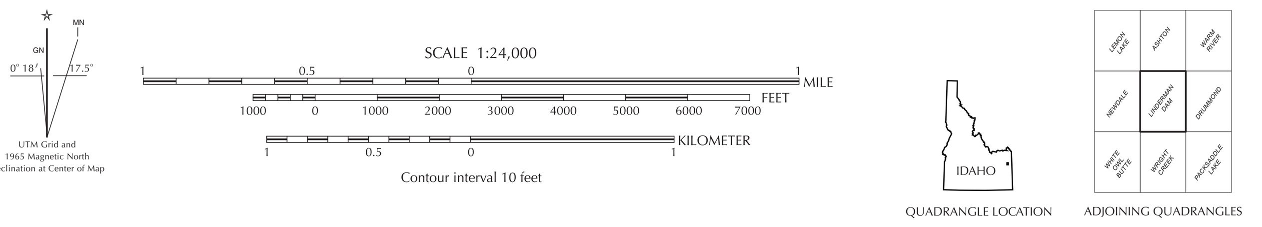
Geologic Map of the Linderman Dam Quadrangle, Fremont, Madison, and Teton Counties, Idaho

Glenn F. Embree[1] and William M. Phillips[2]

2011



Base digitally scanned from 24,000-scale USGS film separates, 1963.
Topography by photogrammetric methods from aerial photographs taken 1963. Field checked 1965.
Projection: Idaho coordinate system, east zone (Transverse Mercator). 1927 North American Datum.
10,000-foot grid ticks based on Idaho coordinate system, east zone.
1000-meter Universal Transverse Mercator grid ticks, zone 12.



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Field work conducted 1977,1978,1988, and 2010.
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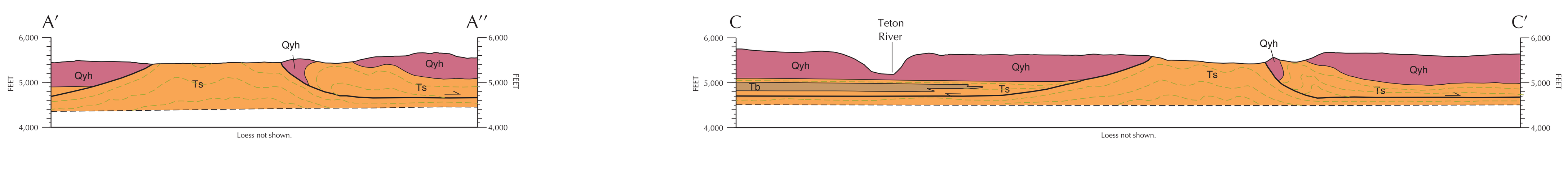
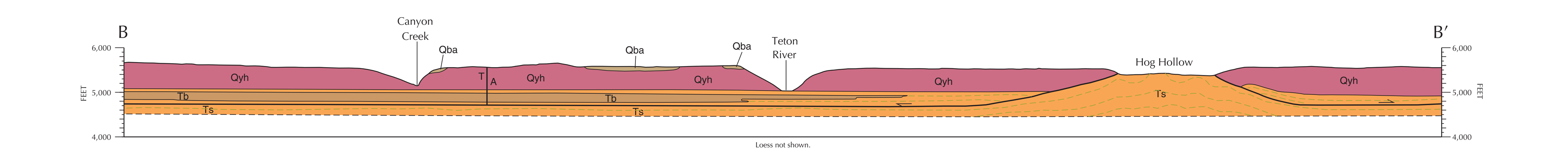
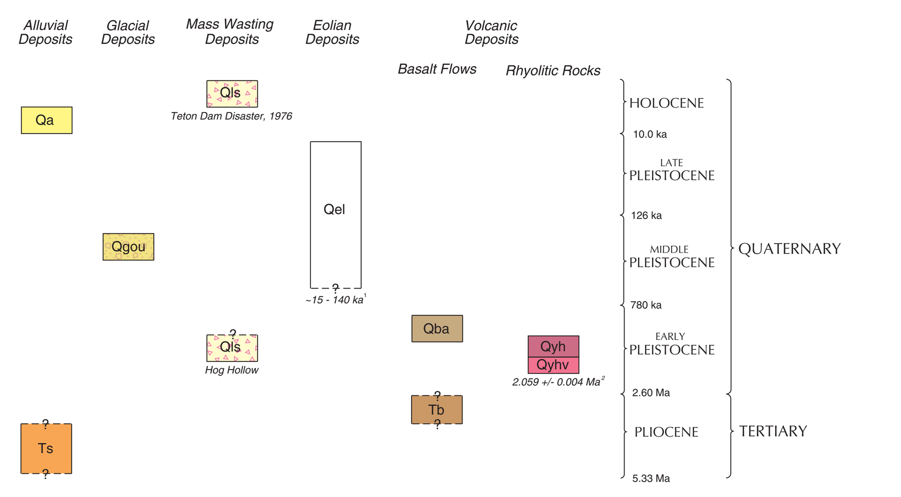
Digital cartography by Jane S. Freed at the Idaho Geological Survey's Digital Mapping Lab.
Reviewed by John D. Kaufman, Idaho Geological Survey.
Map version 10-11-2011.
PDF (Acrobat Reader) map may be viewed online at www.idahogeology.org.





CORRELATION OF MAP UNITS



SYMBOLS

Contact: dashed where approximately located.

Normal fault: ball and bar on downthrown side; dashed where approximately located; dotted where concealed.

Lateral faults: arrows indicate direction of motion; dashed where approximately located; dotted where concealed.

Antiform; dashed where approximately located; dotted where concealed.

Strike and dip of bedding.

Strike and dip of vertical bedding.

Strike and dip of eutaxitic foliation.

Strike and dip of vertical eutaxitic foliation.

Strike and dip of overturned eutaxitic foliation.

Strike and dip of joint.

Boundary of Teton Reservoir on June 5, 1976, elevation 5,301.7 ft.

3739B Paleomagnetic and chemistry sample location (Tables 1 and 2).

INTRODUCTION

The Linderman Dam quadrangle lies within a low basin between the Big Bend Ridge caldera of the Yellowstone Plateau volcanic field (Christiansen, 2001) and the Big Hole Mountains portion of the Rocky Mountain Thrust Belt (Staatz and Albee, 1966; Price and Rogers, 2010). At 2.06 Ma, the Huckleberry Ridge Tuff was erupted from the Big Bend Ridge caldera. The out-flow facies of the tuff swept over Tertiary sediments, basalts, and rhyolitic rocks, and ponded to a depth of about 130 m (425 ft). Immediately following emplacement, the tuff and underlying water-saturated deposits were deformed into large-scale antiform load structures, faults, and a "tectonically" denuded valley (Embree and Hoggan, 1999; Geissman and others, 2010). Best exposures of antiforms are in the Teton River canyon at the boundary of this quadrangle and the adjacent Newdale quadrangle to the west (Figure 1; secs. 16, 20, 21, T. 7 N., R. 42 E.) The valley, called Hog Hollow, extends east-west across the middle of the map and into the adjacent Newdale quadrangle (Embree, Phillips, and Welhan, 2011). The valley have resulted from the formation of a diapiric load structure and associated lateral spreading. Lateral faults produced by this deformation are shallow structures confined to *Qyh* and upper portions of *Ts* and *Tb*. Early to middle Pleistocene basalt flows erupted from vents south and east of this quadrangle and cap the Huckleberry Ridge Tuff (Protska and Embree, 1978). Incision by the Teton River formed the Teton River canyon and its tributaries in which most exposures of bedrock units occur. During the Bull Lake glaciation of the middle Pleistocene, the northeastern edge of the area was the margin of the Yellowstone Plateau-Teton Range ice sheet (Scott, 1982). Till, outwash, and probably loess were deposited at this time. During the Pinedale glaciation of the late Pleistocene, glaciers did not reach the area. However, a thick mantle of loess derived from outwash of Pinedale glaciers was deposited. The loess is the parent material for the rich soils of the region. On June 5, 1976, the Teton Dam in the adjacent Newdale quadrangle failed (Seed and Duncan, 1987). At the time of failure, the reservoir from the dam was at an elevation of ~5,300 ft in Teton canyon. The sudden removal of the reservoir caused dozens of small landslides within the canyon (Figure 1; Schuster and Embree, 1980).

SOURCES OF MAP INFORMATION

Geologic maps by Prostka and Hackman (1974), Raymond and Hansley (1975), Prostka and Embree (1978), and Christiansen (1983, 2001) were compiled and consulted for this study. Additional field work was conducted in 2010. Logs of water wells (Idaho Department of Water Resources, 2010) and drill holes (U.S. Bureau of Reclamation unpublished report) provided information about thickness and extent of units. Paleomagnetic and geochemical studies (Tables 1 and 2) were used to help correlate basalt exposures.

DESCRIPTION OF MAP UNITS

ALLUVIAL AND LACUSTRINE DEPOSITS

Qa **Alluvium of the Teton River and tributary streams (Holocene)**—Unconsolidated clayey silt, silty sand, and gravel. Generally less than 3 m (10 ft) thick.

Qel/Ts, Ts **Tuffaceous lacustrine and alluvial sediments, and interbedded volcanic rocks (Pliocene?)**—Light gray and yellow, weakly cemented, strongly deformed, tuffaceous and arkosic sandstone, siltstone, and conglomerate. Locally interbedded with brown and yellowish-brown palagonite tuff, white diatomite, basalt, and rhyolite. Basalt is mapped as unit *Tb* where possible. Shown as *Qel/Ts* where overlain by loess. Best exposed in Hog Hollow (NE 1/4 sec. 14, T. 7 N., R. 42 E.) where complexly faulted palagonite tuff, gravel, silt, rhyolite glass shards, pumice, glassy scoria, and rhyolite underlie steeply dipping Huckleberry Ridge Tuff (Embree and Hoggan, 1999, p. 201). Disrupted rhyolite flow fragments in this exposure are as much as tens of meters long, are vitrophyric to devitrified, massive to perlitic and locally autoclastic, with 20-25 percent subhedral to anhedral, 1-5 mm phenocrysts of sanidine and quartz. Deformation of *Ts* was created during emplacement of *Qyh* (Embree and Hoggan, 1999; Geissman and others, 2010). In the Teton River canyon (SE 1/4 sec. 16, T. 7 N., R. 42 E.), unit consists of well-rounded cobbles of quartzite and granitic rocks, and weakly cemented sandstone. The unit is present within and south of Hog Hollow (Embree and others, 2011; Phillips, 2010) but likely was not deposited north of this because of a pre-*Qyh* rhyolite flow or dome. Metamorphic and granitic cobbles, arkosic sands, and local diatomite beds suggest deposition in fluvial and lacustrine environments (Christiansen, 1982, p. 353), probably of the ancestral Teton River. Undated. Interbedding of basalt (*Tb*) with a similar stratigraphic position to the ~3.6 Ma basalt of Rexburg (Embree and others, in preparation) suggests a Pliocene age for *Ts*.

MASS WASTING DEPOSITS

Qls **Landslide deposits (early Pleistocene and Holocene)**—There are two sets of landslides: large early Pleistocene features in and around Hog Hollow; and small Holocene (historic) features in Teton canyon. The Hog Hollow landslides consist of hummocky masses of disrupted blocks of *Qyh* and *Ts* that have moved northward from head scarps on the south flank of the Hog Hollow valley (e.g. sec. 14, T. 7 N., R. 42 E.) or eastward from head scarps at the northeast end of the valley flank (e.g. sec. 7, T. 7 N., R. 43 E.). They are inferred to have formed during or soon after deposition of *Qyh* and *Ts* and before the formation of Hog Hollow. Poorly exposed because of thick loess cover.

In Teton canyon, landslides are the result of rapid drawdown of the Teton Reservoir after the failure of Teton Dam on June 7, 1976 (Schuster and Embree, 1980; Figure 1). The majority of these landslides are translational earth slides with failure surfaces near contact between overburden (loess, colluvium, and/or slope wash) and underlying *Qyh*. Thickness from 0.3-0.6 m (1-2 ft) to ~3 m (~10 ft). Where overburden was >3m (>10 ft), landslides began as shallow rotational slumps 6-7.5 m (20-25 ft) thick, then evolved into earth flows and debris flows. Some flows reached out into the river and caused temporary damming or changed stream configurations. Rock falls and slides involving tuff bedrock also occurred. Landslides of all types are more numerous on south side of Teton River because of greater thickness of unconsolidated material from preferential deposition of loess. Most slides occurred at or below the maximum reservoir elevation of 5,301.7 ft. Slides were mapped using air photos taken in June 1976; many of the slides remain visible on images taken in 2004.

GLACIAL DEPOSITS

Qgou **Older glacial deposits, undivided (middle Pleistocene)**—Till and outwash covered by loess. Till consists of pebble to boulder gravel in loose to compact matrix of silty sand to clayey sandy silt; nonsorted to poorly sorted; clasts angular to subround; nonbedded to crudely bedded. Outwash consists of pebble to cobble gravel, locally bouldery, with sand matrix; poor to moderate sorting, clasts subangular to round; bedding is parallel and large-scale cross-bedded; beds are thin to thick (Scott, 1982). Thickness ranges from 1 m (3 ft) to more than 30 m (100 ft). Forms sheet-like deposits with gentle rolling relief (Scott, 1982; Richmond and Hensley, 1975). Poorly exposed in the map area because of thick loess cover. Best exposed in SE 1/4 sec. 30, T. 8 N., R. 43 E. Originally divided by Richmond and Hensley (1975) and Scott (1982) into till and outwash units but exposures in map do not permit this. Undated in the map. Unit can be traced northeast toward the Yellowstone Plateau where it underlies deposits of the last glacial period (Pinedale glaciation). Units with similar stratigraphic position in West Yellowstone and Jackson Hole have dates of about 136-157 ka (Pierce and others, 1976; Licciardi and Pierce, 2008). Based on these dates, the unit probably formed during the Bull Lake glaciation between 140-150 ka.

EOLIAN DEPOSITS

Qel **Loess (late Pleistocene–middle Pleistocene)**—Massive, light gray to light brownish gray silt, clay, and very fine sand; locally crudely bedded by slope processes. In the map area, thickness in well logs ranges from <1.5 to 13 m (<5 to 44 ft). Typically forms drifts downwind from hills, creating linear geomorphic patterns. Deposits are significantly thicker on north and east facing canyon walls due to prevailing southwest winds. Derived from deflation of outwash deposits during glaciations of the Yellowstone Plateau and Teton Range (Scott, 1982). Several depositional units separated by buried soils are present in correlative deposits in the upper eastern Snake River Plain (Pierce and others, 1982; Scott, 1982; McDole, 1969; Lewis and Fosberg, 1982), but have not been documented in the map. Not dated in the map; regional ages range between 15-25 ka, 35 ka, 46 ka, ~68 to 79 ka, and ~130 to 140 ka (Phillips and others, 2009; Pierce and others, 2003, p. 333; Forman and others, 1993).

VOLCANIC ROCKS

Qel/Qba, Qba, Qgou/Qba **Basalt of Ard Farms (early Pleistocene?)**—Dark gray aphanitic to fine-grained basalt with rare plagioclase phenocrysts <2 mm and normal magnetic polarity (Table 1). Shown as *Qel/Qba* where covered by loess, and *Qgou/Qba* where covered by glacial deposits and loess. Erupted from north-trending, loess-covered ridge in the adjacent Drummond quadrangle with a 6,220 ft high-point centered at lat 43.890 N, long -111.230 W. From the vent, flows spread north and west down the north flank of the Big Hole Mountains and along the Teton River and Falls River drainages. Undated. Subdued vent morphology, degree of stream incision, and thick loess cover away from canyon edges suggests eruption during a normal subchron of the Matuyama chron (perhaps subchron C2n (Olduvai) at 1.79-1.95 Ma; polarity timescale from Ogg, 1995), rather than during the Brunhes chron after 0.78 ka.

Qel/Qyh, Qyh, Qgou/Qyh **Unit B, Huckleberry Ridge Tuff (early Pleistocene)**—Compound cooling unit of crystal-rich welded rhyolitic ash-flow tuff. Shown as *Qel/Qyh* where overlain by loess, and *Qgou/Qyh* where overlain by glacial deposits and loess. In lower part of unit, contains 20-30 percent phenocrysts of sanidine and quartz, and sparse plagioclase and pyroxene. Phenocrysts are less numerous (5 percent) near top of unit. Also contains welded pumice inclusions (fiamme). Black basal vitrophyres are exposed locally in the cores of antiforms in the Teton River canyon. Major part of unit composed of light gray to grayish-pink densely welded devitrified tuff with well-developed eutaxitic texture. Thickness is 193 m (634 ft) in drill holes DH11 and DH19. Other well logs and exposures indicate that thickness varies greatly in the map, from about 37-130 m (122-425 ft). This probably reflects rheomorphic deformation (Embree and Hoggan, 1999; Geissman and others, 2010). Total-fusion and incremental-heating ages of sanidine from *Qyh* are 2.059 ± 0.004 Ma (Lanphere and others, 2002). The tuff cooled in a weak transitional geomagnetic field with subhorizontal inclination and southwest declination (Reynolds, 1977). Paleomagnetic studies show that internal deformation, including formation of >120 m amplitude antiforms, occurred while the unit was above the maximum blocking temperature of magnetite (~580° C) (Geissman and others, 2010). Correlated with Unit B of the Huckleberry Ridge Tuff erupted from the Henrys Fork Caldera of the Yellowstone Plateau in the vicinity of Island Park, Idaho (Christiansen, 2001).

Qyhv **Vitrophyres of Unit B, Huckleberry Ridge Tuff (early Pleistocene)**—Dense black welded tuff with phenocrysts of sanidine and quartz set in a glassy groundmass. Consists of basal vitrophyre about 10-15 m (33-49 ft) thick exposed in antiforms in the Teton River canyon. Also exposed as "lateral vitrophyre" ~1-10 m (3-33 ft) thick along flanks of Hog Hollow in S 1/2 sec. 12, T. 7 N., R. 42 E. (Embree and Hoggan, 1999).

Tb **Basalt (Pliocene?)**—Dark gray columnar-jointed lava flows of massive and diktytaxitic basalt containing phenocrysts of plagioclase and olivine. Maximum exposed thickness in the core of anticlines along the Teton River is 79 m (260 ft). In drill holes DH11 and DH19, unit occurs near the top of unit *Ts* and is as much as 59 m (194 ft) thick. Undated. May be broadly correlative with the ~3.6 Ma basalt of Rexburg (Embree and others, in preparation).

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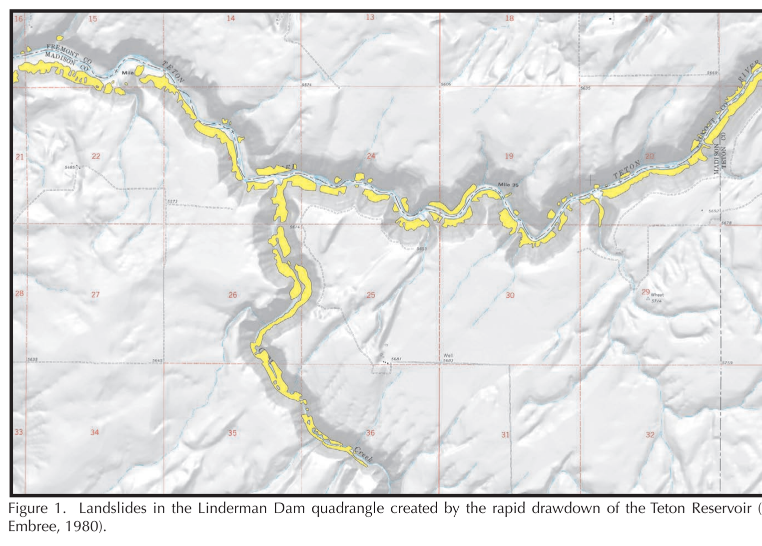

Figure 1. Landslides in the Linderman Dam quadrangle created by the rapid drawdown of the Teton Reservoir (after Schuster and Embree, 1980).

Table 1. Paleomagnetic data for the basalt of Ard Farms collected in the Linderman Dam quadrangle.

Sample number	Unit name	Latitude	Longitude	n	D	I	α_{95}	k	R	Polarity
3739	Qba	43.99	-111.461	7/8	344.7	64.1	1.8	1162	6.9948	N

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.
Analysis by D. Champion, Volcanic Hazards Team, U.S. Geological Survey.

Table 2. Major oxide and trace element chemistry of basalt of Ard Farms collected in the Linderman Dam quadrangle.

Sample number	Latitude	Longitude	Unit name	Map unit	Major elements in weight percent (unormalized)											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	Sm	Nd
3739	43.99	-111.461	basalt of Ard Farms	Qba	45.75	2.51	16.04	14.43	0.24	6.52	9.86	1.89	0.37	0.39	-0.20	95	81	26	319	510	1	273	198	40	21	22	81	132	10	22	46	5	27

* Total Fe expressed as FeO.
Geographic coordinates in North American Datum of 1927.
All analyses by XRF performed at BYU-Provo by Dan Moore, BYU-Idaho.
Sample is at same location as paleomagnetic sample 3739B (Table 1).