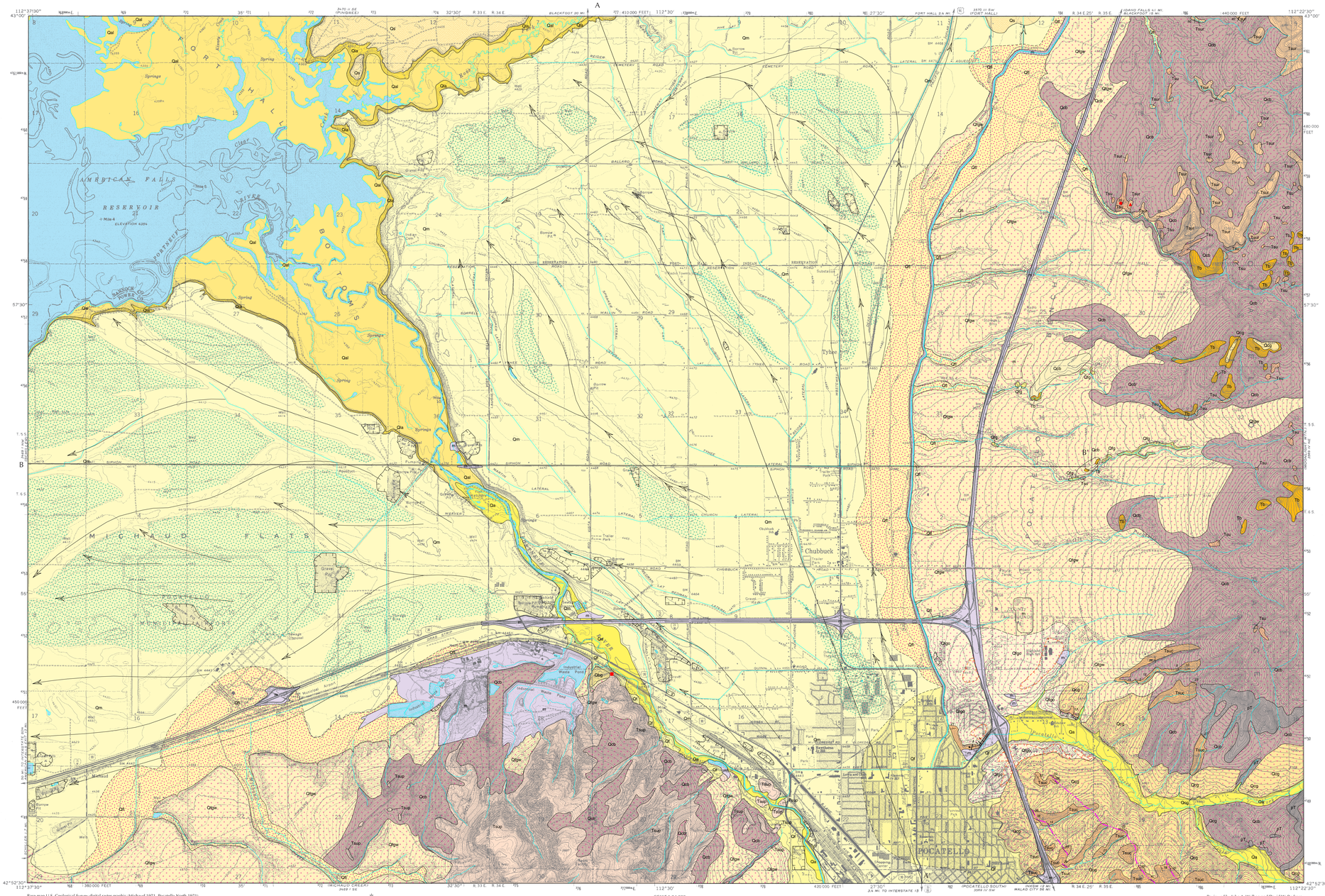
Surficial Geologic Map of the Michaud and Pocatello North Quadrangles, Bannock and Power Counties, Idaho

Kurt L. Othberg

2002



Base map U.S. Geological Survey digital raster graphic (Michaud 1971, Pocatello North 1971).
Control by USGS and NOS/NOAA.
Topography by photogrammetric methods from aerial photographs taken 1969 (Michaud and Pocatello North).
Field checked 1971(Michaud and Pocatello North).
Projection and 10,000-foot grid ticks: Idaho coordinate system, east zone (transverse Mercator).
1,000-meter Universal Transverse Mercator grid ticks, zone 12.
1927 North American Datum.

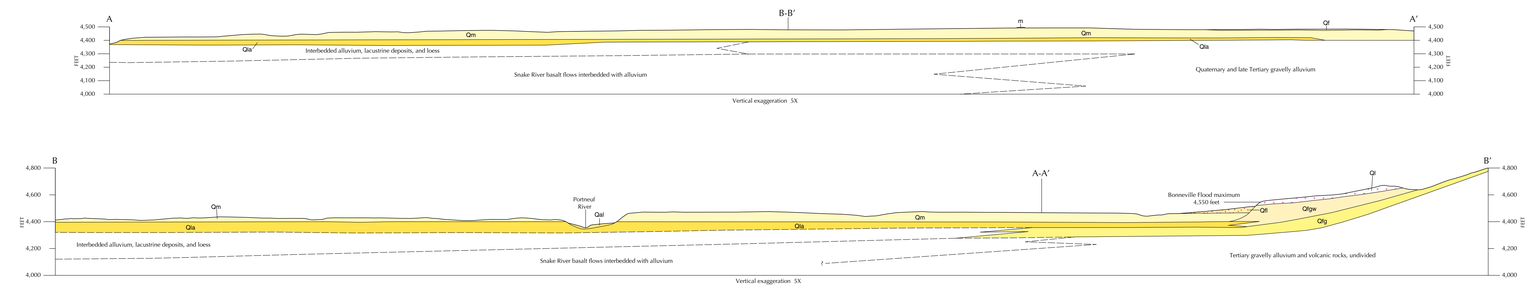
U.Tm Grid and 1977 Magnetic North Declination at Center of Map

SCALE 1:24,000

Michaud quadrangle: Contour interval 10 feet
Dotted lines represent 5-foot contours
Pocatello North quadrangle: Contour interval 20 feet
Dotted lines represent 10-foot contours

QUADRANGLE LOCATION

Reviewed by John A. Welhan and David W. Rodgers.
Digital cartography by Jane S. Freed at the Idaho Geological Survey's Digital Mapping and GIS Lab.
Map edited by Roger C. Stewart.
Note on printing: The map is reproduced at a high resolution of 600 dots per inch. The inks are resistant to run but not to the fading caused by long-term exposure to light.
Map version 9-24-2002.



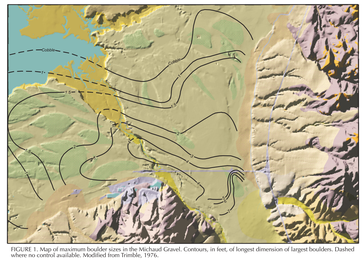
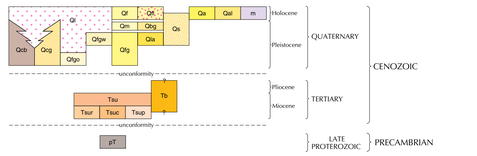


FIGURE 1. Map of maximum boulder sizes in the Michaud Gravel. Contours, in feet, of longest dimension of largest boulders. Dashed where no control available. Modified from Trimble, 1976.

ACKNOWLEDGMENT

David W. Rodgers, Department of Geosciences, Idaho State University, provided new bedding strikes and dips for the upper Starlight Formation conglomerate (*Tsuc*) and two new $^{40}Ar/^{39}Ar$ ages for the rhyolite of Two-and-a-Half-Mile-Creek (*Tr*).

CORRELATION OF MAP UNITS



INTRODUCTION

The surficial geologic map of the Michaud and Pocatello quadrangles provides basic data on the geologic materials found at the surface and shallow subsurface. The map is essential for evaluating the urban impact on the land and for planning the area's growth. The information is directed at a broad range of specialists concerned with land development and its consequences as an increasing population places greater demands on the region's natural resources. Details from the map function, for example, in assessing slope stability, foundation design, sewage drainage, solid waste sites, seismic-shaking hazards, and the extent and limits of the potable ground-water supply. The information depicted at this scale furnishes a useful overview of the area's geology but is not a substitute for site-specific geotechnical evaluations.

The map area includes the northern half of the city of Pocatello, which lies in the northern Portneuf Valley between the Pocatello Range to the east and the Bannock Range to the southwest. The Portneuf River flows northward through an entrenched valley bordered by prominent benches and enters the Snake River Plain where the Portneuf Valley opens northward. The valley is a Tertiary half-graben filled primarily with Miocene sedimentary and volcanic units deposited during the formation of the Snake River Plain. Along this eastern edge of the plain, Pleistocene basalt flows interfinger with sediments of the Portneuf River and the Snake River. Late Pleistocene fan gravels form the Portneuf Valley benches, which were trimmed to their present shape principally by the Bonneville Flood about 14,500 years ago (Scott and others, 1982). The most widespread map unit is the Michaud Gravel, a giant expansion bar of the Bonneville Flood.

The geology of this area was previously published at 1:48,000 scale by Trimble (1976) and for the adjoining Pocatello South 7.5' quadrangle by Rodgers and Othberg (1999). A compilation of the geology of the Pocatello 30' x 60' quadrangle (Link and Stanford, 1999) shows the bedrock geology of the area and includes data from a preliminary surficial geologic map of the Pocatello North quadrangle.

DESCRIPTION OF MAP UNITS

m — **Made ground (historical)**—Artificial deposits of disturbed, transported, and emplaced construction materials derived from various local sources. Primarily formed in the construction of highways, irrigation ditches, and industrial sites.

Qa — **Alluvium of lower Portneuf River and Pocatello Creek (Holocene)**—Stratified and interfingering deposits of sand and gravel veneered by silty reworked loess. Includes small alluvial fans of reworked loess at the mouths of tributary gullies. Thickness 10-20 feet.

Qal — **Alluvium and lacustrine deposits of the Portneuf River and Ross Fork delta (Holocene)**—Laterally discontinuous beds of sand, silt, clay, muck, and peat. Includes sand and gravel beach deposits along the shore of American Falls Reservoir. Thickness 10-30 feet.

Qf — **Alluvial-fan and debris-flow deposits (Holocene)**—Muddy sand and gravel and beds of silty redeposited loess. Gravel clasts range in size from pebbles to boulders. Deposited primarily by infrequent flash floods and debris flows emanating from tributary stream valleys and canyons. Includes the broad apron in north Pocatello formed by Pocatello Creek. Thickness 5-30 feet.

Qfl — **Alluvial-fan deposits composed mostly of reworked loess (Holocene)**—Primarily bedded to massive silt that is redeposited loess. Forms alluvial fans that emanate from the thick loess-mantled benches such as "Pocatello Bench." Buries marginal deposits of the Michaud Gravel. Thickness 2-30 feet.

Qs — **Sand (Holocene and Pleistocene)**—Fine to coarse sand and pebbly sand; surface commonly reworked into stabilized sand dunes. Scott (1982) mapped the sand as eolian. Houser (1992) suggests the sand was Snake River alluvium deposited at the margin of American Falls Lake before the Bonneville Flood and then reworked by the Bonneville Flood. This origin seems plausible, but it is hard to prove since the remnant lenticular bars formed by the Bonneville Flood (see Symbols) are lacking on the surface of the sand unit. The unit's origin is probably some combination of the following: sandy alluvium deposited onto clay of American Falls Lake; sand reworked and redeposited by the Bonneville Flood; sand deposited after the Bonneville Flood by the Pleistocene Snake River; and sand reworked and redeposited by wind during the Holocene. Ross Fork valley separates the sand unit from the Michaud Gravel, and the location of Ross Fork may be a result of differential erosion along the north edge of the Michaud Gravel.

Qm — **Michaud Gravel (late Pleistocene)**—Bouldery gravel and sand; more sand in channeled-flow pathways and in distal parts of deposit where grain size decreases (see Figure 1). Named by Trimble and Carr (1961) and Carr and Trimble (1963) for gravel and sand deposited by the Bonneville Flood when it entered the Snake River Plain: "The Michaud Gravel was dumped into the Pleistocene American Falls Lake as a composite delta-and-fan deposit, and it overlies the American Falls Lake Beds over much of its extent" (Trimble, 1976, p. 56). The bouldery character of the gravel indicates high velocities, and in the absence of foreset bedding, the Michaud Gravel is probably best described as a catastrophic flood expansion bar (O'Connor, 1993). The bar expands from about 1 mile wide at its head in Pocatello to about 11 miles wide at the north and west edges of the map. Over this distance, Trimble (1976) mapped the boulder sizes, which are as much as 7 feet in diameter in Pocatello to less than 1 foot to the north and west (see Figure 1). Estimates of high-water levels during the 14.5 ka Bonneville Flood (Scott and others, 1982; O'Connor, 1993; J.E. O'Connor, written commun., 1996) indicate that the flood-water level rose behind the constriction near present-day American Falls and was about 60-70 feet higher than the Michaud Gravel at Chubbuck, a drop of 85 feet in depth from downtown Pocatello. The Michaud Gravel has features common to the other large Bonneville Flood expansion bars, which include giant boulders at the upstream end of the bar, a gradational decrease in grain size correlating with the expanding width of the bar in the downstream direction (Figure 1), and clear evidence of reworking and channeling of the bar by later, reduced flow regimes of the flood (see *lenticular bar forms* and *Channeled-flow pathways* under Symbols). Trimble (1976) mapped younger terrace sediments deposited on surfaces cut into Michaud Gravel. O'Connor (1993) described a later, lower flow regime discussion of Bonneville Flood expansion bars. He also estimated the total duration of the flood to be only about 3 or 4 months. Therefore, the channel deposits are here included in the Michaud Gravel. The maximum thickness of the Michaud Gravel is 50-80 feet from its contact with the American Falls Lake beds (*Qlg*) at about 4,400 feet in elevation to its upper surfaces at about 4,450-4,480 feet. The minimum thickness occurs in the channeled-flow pathways where the Michaud Gravel is 30-50 feet thick in the Pocatello quadrangle and 10-40 feet thick in the Michaud quadrangle. Loess 1-3 feet thick mantles most of the surface and accounts for the silty surface soils mapped in soil surveys (McDole, 1977; McGrath, 1987). Typical soil series with increasing amounts of loess over gravel include the Broncho, Broxon, Paniogue, and Bahern. McDole (1977) also mapped the sandy soil series, Escalante and Declo, that are typically found in the channeled-flow pathways. Small areas of stabilized, Holocene sand dunes cap the Michaud Gravel east of American Falls Reservoir, primarily in secs. 13, 24, and 25, T. 5 S., R. 3 E.

Qbg — **Gravel deposits of the Bonneville Flood, undifferentiated (late Pleistocene)**—Pebble gravel deposited in eddy bar of Bonneville Flood. As much as 50 feet thick.

Qt — **Loess (Holocene and Pleistocene)**—Calcareous wind-blown silt that mantles benches and bedrock foothills in the Michaud and Pocatello North quadrangles. Primarily shown as a pattern in combination with another unit (*Qfgw*, *Qlgo*, *Qcb*, and *Qcg*). Mapped separately in cross section B-B′ only. In the Pocatello South quadrangle, Rodgers and Othberg (1999) suggest early Wisconsin fan gravels are mantled with late Wisconsin loess probably deposited during the late Pinedale Glaciation and the Bonneville transgressive period of Pleistocene Lake Bonneville, 28-15.2 Ka (O'Connor, 1993). Early Pleistocene fan gravels are mantled by loess of multiple ages. Soils formed in loess thicker than 5 feet include the Lamoak, Pocatello, Portneuf, Rexburg, Ririe, and Wheeler series (McDole, 1977; McGrath, 1987). In some areas of the Michaud Gravel, Holocene loess forms a thin discontinuous cover that allows agriculture, but the loess is too thin to map as a lithologic unit.

Qfgw — **Loess-mantled alluvial-fan gravel of Wisconsin age (late Pleistocene)**—Crudely stratified muddy sand and pebble- to boulder-sized gravel mantled with loess. Forms the surface of the coalesced relict alluvial fans of the prominent "Pocatello Bench" and the bench south of Michaud. Elevations, fan surface gradients, and soil evidence suggest the alluvial-fan gravel was deposited during the high stand of Pleistocene American Falls Lake during the Wisconsin glaciation (Scott and others, 1982; Richmond and Fullerton, 1986). The Wisconsin alluvial fans were graded to the ancestral American Falls Lake, estimated to have been as high as 4,440-4,450 feet in elevation (Scott and others, 1982). The benches formed when the Bonneville Flood truncated the alluvial-fan gravels and the loess. Soil evidence suggests most of the loess was deposited on the fans in late Wisconsin time. *Qfgw* mapped separately in cross section and where loess is thin or absent.

Qfgb — **Loess-mantled alluvial-fan gravel of the ancestral Pocatello Creek (early Pleistocene)**[1]—Crudely stratified, muddy and sandy pebble- to cobble-sized gravel mantled with loess. Remnants of the original surface of the alluvial fan are shown on the map as a stipple pattern. In these areas, well-developed buried soils in the gravel support the interpretation of an early Pleistocene age for the surface. Exposure along Alameda Road (NE¼SE¼ sec. 14, T. 35 E., R. 6 S.) shows large-scale tangential cross beds with an apparent westerly dip, suggesting a westward-prograding alluvial fan deposited by an ancestral Pocatello Creek. The fan gravel overlies a silt bed that in turn caps well-stratified and well-sorted sand and gravel, which to the southwest is in fault contact with interbedded gravel and sand. Paleomagnetic polarity of the silt bed is reversed, indicating an age greater than 780 Ka, i.e., at least as old as early Pleistocene. The gravels and sands below and southwest of the silt bed are clearly faulted and have bedding attitudes similar to those measured in foothill outcrops of the upper Starlight Formation conglomerate (*Tsuc*). Although Trimble (1976, p. 52) suggested a Quaternary age for the "cobbly gravel north and south of the lower end of Pocatello Creek," without additional evidence, the lower, clearly faulted part of the exposure is mapped as *Tsuc*. It is unclear whether the Pleistocene fan gravel that forms the remnant alluvial fan is faulted. Further research of possible Pleistocene faulting in the Portneuf Valley would help constrain neotectonic interpretations in the region (see Pierce and Morgan, 1992; Lageson and others, 1999).

Qcb — **Loess-mantled bedrock colluvium (Pleistocene)**—Wind-blown and redeposited loess that mantles, interfingers with, or is mixed with stony colluvium derived from local bedrock. Loess typically mantles a transition zone from bedrock to the upper part of alluvial fans and loess-mantled colluvial gravel. On steeper bedrock slopes, loess has been mixed with bedrock colluvium during soil creep and debris-flow movement. Combined loess and colluvium thickness is 3-10 feet but may be thicker on north-facing slopes of incised drainages.

Qcg — **Loess-mantled gravelly colluvium (Pleistocene)**—Pebble- and cobble-sized gravel generally forms a thin colluvial cover (5-10 feet) from local weathering and gravity reworking of Tertiary conglomerate (*Tsuc*). Tertiary conglomerate locally outcrops on south-facing slopes, draws, and gullies. Unit includes remnants of pediment gravel that form surfaces graded to higher base levels of the Pleistocene. The loess mantle is 5-20 feet thick and is typically thickest on north-facing slopes and absent on south-facing slopes.

[1]Geologic map of the Pocatello North quadrangle, Bannock and Power counties, Idaho, by K.L. Othberg: Idaho Geological Survey unpublished report, April, 1997, scale 1:24,000.

Qfg — **Alluvial-fan gravel, undifferentiated (Pleistocene)**—Crudely stratified muddy sand and pebble- to boulder-sized gravel. Exposed in gullies and inferred from water-well drillers' logs. Mapped locally and in subsurface where stratigraphic and geomorphic evidence of age is lacking. Cross section B-B′ combines Quaternary fan gravels with late Tertiary alluvium that interfingers with Tertiary-age Snake River Plain basalt flows.

Qla — **Lake sediments of the ancestral American Falls Lake (Pleistocene)**—Primarily thinly laminated to finely bedded clay. Includes beds of diatomaceous clay, silt, and fine sand. Carr and Trimble (1963) restricted the term "American Falls Lake Beds" to the sediments deposited in the lake dammed by the Cedar Butte Basalt (Trimble, 1976). Exposed along bluffs of American Falls Reservoir, Portneuf River, and Ross Fork and readily identified in water-well drillers' logs throughout the lowland area. Evidence from exposures, well logs, and springs indicates the elevation of the clay's upper surface ranges from 4,390 feet to 4,415 feet (Trimble, 1976; Corbett, 1980; Houser, 1992; Welhan and others, 1995). Although the clay beds were probably eroded somewhat by Bonneville Flood waters before the Michaud Gravel prograded onto the lacustrine bed surface (Scott and others, 1982), the surface undulations are minor, and the unit's upper limit is about 4,400 feet in elevation. Reported thicknesses vary. Houser (1992) includes fluvial and flood-plain units that underlie the lake clays in the American Falls Lake Beds, for a possible total thickness of 95 feet, which is somewhat more than Trimble's estimate of 80 feet. The lacustrine unit, which is more readily identified in drillers' logs, is typically 10-33 feet thick.

Bedrock Outcrops and Colluvium

The surfaces of the bedrock foothills and mountains are generally covered by thin colluvium and locally by thick talus deposits. Rock outcrops are few and typically confined to knobs, ledges, and gullies in areas of erosion-resistant units. Much of the colluvium has a component of loess and grades into loess-mantled bedrock colluvium (*Qcb*). Colluvial soil associations mapped by McDole (1977) and McGrath (1987) are grouped as calcareous (Cedarhill and Ireland series) and noncalcareous (Camelback, Hades, and Valmar series), which roughly corresponds to the areal distribution of pre-Tertiary calcareous and siliceous rock units, respectively.

Tb — **Basalt (Pliocene or Miocene)**—Porphyritic basalt localized along an east-northeast-trending fault in the Pocatello North quadrangle. The basalt overlies or intrudes the Starlight Formation and is probably at least as old as the Pliocene basalt of Buckskin Basin that forms a platform beneath Pleistocene Snake River gravels in the Fort Hall quadrangle (Houser, 1992).

Tsu — **Starlight Formation, upper member (Miocene)**—Primarily conglomerate, rhyolite air-fall tuff, and rhyolite lava flows in the Pocatello North quadrangle. Rodgers and Othberg (1999) divide the formation into several informal units and show that these rocks are younger than the 10.3 Ma Arbon Valley Tuff, which composes the middle member of the Starlight Formation (Kellogg and others, 1994; Trimble, 1976).

Tsur — **Rhyolite of Two-and-a-Half-Mile Creek (Miocene)**—Primarily flow-banded rhyolite and obsidian located in the northeast corner of the Pocatello North quadrangle. Named by Kellogg and Marvin (1988) who reported a potassium-argon age of 9.1 ± 0.3 Ma (sample location about 3 miles northeast of Two-and-a-Half-Mile Creek in the adjoining Buckskin Basin 7.5' quadrangle). Forms large hills and is localized along a northeast-southwest trend that may have fault control. Trimble (1976) suggested a Pleistocene or Pliocene age, but the unit is now known to be Miocene and is included in the upper member of the Starlight Formation (Kellogg and others, 1994). D.W. Rodgers (written commun., 2002) provided results from single-crystal $^{40}Ar/^{39}Ar$ analyses for two samples collected near Two-and-a-Half-Mile Creek (NW¼ sec. 19, T. 5 S., R. 35 E.). The new Ar-Ar ages confirm that these rocks belong in the upper member of the Starlight Formation:

DR9844B—Light gray, moderately welded, moderately compacted, lithic-free, quartz-feldspar rhyolite tuff. $^{40}Ar/^{39}Ar$ age is 6.59 ± 0.01 Ma. This age corresponds to that of the tuff of Blacktail Creek (also known as the tuff of Edie Ranch), which is widely exposed on the north flank of the eastern Snake River Plain from Arco to Interstate 15.

DR9844E—Rhyolite mapped by Trimble (1976). The new $^{40}Ar/^{39}Ar$ age is 8.28 ± 0.01 Ma.

Tsup — **Rhyolite porphyry unit**—Porphyritic rhyolite, "rhyolite of west Pocatello," extended northward from mapping in the Pocatello South quadrangle (Rodgers and Othberg, 1999) and from Trimble (1976). Kellogg and others (1994, Table 4, sample FH86-2685B) report potassium-argon ages of 7.9 ± 0.7 Ma (plagioclase) and 7.9 ± 0.4 Ma (whole rock).

Tsuc — **Conglomerate unit**—Clast-supported, moderately indurated cobble conglomerate with clasts of pre-Tertiary rocks in the region. Reddish orange to reddish brown matrix that is typically sandy but locally tuffaceous. Common inclined bedding (strikes and dips provided by D.W. Rodgers, written commun., 2002). Northeast of Pocatello Creek includes sedimentary breccia or diamictite mapped by Trimble (1976). Forms loess- and gravel-covered slopes with rare outcrops. Exposures are few because cobbly gravel, derived by weathering and erosion of the conglomerate, forms a nearly complete cover of colluvial gravel (*Qcg*). The Tertiary conglomerate includes intercalated beds of air-fall tuff, the traces of which were provided by D.W. Rodgers (written commun., 2002). The tuffs are probably equivalent to one or more rhyolite air-fall tuff units mapped in the Pocatello South quadrangle (Rodgers and Othberg, 1999).

pT — **Pre-Tertiary rocks, undivided (Cambrian and Late Proterozoic)**—Primarily outcrops of and colluvium derived from quartzite, argillite, and limestone.

SYMBOLS

- Contact: approximately located; dashed where inferred
- Strike and dip of bedding
- High-angle fault
- Normal fault: bar and ball on downthrown side
- Large gravel pits and other major excavations that expose a map unit
- Remnant surfaces of alluvial fans and terraces of the ancestral Pocatello Creek
- Channeled-flow pathways that form a network of anastomosing channels on the surface of the Michaud Gravel. Formed during the waning, reduced-flow regime of the Bonneville Flood
- Lenticular bar forms that are interfluves among the channeled-flow pathways
- Trace of tuff bed within conglomerate (*Tsuc*)
- Location for sample FH86-2685B (Kellogg and others, 1994), potassium-argon ages 7.9 ± 0.7 Ma (plagioclase) and 7.9 ± 0.4 Ma (whole rock)
- Location for sample DR9844B (D.W. Rodgers, written commun., 2002), $^{40}Ar/^{39}Ar$ age 6.59 ± 0.01 Ma
- Location for sample DR9844E (D.W. Rodgers, written commun., 2002), $^{40}Ar/^{39}Ar$ age 8.28 ± 0.01 Ma

REFERENCES

Carr, W.J., and D.E. Trimble, 1963, Geology of the American Falls quadrangle, Idaho: U.S. Geological Survey Bulletin 1121-G, 44 p.

Corbett, M.K., 1980, An evaluation of thermal water occurrences in the Tyhee area, Bannock County, Idaho, *in* Geothermal Investigations in Idaho, Part 10: Idaho Department of Water Resources Water Information Bulletin No. 30, 67 p.

Houser, B.B., 1992, Quaternary stratigraphy of an area northeast of American Falls Reservoir, eastern Snake River Plain, Idaho, *in* P.K. Link, M.A. Kuntz, and L.B. Platt, eds., Regional Geology of Eastern Idaho and Western Wyoming: Geological Society of America Memoir 179, p. 269-288.

Kellogg, K.S., S.S. Harlan, H.H. Mehnert, L.W. Snee, K.L. Pierce, W.R. Hackett, and D.W. Rodgers, 1994, Major 10.2-Ma rhyolitic volcanism in the eastern Snake River Plain, Idaho—isotopic age and stratigraphic setting of the Arbon Valley Tuff Member of the Starlight Formation: U.S. Geological Survey Bulletin 2091, 18 p.

Kellogg, K.S., and R.F. Marvin, 1988, New potassium-argon ages, geochemistry, and tectonic setting of upper Cenozoic volcanic rocks near Blackfoot, Idaho: U.S. Geological Survey Bulletin 1806, 19 p.

Lageson, D.R., D.C. Adams, L. Morgan, K.L. Pierce, and R.B. Smith, 1999, Neogene-Quaternary tectonics and volcanism of southern Jackson Hole, Wyoming, and southeastern Idaho, *in* S.S. Hughes and G.D. Thackray, eds., Guidebook to the Geology of Eastern Idaho: Pocatello, Idaho Museum of Natural History, p. 115-130.

Link, P.K., and L.R. Stanford, 1999, Geologic map-compilation of the Pocatello 30 x 60 minute quadrangle, Idaho: Idaho Geological Survey Technical Report 99-2, scale 1:100,000.

McDole, R.E., 1977, Soil survey of Fort Hall area, Idaho: U.S. Department of Agriculture Soil Conservation Service, 97 p.

McGrath, C.L., 1987, Soil survey of Bannock County area, Idaho: U.S. Department of Agriculture Soil Conservation Service, 347 p.

O'Connor, J.E., 1993, Hydrology, hydraulics, and geomorphology of the Bonneville Flood: Geological Society of America Special Paper 274, 83 p.

Pierce, K.L., and L.A. Morgan, 1992, The track of the Yellowstone hot spot: Volcanism, faulting, and uplift, *in* P.K. Link, M.A. Kuntz, and L.B. Platt, eds., Regional Geology of Eastern Idaho and Western Wyoming: Geological Society of America Memoir 179, p. 1-53.

Richmond, G.M., and D.S. Fullerton, 1986, Summation of Quaternary glaciations in the United States of America, *in* Vladimir Sibrava, D.Q. Bowen, and G.M. Richmond, eds., Quaternary Glaciations in the Northern Hemisphere, Report of the International Geological Correlation Programme, Project 24: Pergamon Press, p. 183-196, chart.

Rodgers, D.W., and K.L. Othberg, 1999, Geologic map of the Pocatello South quadrangle, Bannock and Power counties, Idaho: Idaho Geological Survey Geologic Map 26, scale 1:24,000.

Scott, W.E., 1982, Surficial geologic map of the eastern Snake River Plain and adjacent areas, 111° to 115° W., Idaho and Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-1372, scale 1:250,000.

Scott, W.E., K.L. Pierce, J.P. Bradbury, and R.M. Forester, 1982, Revised Quaternary stratigraphy and chronology in the American Falls area, southeastern Idaho, *in* Bill Bonnichsen and R.M. Breckenridge, eds., Cenozoic Geology of Idaho: Idaho Bureau of Mines and Geology Bulletin 26, p. 581-595.

Trimble, D.E., 1976, Geology of the Michaud and Pocatello quadrangles, Bannock and Power counties, Idaho: U.S. Geological Survey Bulletin 1400, 88 p.

Trimble, D.E., and W.J. Carr, 1961, Late Quaternary history of the Snake River in the American Falls region, Idaho: Geological Society of America Bulletin, v. 72, p. 1739-1748.

Welhan, John, Chris Meehan, and Ted Reid, 1995, The lower Portneuf River valley aquifer: A geologic/hydrologic model and its implications for wellhead protection strategies: Draft Final Report for the EPA Wellhead Protection Demonstration Project and the City of Pocatello Aquifer Geologic Characterization Project, 41p.

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