PDF (Acrobat Reader) map may be viewed online at

www.idahogeology.org.

INTRODUCTION

The Newdale quadrangle lies on a dissected plateau locally known as the Rexburg Bench. Geologic features of the Rexburg Bench are closely associated with water and agricultural resources. Near-surface geology of the bench consists of the Huckleberry Ridge Tuff and three basalt units. The Huckleberry Ridge is a highly permeable and jointed ash flow tuff. Most high production irrigation water wells in the region draw from the Huckleberry Ridge aquifer. A dam constructed by the US Bureau of Reclamation in the Teton River canyon failed catastrophically in 1976, largely due to uncontrolled seepage of reservoir water through joints and shear zones in the Huckleberry Ridge Tuff. Bedrock outcrops are rare in the Newdale quadrangle outside of the Teton River canyon because of widespread loess cover. The loess is the parent material for the rich soils of the region.

GEOLOGIC HISTORY

The Huckleberry Ridge Tuff was erupted from the Henrys Fork caldera of the Yellowstone Plateau at 2.059 Ma (Lanpere and others, 2002; Christiansen, 2001). Well logs show that the tuff flowed over irregular topography containing at least one large lake, west-flowing streams, basaltic lava flows, and rhyolitic rocks. Large scale gravity sliding and deformation occurred within the lake and stream deposits shortly after the Huckleberry Ridge ignimbrite flowed over them (Geissman and others, 2010; Embree and Hoggan, 1999). A minimum of 1 km (0.6 mi) of horizontal movement caused significant deformation in the still partially fluid tuff sheet. Unusually numerous open joints, shear zones, large scale >150 m (>490 ft) amplitude overturned asymmetric antiforms, and a tectonically denuded valley (Hog Hollow) were created prior to complete welding and devitrification of the ignimbrite.

The basalt of Moody Creek was erupted from a presently obscured vent in the adjacent Moody quadrangle to the south. Following ancestral Moody Creek and flowing around uplands of Huckleberry Ridge Tuff, at least 3 lava flows were emplaced. Pillow basalts at the base of the flows suggest that they encountered the Teton River, diverting or blocking it temporarily at the mouth of the Teton Canyon (Jordan and others, 2010b). The basalt of Moody Creek has not been dated. It has reverse magnetic polarity, indicating that it is probably older than 780 ka.

The basalt of Snake River Plain is tentatively correlated with flows erupted from a low shield volcano in the Ashton quadrangle at 909 ka (D. Champion, oral communication, 2010). The basalt flowed south down the Henrys Fork drainage. It has reverse magnetic polarity.

The basalt of Chester occupies an abandoned stream valley between the highlands of the Huckleberry Ridge and the lowlands of the Snake River Plain. Petrologically similar to the basalt of Moody Creek, the basalt of Chester has an age of about 256 ka (D. Champion, 2010) and normal magnetic polarity.

Downdropping of the upper Snake River Plain and the Teton Basin relative to the adjacent Big Hole Mountains caused the Rexburg Bench to be incised by the Teton River. Most of the incision was accomplished between eruption of the Huckleberry Ridge Tuff and the eruption of basalt of Moody Creek.

During the glacial periods of the middle and late Pleistocene, a large ice sheet and numerous alpine valley glaciers occupied much of the headwaters of Henrys Fork and Teton River in the Yellowstone and Grand Teton areas. Outwash streams from these glaciers deposited thick fills of gravel along the Henrys Fork. At the same time, strong northeast-directed winds deposited loess over the Rexburg Bench. Part of the surface of the basalt of Snake River Plain was probably scoured by outwash streams, as shown by the anomalously thin loess cover on the flow.

TETON DAM DISASTER

On June 5, 1976, the Teton Dam failed catastrophically, killing 14 people and causing \$400 million to \$1 billion dollars (1976 dollars) in flooding damage. The causes of the disaster have been extensively studied (e.g. Seed and Duncan, 1987) and show that poor understanding of the geologic conditions at the dam site contributed directly to the disaster.

The dam site in the Teton River canyon (NE/4, Section 30, T. 7 N., R. 42 E.) consists of Huckleberry Ridge Tuff and a maximum of about 30 m (100 ft) of alluvium in the river channel. Uplands adjacent to the canyon are covered with up to 9 m (30 ft) of loess. The loess was used to construct most of the dam core.

The Huckleberry Ridge Tuff near the dam site is highly jointed and locally folded into large-scale overturned antiforms. This deformation occurred when the tuff was emplaced upon unconsolidated, water-saturated sediments and basalts (Embree and Hoggan, 1999; Geissman and others, 2010). Secondary flow occurred after the upper part of the tuff had welded and jointed but prior to devitrification, causing joint walls to pull apart and form numerous open fissures as much as 1 m (3 ft) wide. Lower in the unit subhorizontal shear zones reflect the transition from brittle to viscous behavior during devitrification. The joints and shear zones form an extensive interconnecting system of fractures which make the tuff extremely permeable and difficult to seal.

During dam construction, the potential for seepage problems through the joints was recognized. Twenty meters (70 ft) of jointed tuff was removed along both sides of the dam and along the base, and grout (mixtures of sand and cement) was pumped into fractures using vertical drill holes spaced 3 m (10 ft) apart. The excavated areas were filled with compacted loess.

Reservoir filling began in November 1975 with an intended filling rate of 0.3 m (1 ft) per day. Late spring snowfall created a heavier runoff than expected. This caused rapid filling rates of about 1.2 m (4 ft) per day in late May. The river outlet works (used to control reservoir elevation below that of the spillway) was also delayed. By the day of failure on June 5, the water level stood at elevation 5,301.7 ft, 1 m (3 ft) below spillway crest elevation and 9 m (30 ft) below the embankment crest. When indications of seepage through the dam first appeared late on June 4, there was no means to reduce the water level. By 7:00 am on June 5, other springs appeared on and adjacent to the dam. Efforts to reduce the leaks were futile and at 11:57 am the dam crest was breached, spilling 0.3 km³ (240,000 acre-ft) of water down the Teton River to the Snake River Plain over a period of 6-8 hours. Property damage was highest in Sugar City and Rexburg.

Reconstruction of the failure indicates that movement of reservoir water along open joints and within loess at the base of dam was the major contributing cause. The grout barrier was ineffective at preventing leakage. Furthermore, use of loess was a poor engineering decision because while possessing good strength and low permeability, loess is erodible by flowing water and can be fractured under some conditions.

The dam break had many geomorphic effects (Scott, 1977). Rapid drawdown of the reservoir caused numerous small landslides (Schuster and Embree, 1980; Figure 1). A peak discharge of 65,000 m³/sec (2.3 x 10⁶ ft³/s) and average velocity of 12 m/s (40 f/s) produced features in the Teton River canyon such as scoured bedrock and large pendent bars similar to those of prehistoric catastrophic floods such as the Missoula Floods or Bonneville Flood.

GEOTHERMAL RESOURCES Numerous thermal wells with anomalous geothermal gradients are present

in the Rexburg Bench/Newdale area (Brott and others, 1976; Blackwell and others, 1992). In the Newdale quadrangle, Dansart and others (1994) reported 20 thermal wells. These wells extend northeast about 11 km (7 mi) from the town of Newdale to the southern edge of Hog Hollow. Temperatures range from 23.0°C to 87.0°C. Well depths vary from <122 m (400 ft) to 1033 m (3389 ft). The best documented wells are UNST-7 and UNST-8, drilled by Union Oil Company, Geothermal Division in 1981 (Phillips, 2010). They show the presence of a major thermal aquifer at depths of 550 - 600 m (1800 - 1970 feet). Brott and others (1976, plate 3 and p. 49) suggest that hot fluid circulation along concealed NE-trending faults is responsible for the thermal features. In 2009, Standard Steam Trust, LLC. drilled 19 shallow geothermal gradient wells in the Newdale quadrangle. Drillers logs for the Standard Steam Trust wells are available from the Idaho Department of Water Sources water well database at http://www.idwr.idaho.gov/apps/appswell/searchWC.asp.

SOURCES OF MAP INFORMATION

Geologic mapping in the Newdale quadrangle is after Prostka and Embree (1978) and Prostska and Hackman (1974), with corrections and updates by G.F. Embree between 1978 and 2009. Surficial deposits and extent of flooding from the 1976 Teton Dam failure are from Scott (1977). Landslides in the Teton River canyon are from Schuster and Embree (1980).

DESCRIPTION OF MAP UNITS

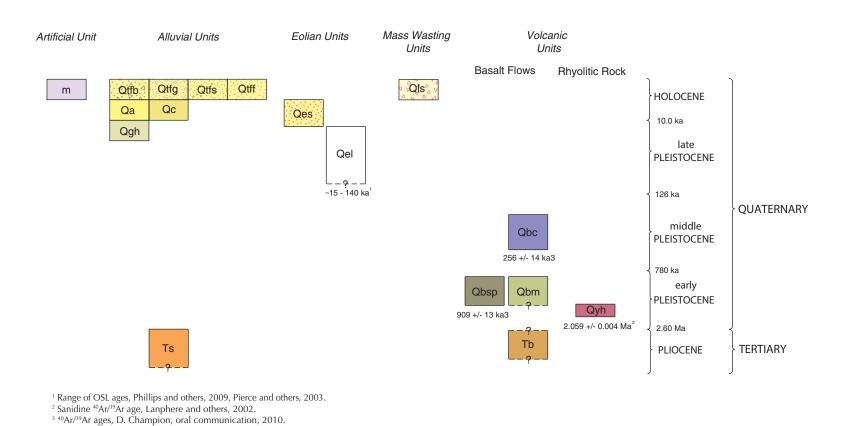
DEPOSITS OF THE TETON DAM FAILURE M Artificial fill (Holocene)—Remnants of breached Teton Dam core; composed

of locally mined, compacted loess and small amounts of sand and gravel. **Boulder gravel (Holocene)**—Boulders mixed with cobbles and pebbles, and boulders in open-work deposits; boulders angular to subrounded; boulder dimensions typically 0.5-2 m (1.6-6.6 ft) on a side; largest are 11 x 8 x 4 m (36 x 26 x 13 ft) and weigh as much as 810 tonnes (896 tons); boulders composed of Huckleberry Ridge Tuff and basalt of Moody Creek derived from nearby talus or bedrock in canyon of Teton River. Most boulders are concentrated within 500 m (1,640 ft)) of their source and form pendant bars

up to 12 m (39 ft) thick downstream from bedrock projections.

Qtfg Gravel (Holocene)—Mixed pebbly gravel and sand to cobble gravel; clasts rounded to subrounded; derived from fill of the Teton Dam, gravel along the Teton River, and from gravel in road fills, irrigation canals, and terrace scarps; composed of a variety of igneous and sedimentary rocks. Forms pendant bars as much as 10 m (33 ft) thick in canyon downstream of bedrock projections. Also forms gravel sheets as much as 5 m (16 ft) thick at mouth of Teton River canyon and 1 m (3.3 ft) thick downstream from scoured road fills, irrigation canals, and terrace scarps. Gravel surfaces locally display asymmetric ripples. Locally covered by <10 cm (4 in) of fine sand and silt in areas inundated by slack water during flood recession.

CORRELATION OF MAP UNITS



Sand (Holocene)—Sand and pebbly sand; forms parts of pendant bars in canyon and sheet-like deposits at canyon mouth and farther downstream; downstream deposits derived from scour of sandy road fills, irrigation canals, and terrace scarps; canyon deposits as thick as 3 m (10 m); deposits downstream <1 m (3.3 ft) thick.

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

Otff Fine sand and silt (Holocene)—Fine sand, silt, and clay in deposits; <20 cm (8 in) thick on flood plains, in depressions, and in fields surround by dikes, roads or irrigation canals. Found where slack water was present during flooding. Mapped where thicker than 5 cm (2 in). Sources were compacted loess core of the Teton Dam, eolian sand, fine-grained artificial fills, and the fine fraction of gravelly embankments.

Landslide deposits (Holocene)—Landslides resulting from the rapid drawdown of the Teton Reservoir after the failure of Teton Dam (see Figure 1). Majority of landslides are translational earth slides with failure surfaces near contact between overburden (loess, colluvium, and/or slope wash) and underlying Huckleberry Ridge Tuff. 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.

ALLUVIAL, COLLUVIAL AND LACUSTRINE DEPOSITS

Alluvium of the Teton River, Falls River, and Henrys Fork (Holocene)—Unconsolidated clayey silt, silty sand, and gravel. Generally less than 3 m (10 ft) thick.

Qc Colluvium and slope wash (Holocene)—unconsolidated angular blocks of tuff in silty tuffaeous matrix at base of steep slopes in Teton River canyon.

Generally <5 m thick (16 ft).

Qgh

Gravel alluvium of the Henrys Fork and Falls River (late Pleistocene)—Poorly to moderately sorted gravel and sand; thickness from <10 m to about 50 m (<10 ft to 164 ft). Consists of outwash deposits from Pinedale-age glaciers in the headwaters of Falls River and Henrys Fork. Undated in map area.

Tuffaceous lacustrine and alluvial sediments (Pliocene?)—Light-gray and yellow, poorly consolidated diatomite, tuffaceous and arkosic sandstone, siltstone, and conglomerate; locally contains brown and yellowish-brown basaltic tuff. Shown as *Qel/Ts* where overlain by loess. Best exposed in the core of anticlines in the Teton River canyon where it has maximum thickness of about 100 m (330 ft). Correlated with widespread tuffaceous clay, sand, and gravel deposits encountered in well logs below unit *Qyh*. Unit is 115 m (378 ft) thick in drill hole DH651B (SE 1/4 sec. 19, T. 7 N., R. 42 E.). In geothermal UNST-8 (NE/4 S. 9, T. 7 N., R. 42 E.), unit consists of 18 m (60 ft) of gravel composed of quartzite, schist, basalt, rhyolite, and granite beneath about 30 m (100 ft) of clay and arkosic sand. Not dated.

EOLIAN SEDIMENTS

Qes Sand dunes and sheets (Holocene–late Pleistocene?)—Light brown to gray, moderately to well sorted, fine to coarse sand forming mostly stabilized parabolic dunes. Thickness varies from <1 to 10 m (3 ft to 33 ft). Undated

Qel Loess (late Pleistocene–middle Pleistocene)—Massive, light gray to light brownish gray silt, clay, and very fine sand. Thickness generally 2 to >5 m (6.5 to >16 ft) over units *Qbm*, *Qbc*, *Qyh*, *Ts*; much thinner to absent on *Qa* and *Qbsp*. Derived from deflation by dominantly southwest winds of silty sediment from outwash deposits during glaciation of the Snake River headwaters. Several depositional units separated by buried soils are likely present but have not been documented in the map area (Pierce and others, 1982; Scott, 1982). Not dated in the map area; regional ages range between 15 to 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).

VOLCANIC ROCKS

Basalt of Chester (middle Pleistocene)—Medium-gray, fine-grained basalt with sparse phenocrysts of plagioclase; similar in appearance to *Qbm*. Shown as *Qel/Qbc* where overlain by loess. Locally has platy foliation and numerous cavities filled with a yellow mineral (SW 1/4 sec. 22, T. 7 N, R. 41 E.). Fills paleovalley between units *Qyh* and *Qbsp*. Vent area uncertain but probably north of the Falls River in the adjacent Lemon Lake or Ashton quadrangles. Normal magnetic polarity (Table 2). Dated by ⁴⁰Ar/³⁹Ar at 256 ± 44 ka in SE/4 sec. 2, R. 41 E. (oral communication, D. Champion, 2010).

Basalt of Moody Creek (early Pleistocene)—Medium gray, fine-grained, locally diktytaxitic basalt with sparse phenocrysts of plagioclase as much as 5 cm in length and 7-10 percent olivine. Shown as *Qel/Qbm* where overlain by loess. Thickness ranges between about 18 m tp 43 m (60 ft to 140 ft). Vent obscured by younger flow units but probably is in the Moody quadrangle south of the map area. A 25 m (82 ft) section of three flows of the basalt, each with well developed pillows as much as 0.5 m in diameter at the base, is exposed on the northern wall of the Teton River canyon (sec. 25, T. 7 N., R. 41 E.; Jordan and others, 2008; 2010; Embree and Hoggan, 1999, p. 201). The pillows indicate temporary damming of the Teton River by the flows. Not dated. Reverse magnetic polarity (Table 1) suggests that age is

fine-grained diktytaxitic and glomeroporphyritic basalt. Shown as *Qel/Qbsp* where overlain by loess. Abundant small (~1 mm) plagioclase phenocrysts and moderately abundant ~2 mm olivine phenocrysts. Water well logs indicate at least two flows separated by thin clay and gravel deposits. Thickness ranges from about 13 m to 41 m (44 ft to 136 ft). Thickness is greatest adjacent to the Henrys Fork. Not dated in map area. Reverse magnetic polarity (Table 1). Correlated with basalts erupted from a low shield volcano in the Ashton quadrangle (sec. 14, R. 42 E., T. 8 N.) with an ⁴⁰Ar/³⁹Ar age of 909 ± 13 ka (oral communication, D. Champion, 2010).

between ~780 ka and 2.059 Ma (age of unit Qyh).

Unit B, Huckleberry Ridge Tuff (early Pleistocene)—Compound cooling unit of crystal-rich welded rhyolitic ash-flow tuff erupted from the Henrys Fork Caldera of the Yellowstone Plateau (Christiansen, 2001). Shown as Qel/Qyh where overlain by loess. Major phenocrysts are sanidine and quartz, with sparse plagioclase and pyroxene. Phenocrysts are abundant (<5 percent) near the top. A black basal vitrophyre is exposed locally in the Teton River canyon in the cores of large amplitude antiforms (e.g. NW 1/4 sec. 29, T. 7 N., R. 42 E.; Embree and Hoggan, 1999, p. 200). Above this, the major part of the unit is composed of light-gray to grayish-pink densely welded devitrified tuff with well developed eutaxitic texture. Locally, a thin (<7 m; 23 ft) sheet of orange crystal-rich welded ash-flow tuff overlies the main sheet of the unit (e.g. NE 1/4, sec. 15, T. 5 N., R. 41 E.). This tuff is distinguished by its lack of devitrification, presence of fresh nonflattened white and pink pumices, and distinctive black glass shards in an orange matrix. A weathering horizon consisting of about 2-10 m (6.5-33 ft) of red clay and partially decomposed tuff is locally present on top of the Huckleberry Ridge Tuff. Exposed thickness in the Newdale quadrangle of the Huckleberry Ridge Tuff is at least 125 m (410 ft). Well logs indicate that thickness varies greatly, from about 11 m to 232 m (35 ft to 760 ft). This probably reflects both emplacement onto landscape with tens of meters of relief and post-emplacement deformation. Correlated with Unit B of the Huckleberry Ridge Tuff (Christiansen, 2001, p. G58, Fig. 33). Total-fusion and incremental-heating ages of sanidine 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).

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 well logs, the unit occurs near the top of unit *Ts* and is as much as 90 m (300 ft) thick. Undated. May be broadly correlative with the Pliocene basalt of Rexburg exposed in the Ririe and Rexburg 7.5 minute quadrangles.

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.

Fold axis; arrow indicates direction of plunge.

Overturned antiform; dashed where approximately located; dotted where concealed.

Antiform; dashed where approximately located; dotted where concealed.

 \\$\chi^{60}\$ Strike and dip of bedding.

 \\$\chi\$ Strike and dip of vertical bedding.

 \\$\chi_{22}\$ Strike and dip of eutaxitic foliation.

Strike and dip of vertical eutaxitic foliation.

Strike and dip of overturned eutaxitic foliation.

Boundary of Teton Reservoir on June 5, 1976, elevation 5301.7 ft.

Boundary of area inundated by floodwater from Teton Dam Flood of June 1976. Because of errors in the original quadrangle

phy in all areas.

(Asymmetric ripples in deposits of the Teton Dam failure; ripples are 0.3 to 3 m thick and 2 to 50 m long. The larger ripples occur on bars in the Teton River canyon and at the canyon mouth; smaller ripples occur in downstream areas.

base map, the extent of flooding may not agree with topogra-

Thermal wells showing maximum temperature (°C).

Paleomagnetic sample (see Table 1).

3499B

Geochemical sample location (see Table 2).

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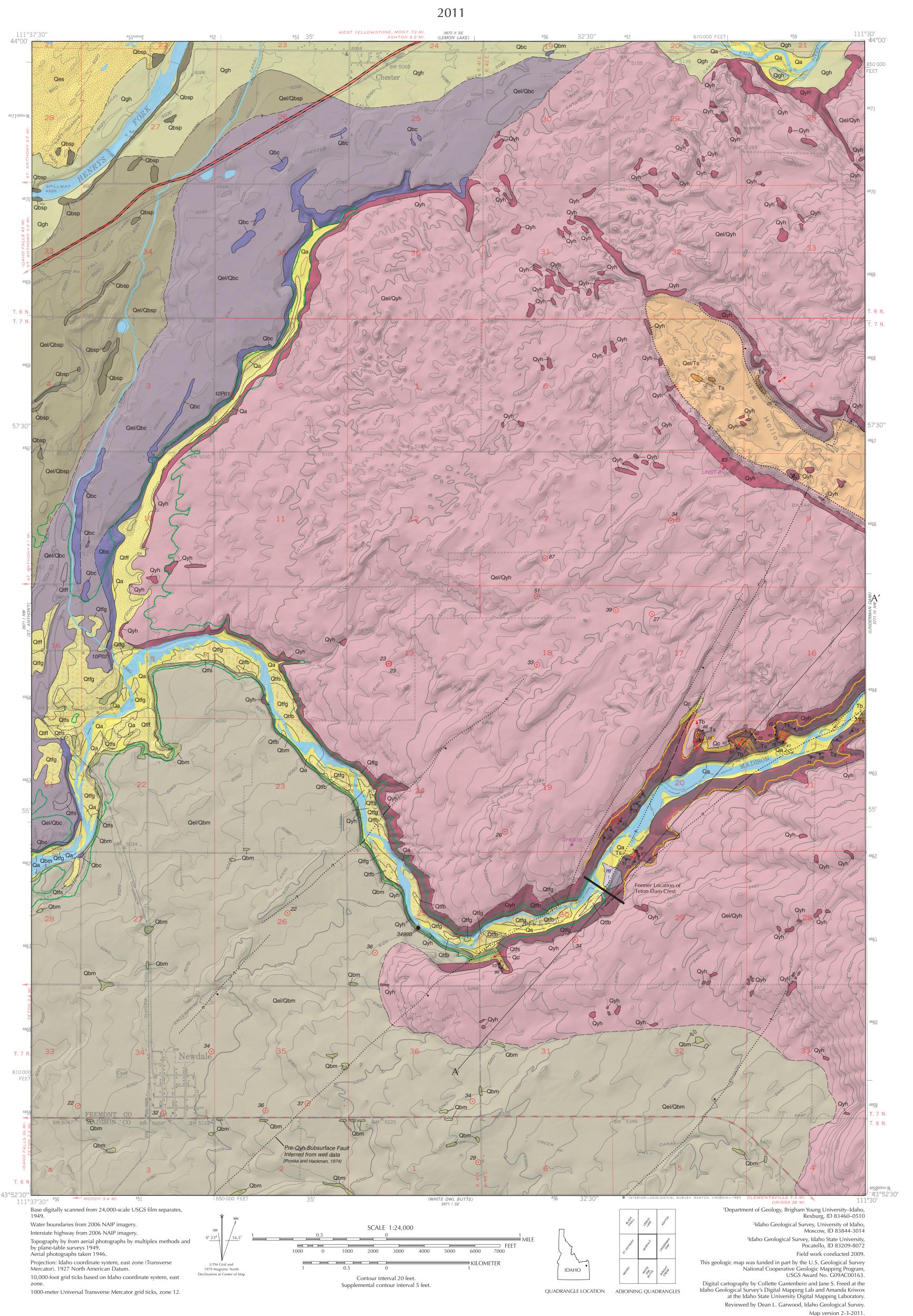
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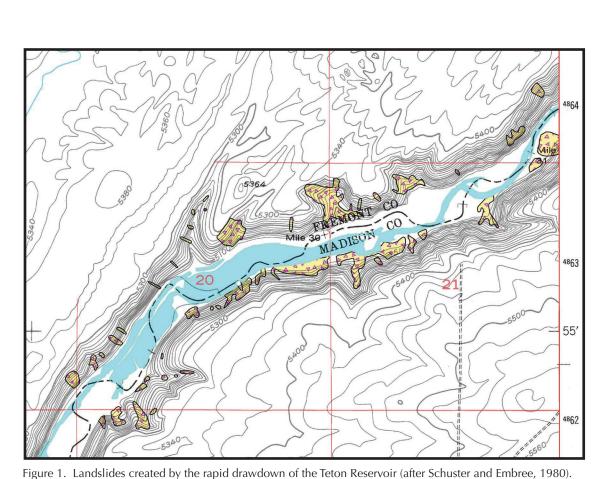
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Geologic Map of the Newdale Quadrangle, Fremont and Madison Counties, Idaho

Glenn F. Embree¹, William M. Phillips², and John A. Welhan³





View of Teton Dam after collapse.

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

Table 1. Paleomagnetic data for the Newdale quadrangle.

 10P01
 Qbc
 43.96157
 -111.59489
 6/8
 9.0
 60.7
 7.8
 76
 N
 60

 10P02
 Qbc
 43.93378
 -111.61322
 8/8
 18.6
 57.0
 3.7
 224
 N
 60

 10P06*
 Qbsp
 44.00715
 -111.54471
 5/8
 214.2
 -66.5
 3.1
 598
 R
 60

3499B** Qbm 43.90353 -111.56731 8/8 157.5 -69.3 2.2 640 R

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

number name Latitude Longitude n D I

D = site mean declination of characteristic remnant magnetism. I =site mean inclination of characteristic remnant magnetism. $\square_{or} =$ confidence limit for the mean direction at the 95% level.

n = number of oriented cores.

*Locality in the Lemon Lake 7.5' quadrangle.

= precision parameter.

Sample number Latitude Longitude Unit name unit SiO₂ TiO₂ Al₂O₃ FeO* MnO MgO CaO Na₂O Na₂O Na₂O Na₂O Na₂O Na₂O Na₂O Na₃O Na₄O Na₅O Na₅

* Total Fe expressed as FeO.

All analyses by XRF performed at Washington State University GeoAnalytical Laboratory, Pullman, Washington.

Sample is at same location as paleomagnetic sample 3499B (Table 1).