

ENERGY AND MINERAL RESOURCES

Several deep irrigation wells on the Rexburg bench have produced warm water (about 20°C to 26°C; Dansart and others, 1994). Exploration for geothermal energy was conducted in the area in the late 1970s and early 1980s (Prostka and Embree, 1978; Embree and others, 1979; Kunze and Marlor, 1982).

Sand and gravel are mined in several pits in the quadrangle from units *Qgh* and *Qgsr* (Gillerman and Weppner, 2014). Crushed rock has been mined from unit *Tbr* in SW1/4 sec. 18, T. 5 N., R. 40 E.

DESCRIPTION OF MAP UNITS

SEDIMENTARY DEPOSITS

Man-made land (Holocene)—Engineered fill along US Highway 20.

Qas

Alluvium of side streams (Holocene)—Gravel, sand, silt and clay contained in relic channels of the Snake River and South Fork Teton River. Thickness less than 9 m (30 ft). Subject to flooding and high water tables during spring and early summer.

Qaht

Alluvium of the Henrys Fork and South Fork Teton River (Holocene)—Gravel, sand, silt and clay of active floodplains of the Henrys Fork and South Fork Teton River. Deposited in numerous meandering channels, oxbows, and point bars. Thickness is generally less than 9 m (30 ft). Subject to seasonal flooding and standing water.

Qth Fill-cut terrace alluvium of the Henrys Fork and South Fork Teton River

(Holocene-late Pleistocene)—Sand, clay, and gravel in terraces separated by 1.5-3 m (5-10 ft) scarps from the floodplain and active channels of the Henrys Fork and South Fork Teton River. Terrace riser height generally increases to the north along the Henrys Fork. Poorly drained, with the water table fluctuating to within 0.6 to 1.2 m (2 to 4 ft) of the surface during wet seasons (Soil Survey Staff, 2015). Thickness is uncertain because of poor exposures and because terrace deposits cannot be reliably separated from older units in well logs. Approximate thickness is 0.9 to greater than 1.5 m

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 (Gillerman and Weppner, 2014, site Ma-22c). 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. Sand beds are locally black because of high obsidian content. Thickness of gravels above basalt in water well logs is 20 to 63 m (60 to 190 ft). Most of unit is a braidedstream deposit formed during the Pinedale glaciation (circa 13 to 26 ka; Licciardi and Pierce, 2008) of the Yellowstone Plateau and Teton Range (Scott, 1982). Clays and sands about 3 to 23 m (10 to 75 ft) in thickness are present at the base of the gravel section in many water well logs; these may represent pre-Pinedale deposits (see unit Qc). Contact with Qgsr is identified by change of regional slope of land surface from NE-SW to SE-NW.

Unit is an aggregate resource and unconfined aquifer for domestic and municipal water supplies. Gravelly outwash of South Fork Snake River (late Pleistocene)—Massive to thickly bedded, planar, well-rounded cobble to pebble gravel, with an open-framework filled by subangular sand. Beds of cross-bedded coarse to medium sand locally present. Gravel clasts are dominated by pink, white, or gray quartzite with lesser limestone, dolomite, rhyolite, basalt, sandstone, siltstone, and granite (Gillerman and Weppner, 2014, site Ma-68c). The near-absence of obsidian sands and abundant quartzite cobbles is diagnostic of this unit. Water well logs indicate minimum thickness of about 50 m (164 ft); maximum thickness uncertain because wells do not generally penetrate basal contact with deeper lithologies. Unit is a braided-stream deposit formed during the Pinedale glaciation of the Teton range (Scott, 1982). Correlative deposits in Idaho Falls area are dated by optically stimulated luminescence between about 13 and 26 ka (Phillips and others, 2009), consistent with cosmogenic surface exposure ages of moraines in the Teton range (Licciardi and Pierce, 2008). Unit is an aggre-

gate source and unconfined aquifer for domestic water supplies.

Alluvial fans (Holocene-late Pleistocene)—Brown to light-gray silt, clay, and very fine sand (reworked loess); crudely bedded; about 3 to over 4.6 m (10

Gravel and sand, undivided (Holocene-Pleistocene)—Used in cross sections where water well logs lack sufficient detail to subdivide or correlate Quaternary deposits. Gravel and sand with lesser silt and clay; includes units *Qgsr*, *Qgh*, *Qth*, *Qaht*, and *Qas*. Thickness ranges from less than 16 m (50 ft) to greater than 69 m (210 ft) and generally increases from east to west across the quadrangle.

Fine-grained sediments (middle-early Pleistocene)—Not exposed in the map area; used in cross sections. Clay and sand encountered in water well logs above *Qb* and below gravels and sands of *Qs*. Thickness ranges from about 3 to 23 m (10 to 75 ft). These deposits may have formed in shallow lakes created by drainage disruption following eruption of basaltic lavas (unit *Qb*).

Qel Loess (late-middle Pleistocene)—Massive, light-gray to light brownish gray silt, clay, and very fine sand. Thickness is 2 m to 8 m (6 to 24 ft) and is greatest

on the Rexburg bench. Carbonate content is 15-20% throughout loess deposits except in leached upper horizons or in horizons of soil carbonate accumulation. The Rexburg and Ririe soil series on the Rexburg bench contain pedigenic carbonate horizons generally corresponding to carbonate morphology stages II to III. In secs. 29 and 32, T.6 N., R.40 E., unit *Tbr* is capped with up to 1 m (3 ft) of carbonate-silica duripan developed in loess. Units *Qgsr* and *Qgh* are locally capped with loess (not mapped) about 50 to 127 cm (20 to 50 in) thick and have stage I+ to II carbonate morphology stages. Loess was derived from deflation of fine-grained sediment on outwash plains by NE-directed winds during glaciations of the Snake River headwaters. Regionally, loess in the Eastern Snake River Plain consists of several depositional units separated by buried soils (Pierce and others, 1982; Scott, 1982). Periods of loess deposition range between 15 to about 154 ka (Phillips and others, 2009; Pierce and others, 2011). Loess is parent material for the fertile soils on the Rexburg bench.

VOLCANIC ROCKS

Basalt, undivided (middle-early Pleistocene)—Basalt flows locally interbedded with gravel and sand. Not exposed in the quadrangle. Used in cross sections based upon exposures in nearby areas or from water and geothermal test wells. Basalts of several ages and sources are placed into this unit because well logs do not permit reliable subsurface correlations. All of the basalts included in *Qb* are stratigraphically above unit *Qyh*. The Sugar City and Madison County geothermal test wells intersected two basalt intervals above *Qyh* (Fig. 2; Embree and others, 1978; Kunze and Marlor, 1982; Jean and Shervais, 2010; M. Jean, written communication, 2014). The upper sequence consists of medium-gray to black, aphanitic to microphyric, locally diktytaxitic, vesicular basalt, about 34 m (112 ft) thick. At least 3 flows with normal magnetic polarity are present, separated by thin beds of pebbly arkosic sand, tuffaceous sand, gravel, silty clay and sand. Vent locations for the upper sequence are unknown. Possibilities include vents on the Snake River Plain north or northwest of the map area. The lower

basalt sequence is correlated with unit *Qbm* (see description below).

Qbm Basalt of Moody Creek (middle?-early Pleistocene)—Used in Fig. 2 only; cannot be reliably correlated in subsurface with available well data Medium-gray, fine-grained, locally diktytaxitic basalt with sparse plagioclase phenocrysts as much as 5 cm in length and 7 to 10 percent fine-grained olivine. Consists of the lower basalt sequence above Qyh in the Sugar City geothermal test well (Fig. 2). Not exposed in map area; correlated with basalt of Moody Creek on basis of geochemistry and paleomagnetic inclination. Unit named from exposures in the Moody and White Owl Butte quadrangles east of the map; also well-exposed in the Teton River canyon in the Newdale quadrangle (Embree and others, 2011). Vent is at lat 43.7989°N., long 111.5594°W. In the Sugar City geothermal test well, consists of three flows with total thickness of about 26 m (80 ft). The basalt of Moody Creek has reverse paleomagnetic polarity with an inclination of about -70° (Table 1), and relatively elevated incompatible and large ion lithophile elements (e.g. Ti, Zr, Nb, Ba; Table 3). The reverse magnetic polarity suggests that unit age is between 781 ka and about 2.1 Ma (age of Qyh). However, ${}^{40}\text{Ar}/{}^{39}\text{Ar}$ dating yielded an age of 440 \pm 50 ka for a sample from the Newdale quadrangle (B. Turrin, written communication, 2012). This age may not be reliable because the global geomagnetic polarity timescale

Basalt of Sommers Butte volcanic rift (early Pleistocene)—Dark greenish-gray basalt, dense to vesicular, with locally abundant plagioclase phenocrysts 1-2 mm and abundant reddish-brown olivine 0.25 to 0.5 mm. Not exposed in map area; used only in cross section B-B'. Erupted from vents along the 22 km (13 mi) Sommers Butte-Lyons Creek volcanic rift in the Heise and Moody quadrangles (Phillips and others, 2016; Embree and others, 2016). Unit flowed into the South Fork of the Snake River where it interacted with wet sediments. Water well logs suggest that the unit reached Thornton in the SW portion of the map where it is as much as 18 m (60 ft) thick. Contains elevated incompatible and large ion lithophile elements similar to unit *Qbm* (Phillips and others, 2016). Reverse paleomagnetic polarity with very steep inclination of about 86°. Correlative basalts in the Moody quadrangle are dated by whole rock 40Ar/39Ar analyses at about 2.0 Ma (M.

Basalt of Rexburg (Pliocene)—Dark-gray columnar-jointed flows of dense to vesicular and diktytaxitic basalt containing sparse phenocrysts of plagioclase and olivine. Generally interbedded with cinders and scoria in well logs. Shown as Qel/Tbr where covered by loess. Erupted from a shield volcano that comprises most of the Rexburg bench in the map area. Depressions on the flanks of the shield are interpreted as pit craters. The craters are flat-bottomed, less than 9 m (30 ft) deep, and located adjacent to, and elongated parallel to, normal faults trending approximately 355° Best exposures of the unit are along the Rexburg fault scarp in the map and adjacent Ririe quadrangle (Phillips and others, 2014). Maximum exposed thickness in the map is about 50 m (165 ft); thickness is 32 m (104 ft) in the Sugar City geothermal test well (Fig. 2). On the Rexburg bench, water wells show about 122 m (400 ft) of interbedded lava flows and cinders. Dated by 40 Ar/ 39 Ar at 3.29 \pm 0.02 Ma with a sample from the Ririe quadrangle (B. Turrin, written communication, 2012; Phillips and others, 2014), and at about 3.6 Ma from an excavation on the BYU-Idaho campus in the city of Rexburg (M. Kuntz, written communication, Table 1). Reverse paleomagnetic polarity of about -60° (Table 2). Unit lacks the elevated incompatible and large ion lithophile element concentrations of units *Qbm* or *Qbl* (Table 3). Unit is important deep aquifer for irrigation wells on the Rexburg bench.

Kuntz, written communication, 2006).

Rhyolites

Huckleberry Ridge Tuff of the Yellowstone volcanic field (early Pleistocene)— Rhyolitic ignimbrite, densely to moderately welded, with moderately abundant (about 10 percent), small (1 to 4 mm) phenocrysts of sanidine and quartz with lesser plagioclase and pyroxene. Shown as Qel/Qyh where covered by loess. Phenocrysts tend to be concentrated (20 to 30 percent) in lower portion of unit and sparse (<5 percent) higher up in the unit. Most exposures in map area consist of platy ledges of light-gray to grayish-pink, densely welded, devitrified tuff with eutaxitic to lithophysal fabric. Lithophasae about 0.5 cm in diameter comprise about 70% of rock. Three Huckleberry Ridge Tuff members (A, B, and C) were erupted from the Big Bend Ridge caldera segment in the Yellowstone volcanic field about 48 km (30 mi) north of the map (Christiansen, 2001). Known exposures in map area are probably Member A (C. Wilson, written communication, 2015). Water wells on the Rexburg bench show thickness ranges from about 6 to 25 m (21 to 83 ft). Thickness in the Sugar City geothermal test well (Fig. 2) is about 11.5 m (35 ft). Magnetic polarity is excursional with subhorizontal inclination and southwesterly declination (Reynolds, 1977). Ages from single-crystal laser-fusion 40Ar/39Ar analyses of sanidine range from 2.123 to

2.0794 Ma (Ellis and others, 2012; Rivera and others, 2014).

Rhyolitic volcanic rocks of the Heise volcanic field, undivided (Pliocene- Late Miocene)—Welded and unwelded rhyolite tuffs and rhyolite lava flows; locally interbedded with tuffaceous, weakly cemented, clay, sand, and gravel. Not exposed in the map area; used on cross sections and Fig. 2. Water and geothermal test wells indicate as much as 700 m (2300 ft) of rhyolitic rocks underlie the map area (Embree and others, 1978; Kunze and Marlor; 1982). The HVF tuffs consist mostly of large-volume, generally densely welded ignimbrites erupted from overlapping, nested calderas. However, rhyolitic lavas apparently comprise much of the section penetrated by the Madison County geothermal test well. HVF ignimbrites range in age from about 6.62 Ma to 4.46 Ma, while rhyolitic lavas ages range from about 6.2 Ma to about 3.5 Ma (Morgan and McIntosh, 2005;

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Figure 1. Major structural features of the map area. Location of Rexburg quadrangle indicated with box. Red stars are basaltic vents. Green stars are pit craters on Rexburg bench. RF is Rexburg fault. HF is Heise fault. GVF is Grand Valley Fault. MB are Menan Buttes volcanic rift. SBLC is Sommers Butte-Lyons Creek volcanic rift. Thin yellow lines are small offset faults and

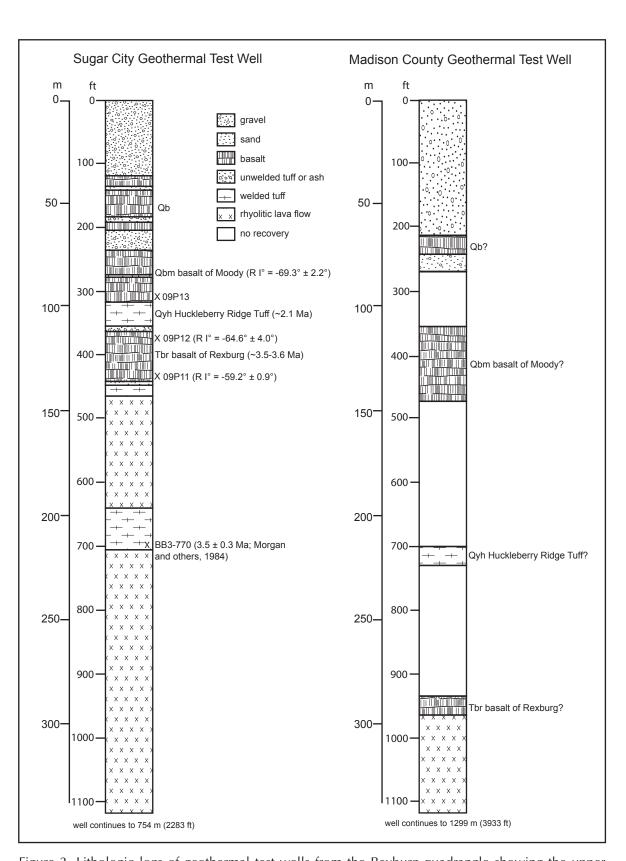


Figure 2. Lithologic logs of geothermal test wells from the Rexburg quadrangle showing the upper 360 m (1100 ft) of each well. The Sugar City log is based upon continuous cores (Embree and others, 1978) while the Madison County log is based upon drill cuttings (Kunze and Marlor, 1982). Samples of basalts from the Sugar City cores were analyzed for paleomagnetic inclination (Table 2) and for major and trace elements (Table 3). A rhyolite at 229 m (693 ft) in the well was dated by the zircon fission track method at about 3.5 Ma (sample BB3-770; Morgan and others, 1984).

Table 1. 40 Ar/ 39 Ar ages for groundmass concentrate from the basalt of Rexburg (M. Kuntz, written communication, 2006). Two aliquots of the same sample were step-heated (8 steps) from 750° to 1450° C. Errors are 2σ . Steps Plateau Steps Plateau Age Nage (Ma) Used Steps Plateau Age Nag

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

Table 2. Paleomagnetic data for the Sugar City geothermal test well in the Rexburg quadrangle.

Sample number	Unit name	Latitude	Longitude	Sample Depth (ft.)	n	D°	I°	α_{95}	R	κ	Polarity	Treatment
09P11	Tbr	43.88400	-111.77200	428	3	255	-59.2	0.9	3.000	19661	R	PCA
09P12	Tbr	43.88400	-111.77200	369	3	208	-64.5	4.0	2.998	950	R	PCA

Polarity: N = normal; R = reverse.

Table 3. Major oxide and trace element chemistry of basalt from the Sugar City geothermal test well collected in the Rexburg quadrangle.

| Sample number | Latitude | Longitude | Depth (ft.) | Depth (ft.) | Unit | SiO₂ | TiO₂ | Al₂O₃ | FeO** MnO MgO CaO Na₂O Na₂O

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