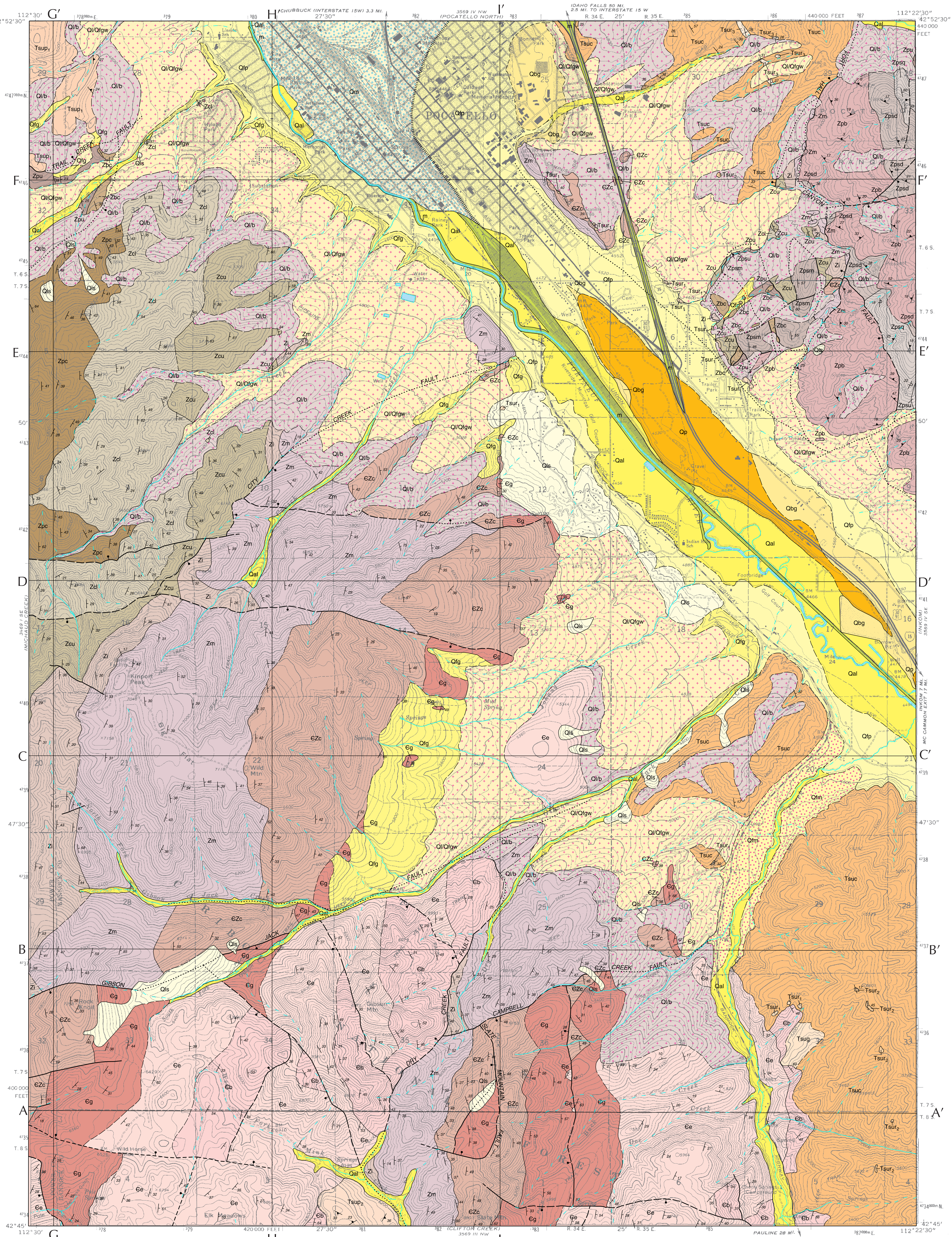
Geologic Map of the Pocatello South Quadrangle, Bannock and Power Counties, Idaho

David W. Rodgers[1] and Kurt L. Othberg[2]

1999



Base map USGS digital raster graphic.
Hydrography from Idaho Department of Lands digital line graph.
Control by USGS and USC&GS.
Topography by photogrammetric methods from aerial photographs taken 1969. Field checked 1971.
Projection and 10,000-foot grid ticks: Idaho coordinate system, east zone (Transverse Mercator).

UTM Grid and 1971 Magnetic North Declination at Center of Map

SCALE: 1:24,000

Contour Interval 40 Feet
Dotted Lines Represent 20-Foot Contours

QUADRANGLE LOCATION

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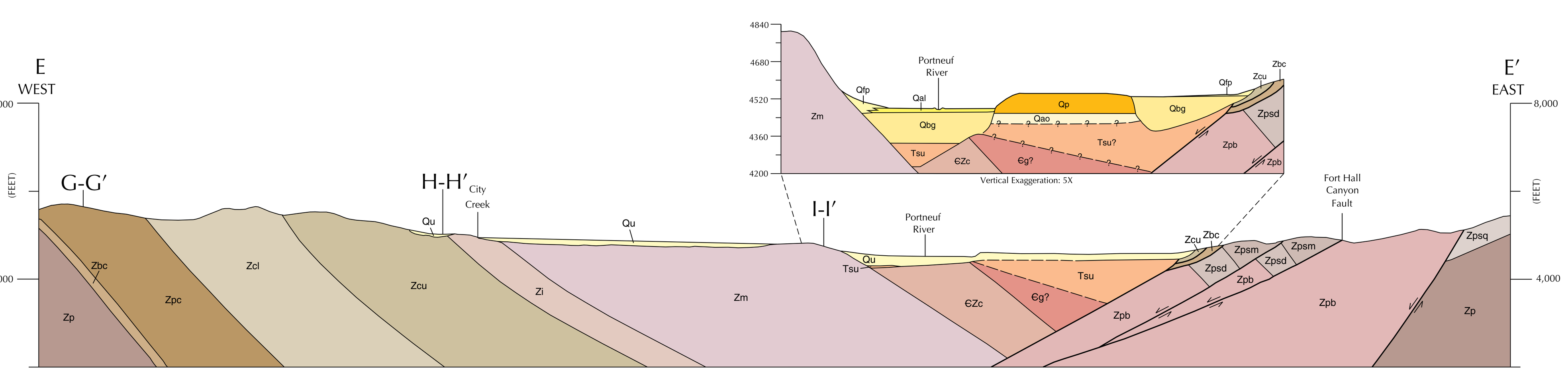
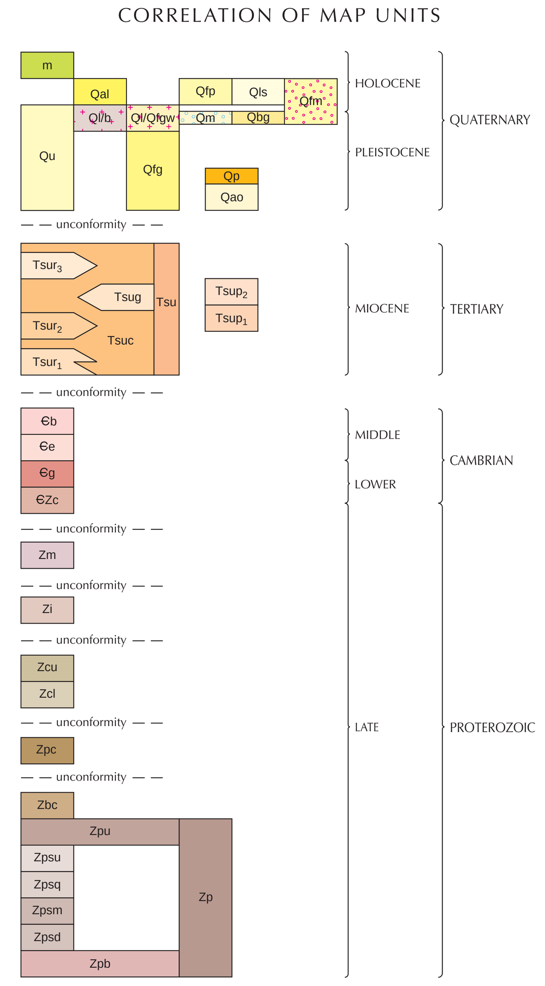
Digital cartograph by Jane S. Freed at the Idaho Geological Survey's Digital Mapping and GIS Lab.



CORRELATION OF MAP UNITS



INTRODUCTION

The Idaho Geological Survey has produced the geologic map of the Pocatello South quadrangle in cooperation with the U.S. Geological Survey's STATEMAP program. The map details the surficial and bedrock geology of this rapidly growing urban area. It provides the basic data for interpreting slope stability, on-site sewage drainage, solid waste sites, and seismic shaking hazards. In addition, the map is a crucial analytical tool for understanding the Portneuf River valley aquifer, the sole source of water for the city of Pocatello. The map will be useful to scientists; city, county, and general public.

SETTING AND PREVIOUS WORK

The map area includes the southern half of the city of Pocatello, which lies in the southern Portneuf Valley between the Pocatello Range to the northeast and the Bannock Range to the southwest. The Portneuf Valley is an entrenched valley occupied by the north-flowing Portneuf River and bordered by prominent benches. The elevation of the valley floor is about 4,500 feet. The Pocatello Range extends for several miles east of the Portneuf Valley, but the main crest of the range is along the eastern edge of the map area where it reaches a maximum elevation of 6,200 feet. The Bannock Range extends for a few miles west of the Portneuf Valley and several tens of miles to the south. The north-trending range crest has a maximum elevation of about 7,200 feet. A few miles to the north of the map area, the Portneuf Valley and adjacent ranges merge into the Snake River Plain.

Early studies of the geology in the Pocatello region reported on the location and quantity of mineral resources, including copper (Weeks and Heikes, 1908) and cement (Anderson, 1928). Mansfield (1927) mapped the Fort Hall Indian Reservation to the west, north, and east of the map area. Ludlum (1942, 1943) mapped the southern quarter of the Pocatello South quadrangle as well as several quadrangles further south. More recent publications include a 1:48,000-scale map and detailed explanation of the regional geology by Trimble (1976) and the geologic map of the Clifton Creek quadrangle by Platt (1995) just south of the Pocatello South quadrangle. Link (1983) and his students (LeFebre, 1984; Jansen, 1986; Burgel, 1986) at Idaho State University have studied the stratigraphy and structure of the Pocatello region (Link and others, 1985, 1987), and mostly through this latter work the need was recognized for a new, 1:24,000-scale geologic map of the Pocatello South quadrangle.

This map was constructed in two stages. The surficial geology, including Quaternary and Tertiary rock units, was mapped by T.A. Osier and K.L. Othberg (unpub. mapping, 1995), and the bedrock geology, including pre-Tertiary rock units and associated structures, was mapped by Rodgers. About forty field days in the fall of 1995 were required to complete the bedrock map. Map compilation, cross-sections, and the report for the bedrock were completed in January 1996. Additional field work in 1996 led to reinterpretations of the surficial geology, and the final combined map and text were completed in September 1997.

DESCRIPTION OF MAP UNITS

The following descriptions of map units are based on field observations and generally agree with those of Trimble (1976), Jansen (1986), and Link and others (1987) and replace those of T.A. Osier and K.L. Othberg (unpub. mapping, 1995). Published descriptions by Crittenden and others (1971), Harper and Link (1986), Link (1982, 1983), LeFebre (1984), and Link and others (1985) provide additional details on specific map units.

m **Made ground (Holocene)**—Large gravel pits and major artificial cuts and fills formed in the construction of interstate highways, irrigation ditches, and larger sites of urban construction.

Qal **Alluvium of the lower Portneuf River (Holocene)**—Stratified and interfingering deposits of sand and gravel veneered by silty reworked loess.

Qfp **Alluvial fan deposits of the lower Portneuf River Valley(Holocene)**—Muddy sand and gravel and beds of silty reworked loess. Gravel clasts range from pebble to boulder gravel. Deposited primarily by infrequent flash floods and debris flows emanating from tributary stream valleys and canyons.

Qls **Landslide deposits (Holocene)**—Rock and soil masses varying from transported coherent blocks to unsorted, unstratified colluvium. Unit includes scar area at the head of each identified landslide.

Qfm **Alluvial fan gravel of Mink Creek valley (Holocene and Pleistocene)**—Muddy sand and gravel and beds of silty reworked loess. Similar to *Qfp*, but mapped separately because part of unit is modified by the Bonneville Flood.

Qm **Michaud Gravel (late Pleistocene)**—Named by Trimble and Carr (1961) and Carr and Trimble (1963) for gravel and sand deposited by the Bonneville Flood: "upon its emergence onto 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. 58). Estimates of high-water levels during the 14.5 Ka Bonneville Flood (O'Connor, 1993; J.E. O'Connor, written commun., 1996) indicate that hydraulically the flood water level rose behind the constriction near present-day American Falls and that the Michaud Gravel was deposited by flood waters about 46 meters (150 feet) higher than the surface of the boulder gravel underlying downtown Pocatello. The bouldery character of the gravel indicates extremely high velocities for the flood, and in the absence of evidence of forset bedding, the Michaud Gravel is described as a giant expansion bar by O'Connor (1993), who has described in detail a similar Bonneville Flood expansion bar downstream of Swan Falls Dam. Principal shared features 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; and clear evidence of reworking and channeling of the bar by later, reduced flow regimes of the flood. Alluvial fan deposits (*Qfp*) partly bury the Michaud Gravel on the northeast side of the Portneuf River valley. Elsewhere, the Michaud Gravel is mantled by thin loess (<1 m).

Qbg **Gravel deposits of the Bonneville Flood, undifferentiated (late Pleistocene)**—Boulder to pebble gravel deposited in various environments and energy regimes of the Bonneville Flood. Includes local boulder gravel adjacent to flood-scoured surfaces of the basalt of Portneuf, cobble-pebble gravel and pebbly sand deposited on and adjacent to the basalt of Portneuf, and an eddy bar open-work pebble gravel that forms the north-campus bench of the Idaho State University.

Quaternary loess—Thick Pleistocene loess mantles many surfaces in the Pocatello South quadrangle. Where loess buries alluvial fan gravel, soil evidence suggests the loess is equivalent in age to the late Wisconsin glaciation and was deposited during the time of the Bonneville transgression of Pleistocene Lake Bonneville, 28-15.2 Ka (O'Connor, 1993). Holocene loess forms a thin cover on deposits of the Bonneville Flood (Pierce and others, 1982).

Ql/b **Loess mantling bedrock of various lithologies (late Pleistocene)**—Primary and reworked loess interfinger with and are mixed with stony colluvium derived from local bedrock. Loess typically mantles a transition zone from bedrock to the heads of alluvial fans. Where loess mantles steep bedrock slopes, it is commonly mixed with bedrock colluvium during ground creep and debris flow movement. As a result, reworked loess is an important component of debris flows within the deeply incised tributaries to the Portneuf River.

Ql/Qfgw **Loess blanketing alluvial fan gravel of Wisconsin Age (late Pleistocene)**—Crudely stratified muddy sand and pebble-to-boulder gravel overlain by calcareous loess that together form the surface of the coalesced relict alluvial fans of the prominent "east" and "west" benches in Pocatello. Elevations, fan surface gradients, and soil evidence suggest the upper part of 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 Portneuf River, which in turn was graded to the ancestral American Falls Lake, estimated to have been as high as 4,440-4,450 feet in elevation. The alluvial fans were entrenched after the lake lowered prior to the Bonneville Flood (Scott and others, 1982). Soil evidence suggests the loess blanketed the fans in late Wisconsin time. The benches formed when the Bonneville Flood truncated the alluvial fan gravels and the loess. The loess is thickest on flatter slopes and absent on some south-facing slopes. Core drilling performed on both the east and west benches (sec. 31, T. 6 S., R. 35 E., and sec. 2, T. 7 S., R. 34 E.) indicates the loess ranges in thickness from 1 to 6 meters (about 3 to 20 feet) and locally buries alluvial fan gravel by as much as 12 meters (40 feet).

Qfg **Alluvial fan gravel, undifferentiated (Pleistocene)**—Crudely stratified muddy sand and pebble-to-boulder gravel exposed along the truncated edges of relict alluvial fans. Clear evidence of age is lacking, but the gravels probably represent a complex late Pleistocene history with deposits of Wisconsin and pre-Wisconsin age. Also mapped locally where stratigraphic and geomorphic evidence of age is lacking.

Qp **Basalt of Portneuf Valley (middle Pleistocene)**—Two superimposed dark gray to black basalt flows with locally well-developed diktytaxitic texture. Well-formed columnar joints in both flows. No recognizable soil or evidence of erosion have been seen at the contact between the two flows. The top surface of the unit lacks flow breccia and other flow-top features because of scour by the Bonneville Flood. The edges of the basalt flows were plucked by the high-energy flood waters. Age of 0.583 +/- 0.104 Ma based on a K/Ar date reported by Scott and others (1982).

Qao **Older alluvium (middle Pleistocene)**—Alluvium of the ancestral Portneuf River, known only from Trimble (1976) that describes alluvium 31 feet thick, the top of which was baked by the lower flow of the basalt of Portneuf Valley. Shown only in cross section E-E'.

Qu **Quaternary deposits, undifferentiated**—Unconsolidated to weakly consolidated alluvium, colluvium, and eolian sediments. Mapped only in cross sections where the vertical scale requires combining the relatively thin Quaternary units.

Tsu **Starlight Formation, upper member (upper Miocene)**—Conglomerate, rhyolite air-fall tuff, rhyolite lava flows, and rare sandstone and marl. Divided into several informal units. Conglomerate and intercalated rocks were assigned by Trimble (1976) to the lower member of the Starlight Formation, but geologic mapping, radiometric dating, and geochemical analyses indicate these rocks overlie and are younger than the 10.2 Ma Arbon Valley Tuff (Kellogg and others, 1994), which composes the middle member of the Starlight Formation (Trimble, 1976).

$Tsup_2$ **Rhyolite porphyry, unit 2**—Porphyritic rhyolite with 15-20 percent phenocrysts of coarse-grained sanidine, plagioclase, and quartz and fine-grained biotite and hornblende. Devitrified, pink to light gray stoney groundmass with zeolite-filled cavities and well-developed flow banding. Lower contact placed at the base of lowest volcanic rock. Forms slopes and rare ledges. Thickness at least 500 feet. Trimble (1976) and Platt (1995) mapped a depositional upper contact for this unit and considered it to be a Quaternary or late Tertiary flow. Trimble (1976) inferred that the lava flowed into a valley cut along a fault contact. In fact, the upper contact is faulted and the unit is similar to $Tsup_1$, suggesting that it is Miocene in age.

$Tsup_1$ **Rhyolite porphyry, unit 1**—Porphyritic rhyolite with about 20 percent phenocrysts of coarse-grained plagioclase, quartz, and sanidine and fine-grained magnetite and pyroxene. Devitrified pink to gray stoney groundmass with a vesicular texture and some flow banding. Locally displays a parting spaced about 10 centimeter. Dated at 7.9 +/- 0.4 Ma by Kellogg and others (1994), who called it the rhyolite of west Pocatello. Lower contact not exposed in map area. Forms ledges and cliffs. Maximum thickness about 600 feet. Trimble (1976) referred to this unit as a porphyritic trachyandesite, but its high silica weight percent indicates a rhyolite according to currently accepted classification schemes (Kellogg and others, 1994).

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. Very rare sandstone and marl interbeds. Contains three persistent but discontinuous air-fall tuff beds (described below). Abrupt lower contact placed at the base of cobble conglomerate which coincides with the top of Cambrian/Late Proterozoic bedrock or more rarely with the top of air-fall tuff (*Tsur1*). Forms gravel-covered slopes with very rare outcrops. Thickness (including air-fall tuff units) at least 3,200 feet in the southeast map area and 50 feet to 3,300 feet in the northeast map area. Forms gravel-covered slopes with very rare outcrops. Exposures are few because cobbly gravel, derived by weathering of the conglomerate, forms a nearly complete cover of colluvial gravel. In outcrop, *Tsuc* can be distinguished from Quaternary fan gravels because it has a coarser, more brightly colored and locally tuffaceous matrix. *Tsuc* is also better indurated and dips more steeply than Quaternary fan gravels.

$Tsur_3$ **Rhyolite air-fall tuff, unit 3**—Laminated to thick-bedded, white to light gray, air-fall tuff. Tuff contains glass shards (>95%), sanidine crystals (<1%) and lithic fragments (<5%). Marl, sandstone, and pebble conglomerate are rarely intercalated. Abrupt upper and lower contacts. Forms slopes and rare ledges. Occurs as discontinuous lenses and pods. Age unknown but the unit lies between two ashes whose ages are 7.39 Ma and 8.3 +/- 0.5 Ma. Thickness as much as 100 feet.

$Tsur_2$ **Rhyolite air-fall tuff, unit 2**—Laminated to massive, white to light gray, air-fall tuff. Tuff contains glass shards (>95%), sanidine crystals (<1%), and lithic fragments (<5%). Marl, sandstone, and pebble conglomerate are rarely intercalated. Abrupt upper and lower contacts bracket air-fall tuff. Forms slopes. Occurs as discontinuous lenses and pods. Age unknown, but the unit lies between two ashes whose ages are 7.39 Ma and 8.3 +/- 0.5 Ma. Thickness less than 10 feet.

$Tsur_1$ **Rhyolite air-fall tuff, unit 1**—Laminated to massive, white to light gray, air-fall tuff. Tuff contains glass shards (>95%), sanidine crystals (<1%), and lithic fragments (<5%). Marl is rarely intercalated. Located at or near (<20 m) stratigraphic base of Tertiary section overlying Late Proterozoic to Middle Cambrian rocks. Forms slopes. Occurs as discontinuous lenses and pods as much as 50 feet thick. Electron microprobe and X-ray fluorescence analyses of glass shards support a correlation with the informally named Inkom ash (D.W. Rodgers, unpub. data), which has an estimated age of 8.3 +/- 0.5 Ma (Perkins and others, 1998).

Tsug **Gravity slide block**—Isolated block of pre-Tertiary basement within *Tsuc* east of Mink Creek.

Єb **Bloomington Formation (Middle Cambrian)**—Limestone and minor shale. Medium gray to blue-gray, thin- to thick-bedded oolitic, micritic, and rarely conglomeratic limestone with abundant silty partings and uncommon intercalated shale. Silt is tan to khaki; shale is dark green to olive-green with horizontal trace fossils. A few hundred feet of quartz arenite sandstone occurs about 1,200 feet above the base. Lower contact is placed above an interval of very light gray laminated micritic limestone. The base of the lowest shale is typically a dark green slope. The unit forms ledges with intervening slopes. About 1,700 feet of the section is exposed in the map area. Limestone above elevations of 5,600 feet contains several closed or cirque-shaped depressions interpreted to be karst. The Bloomington Formation is distinguished from the Elkhead Limestone by green shale interbeds, abundant tan silt laminations, a preponderance of thin to thick beds, and quartz arenite sandstone.

Єe **Elkhead Limestone (Middle Cambrian)**—Limestone. Most limestone is light to medium gray, thick-bedded to massive, oolitic, with some planar and cross-stratification. Subordinate limestone is thin- to thick-bedded micrite with uncommon tan silty partings. One interval of dark gray shale is located a few hundred feet above the base. Lower contact is typically abrupt and placed at the base of lowest limestone. Forms prominent ledges. Thickness is about 2,300 feet. Limestone above elevations of 5,600 feet contain several closed or cirque-shaped depressions interpreted to be karst. The Elkhead Limestone is distinguished from the Bloomington Formation by thick-bedded to massive, pure limestone without significant siliciclastic detritus.

Brigham Group—The Brigham Group was originally described as Brigham Quartzite by Anderson (1928), a name dropped by Crittenden and others (1971) and Trimble (1976) who divided it into six formations: Gibson Jack Formation, Camelback Mountain Quartzite, Mutual Formation, Inkom Formation, Caddy Canyon Quartzite, and Papoose Creek Formation. Link and others (1987) placed these formations into the formally defined Brigham Group.

Єg **Gibson Jack Formation (Lower Cambrian)**—Shale, siltstone, and sandstone. Khaki to olive-green shale and siltstone are laminated and show good slaty cleavage. Sandstone is thin- to medium-bedded quartz arenite. Three informal members identified by Trimble (1976) an upper shale, middle sandstone, and lower shale are persistent throughout the study area but were not distinguished on this map. Lower contact is placed at the base of the lowest shale. The unit forms slopes. Thickness is about 1,100 feet. The slate of the Gibson Jack Formation and Inkom Formation is nearly identical. The medial sandstone and nonresistant character of the Gibson Jack Formation help to distinguish it from the Inkom Formation.

ЄZc **Camelback Mountain Quartzite (Lower Cambrian and Late Proterozoic)**—Quartzite with basal conglomerate and uncommon thin shale beds. White to tan to light gray, thick-bedded quartzite is fine- to coarse-grained and moderately well-sorted with planar cross-stratification; its protolith was quartz arenite. Thin-bedded, brown shale interbeds are rarely present. In the basal 100 feet, quartzite is intercalated with beds of pebble conglomerate containing rounded quartzite, red chert, and red siltstone pebbles. Transitional lower contact placed above arkosic red quartzite and at the base of the lowest white pebble conglomerate. Forms ledges and cliffs. Thickness is about 2,400 feet north of Gibson Jack Creek, thinning to about 1,200 feet south of the creek. The Camelback Mountain Quartzite can be distinguished from the lower member of the Caddy Canyon Quartzite by comparing basal and top lithologies: the Camelback Mountain Quartzite has a basal pebble conglomerate and thick-bedded quartzite at the top, whereas the lower member of the Caddy Canyon Quartzite has intercalated siltstone at the base and shale, laminated quartzite, and marble at the top.

Zm **Mutual Formation (Late Proterozoic)**—Quartzite and pebble conglomerate with minor shale. Medium- to thick-bedded quartzite is pink, red, or maroon, medium-grained to gritty, and poorly sorted; its protolith was probably a subarkosic to sublithic arenite. Conglomerate is maroon to purple with clasts of quartzite, chert, and siltstone. Both quartzite and conglomerate have abundant cross-stratification. Maroon to rarely olive-green shale and siltstone form a persistent 300-foot-thick bed, located 300-600 feet above the base of the unit, and they also occur as discontinuous lenses. Overall, the formation appears to fine upward. Lower contact is placed above the highest green to maroon shale of the Inkom Formation; this contact is abrupt to the southwest and northwest but transitional, with intercalated shale and pebble conglomerate, in the west-central map area. Although the formation is resistant and underlies prominent hills, these hills are characterized by talus rather than outcrops. Thickness is about 3,800 feet. The Mutual Formation can be confused with the upper member of the Caddy Canyon Quartzite. However, the Caddy Canyon Formation is typically quartzite without conglomerate or shale. Its color is restricted to reddish hues, and it lacks abundant cross-stratification. The only important exception is the uppermost Caddy Canyon Formation (the upper member of Jansen, 1986), which contains intercalated shale and conglomerate similar to parts of the Mutual Formation. The Mutual Formation is much thicker and has a greater percentage of conglomerate than this part of the Caddy Canyon Formation, which should be sufficient to distinguish them.

Zi **Inkom Formation(Late Proterozoic)**—Slate and phyllite with minor medium-grained quartzite. Olive-green, laminated to thin-bedded slate is typical; maroon slate and fine-grained quartzite with thin, normally graded beds, ripples, and flame structures are present in the uppermost 15-50 feet. Subarkosic quartzite and pebble conglomerate beds are present in the upper 150 feet in the west-central map area. Lower contact is placed above the highest quartzite or conglomerate bed of the Caddy Canyon Quartzite. Forms low ledges and intervening slopes. Thickness changes along strike from about 1,400 feet in the west-central map area to about 600 feet in the northwest and northeast. The slate of the Inkom Formation and Gibson Jack Formation is nearly identical. The medial sandstone and nonresistant character of the Gibson Jack Formation help to distinguish it from the Inkom Formation. Jansen (1986) mapped a faulted lower contact of the Inkom Formation in the west-central area based on the abrupt change from conglomerate to overlying green slate and the atypical thinness of the Inkom Formation. This contact is herein interpreted to be depositional because the rocks are undeformed, the thinning is progressive, and to the north the even thinner Inkom Formation has a transitional lower contact. Link and others (1987) emphasize the abrupt nature of the upper contact of the Inkom Formation, associating it with a sequence boundary, but the intercalated slate and conglomerate in the west-central map area provide evidence of a gradual lithologic transition in some localities.

Caddy Canyon Quartzite (Late Proterozoic)—Quartzite, minor conglomerate, and rare slate and marble. Divided into two informal members: a lower member that correlates to the lower member of Jansen (1986) and Link and others (1987), and an upper member that correlates to the middle and upper members described by these authors.

Zcu **Caddy Canyon Quartzite, upper member (Late Proterozoic)**—Quartzite and minor pebble conglomerate. Pink, red, red-violet, and rarely purple or tan, thick-bedded to massive quartzite is fine-grained to gritty and poorly sorted; its protolith was probably a subarkosic to sublithic arenite. Pebble conglomerate with clasts of quartzite and chert is rare except at the top. Uppermost 100 feet includes intercalated gritty quartzite and matrix-supported pebble conglomerate in the west-central study area, but changes to quartzite and conglomerate with subordinate olive-green slate in the northwest. Lower contact approximately coincides with the lowest red quartzite and is placed at the top of a prominent marble marker bed or, in its absence,laminated slate and fine-grained sandstone. The member is resistant and underlies prominent hills. Thickness is about 2,800 feet. This member correlates to the middle and upper members described by Jansen (1986), Link and others (1987), and J. Riesterer and P.K. Link (2000). The upper member of the Caddy Canyon Quartzite can be confused with the Mutual Formation, but it contains quartzite without conglomerate or shale. In addition, its color is restricted to reddish hues, and it lacks abundant cross-stratification. The only important exception is the uppermost Caddy Canyon Quartzite (the upper member of Jansen, 1986), which contains intercalated shale and conglomerate similar to parts of the Mutual Formation. The Mutual Formation is much thicker and has a greater percentage of conglomerate than this part of the Caddy Canyon Quartzite, which should be sufficient to distinguish them.

Zcl **Caddy Canyon Quartzite, lower member (Late Proterozoic)**—Quartzite with minor slate and metasiltstone. Tan to brown to white, thick-bedded to uncommonly massive quartzite is fine- to coarse-grained, rarely gritty, and moderately well-sorted and has both planar and cross-stratification; its protolith was quartz arenite. Laminated fine-grained brown quartzite and olive-green or maroon slate with discontinuous lenses of marble at top of member. Marble is thin-bedded to massive, tan to dark gray, typically composed of calcite but locally dolomite, and as much as 30 feet thick. Quartzite is interbedded with interlaminated metasiltstone and fine-grained quartzite, typical of the Papoose Creek Formation, in the lower 100-300 feet. Lower contact is placed at the base of the lowest quartzite bed, which is typically white to tan; this quartzite fills at least one channel cut about 50-100 feet deep and several hundred feet wide into underlying rocks in the northwest map area. Forms prominent ledges and talus-covered slopes. Thickness is about 2,100 feet. The lower member of the Caddy Canyon Quartzite can be distinguished from the Camelback Mountain Quartzite by comparing basal and top lithologies: The Camelback Mountain Quartzite has a basal pebble conglomerate and thick-bedded quartzite at the top, whereas the lower member of the Caddy Canyon Quartzite has intercalated siltstone at the base and shale, laminated quartzite, and marble at the top.

Zpc **Papoose Creek Formation (Late Proterozoic)**—Intercalated argillite and quartzite. Thin-bedded argillite is dark to reddish brown; fine-grained quartzite laminae are light gray to tan. Thinly interbedded argillite and quartzite are distorted by common syneresis structures and other soft sediment deformation. Other sedimentary structures include flaser bedding and ripples. Lower contact is not exposed in the map area. Forms low ledges. Thickness is at least 1,000 feet. The Papoose Creek Formation slightly resembles the upper member of the Pocatello Formation in that both units contain reddish brown and silver-gray laminations. The coarse grain size and syneresis cracks, however, distinguish the Papoose Creek Formation. The basal 100-300 feet of the lower member of the Caddy Canyon Quartzite contains some beds identical to the Papoose Creek Formation.

Zbc **Blackrock Canyon Limestone (Late Proterozoic)**—Limestone or dolomite marble with intercalated quartzite and shale. Limestone and dolomite are dark gray, massive (upper half) or medium-bedded (lower half) with small resistant laminae of sandstone or chert. Abrupt lower contact is placed at base of lowest marble bed. Forms low ledges. Thickness ranges from 50 to100 feet.

Zp **Pocatello Formation (Late Proterozoic)**—Interbedded quartzite, metavolcanic rocks, metadiamictite, phyllite, and rare marble. Divided into three members: the informal upper member, the Scout Mountain Member (itself subdivided into four informal units), and the Bannock Volcanic Member. These members and units generally correlate to ones defined by Link (1983) and Link and LeFebre (1983), who modified the stratigraphy of Trimble (1976).

Zpu **Upper member**—Phyllite and minor quartzite. Finely laminated, reddish brown and silver-gray phyllite, intercalated at its base with reddish brown, medium-grained, medium-bedded quartzite. Lower contact is placed at base of lowest phyllite. Forms slopes. Thickness is poorly constrained at about 400-800 feet. The upper member of the Pocatello Formation slightly resembles the Papoose Creek Formation in that both units contain reddish brown and silver-gray laminations. The upper member of the Pocatello Formation, however, is distinguished by phyllite with very fine, continuous laminations.

Scout Mountain Member—Quartzite, metadiamictite, metasiltstone, and rare marble. Link (1983) describes the member in detail and gives evidence for a tillite protolith for the metadiamictite. Divided into four informal units that generally correspond to ones recognized by Link (1983) and LeFebre (1984). Recognition and correlation of these units are based upon lithology and stratigraphic position; however on-strike lithologic changes as well as faulted contacts, ductile shear, and upper greenschist facies metamorphism obscure some relations. The four units have been correlated to units of Link (1983) and LeFebre (1984) as follows: an upper unit to the "upper sandstone and limestone unit" and "upper diamictite unit"; a quartzite unit to the "lower sandstone unit, number 3"; a metasiltstone unit to the "lower sandstone unit, number 1"; and a diamictite unit to the "lower diamictite unit."

Zpsu **Upper unit**—Quartzite and metadiamictite. Upper half is fine- to medium-grained, brownish gray to greenish gray, thick-bedded quartzite. Lower half is metadiamictite with subrounded to angular pebble- and cobble-sized clasts of quartzite, plutonic rocks, and argillite in a brown to rust-colored sandy and silty matrix. Lower contact is placed at the base of metadiamictite, or, in its absence, at the base of greenish gray quartzite. Thickness poorly constrained at about 400 feet.

Zpsq **Quartzite unit**—Medium- to thick-bedded, tan to light gray to light green, fine- to coarse-grained, moderately well-sorted quartzite. Moderately indurated in places, possibly the evidence of calcite cement dissolution. Quartz arenite sandstone protolith. Sedimentary structures include uncommon planar laminations and rare cross-stratification. Abrupt lower contact is placed at the base of lowest quartzite bed. Forms ledges. Thickness is about 750 feet east of the Fort Hall Canyon fault where rocks are overturned, but the unit is absent west of the fault where rocks are upright.

Zpsm **Metasiltstone unit**—Metasiltstone with subordinate quartzite. Upper half is green, thin- to medium-bedded, laminated metasiltstone and fine-grained quartzite. Downsection the green metasiltstone and quartzite are intercalated with lenses of brown to gray, medium- to thick-bedded, gritty to fine-grained quartzite that commonly has normal grading; the quartzite protolith was probably a subarkosic arenite. Both upper and lower contacts of this unit are fault bounded. Forms low ledges with intervening slopes. Thickness at least 1,000 feet in one fault block, but unit is absent east of Fort Hall Canyon fault where rocks are overturned.

Zpsd **Diamictite unit**—Metadiamictite with subordinate quartzite and schist. Metadiamictite is a brown to medium gray to green, massive rock with a matrix of silt- and sand-sized grains supporting pebble-, cobble-, and rarely boulder-sized clasts. Clasts are rounded to subrounded and include quartzite, volcanic porphyry, siltstone, and granite. Quartzite is similar to metadiamictite without clasts. Schist contains chlorite, muscovite, quartz, and feldspar with porphyroblasts of actinolite and garnet; it forms a layer up to 100 feet thick at the top of the unit in the east-central map area, where the rocks are overturned. Lower contact is placed at the base of the lowest metadiamictite, which generally coincides with the top of a laminated volcanic diamictite. Forms ledges. Thickness varies greatly: about 1,700 feet in the northeast map area, and up to 150 feet in the east-central map area where it is overturned.

Zpb **Bannock Volcanic Member**—Greenstone with subordinate amphibolite, phyllite, schist, and rare metadiamictite. Massive, poorly to moderately foliated greenstone is composed of chlorite, actinolite, quartz, epidote, and feldspar; many beds have distorted vesicles indicating a basalt protolith. Amphibolite is greenstone with common porphyroblasts of hornblende and sparse garnet. Phyllite and schist are well-foliated chlorite-, actinolite-, epidote-, quartz-, and feldspar-bearing rocks that may have originated as epiclastic sediments. Metadiamictite consists of flattened volcanigenic siltstone clasts in a volcanigenic siltstone matrix; the clasts may weather purple whereas the matrix weathers silver-gray. Metadiamictite appears to be restricted to the upper 100 feet or so of the member, where it occurs with laminated and silicified metasiltstone. Lower contact is not exposed. Forms ledges and weathers to a distinctive green color. Thickness unknown because of folding and lack of bedding.

SYMBOLS

Contact: dashed where approximately located; dotted where concealed.

Gradational contact.

Fault: dashed where approximately located; dotted where concealed; small dash where inferred; normal faults indicated with ball and bar on downthrown side.

21 Inclined strike and dip of bedding.

20 Overturned strike and dip of bedding.

17 Inclined strike and dip of foliation.

STRUCTURAL GEOLOGY

DESCRIPTION OF GEOLOGIC STRUCTURE

Bedding

Pre-Quaternary sedimentary and volcanic beds are no longer horizontal but instead dip moderately east in most places. Proterozoic and Paleozoic rocks west of the Portneuf Valley strike north and dip about 40º E., as shown in the accompanying cross sections. Proterozoic and Paleozoic rocks northeast of the Portneuf Valley similarly strike north and dip moderately east, except for some that dip gently west because they lie in the overturned limb of the Blackrock Canyon fold. Bedding of the Miocene Starlight Formation also strikes north and dips east, except that the average dip is about 25º E.

Angular Unconformities

Angular unconformities bracket the Miocene Starlight Formation. West of the Portneuf Valley, the basal unconformity separates the Starlight Formation from Cambrian rocks ranging from the lower Bloomington Formation to the upper Camelback Quartzite. Northeast of the Portneuf Valley, the basal unconformity everywhere separates the Starlight Formation from the Camelback Quartzite. In both places the difference in bedding attitudes across the unconformity is 10-20 degrees. Above the Starlight Formation lies untilted Quaternary gravels and basalt, yielding an angular unconformity of about 25 degrees.

Folds

The Blackrock Canyon fold, a large-scale recumbent fold involving the Pocatello Formation, is present along the northeastern edge of the study area. The overturned limb is evident in the uplifted footwall of the Fort Hall Canyon fault, where an inverted sequence of the Bannock Volcanic Member and Scout Mountain Member shows significant thinning, a relatively strong foliation, and inverted cross stratification. The upright limb is represented by east-dipping rocks of the Bannock Volcanic Member and Scout Mountain Member that are downfaulted along splays of the Fort Hall Canyon fault. The axial region is east of the map area in Blackrock Canyon (N. McQuarrie and others, unpub. mapping, 1997). This fold resembles the one first described by LeFebre (1984) and the Rapid Creek fold described by Burgel (1986), although the geometry is somewhat different: The Blackrock Canyon fold is a north-trending, subhorizontal, recumbent anticline that shows eastward vergence. A more complete description of the fold is presented by N. McQuarrie and others (unpub. mapping, 1997).

The only other folds identified in the map area include rare unmapped outcrop-scale folds in the Papoose Creek Formation along the northwest edge of the map area and gentle undulations of bedding in all pre-Miocene formations throughout the region.

Foliation

A well-developed foliation is present in many rocks of the Pocatello Formation and more rarely in the Blackrock Canyon Limestone and Inkom Formation. Overturned rocks of the Pocatello Formation have a weak to strong foliation defined by aligned chlorite, muscovite, and quartz in schists, flattened quartz in quartzites, flattened cobbles in diamictite, and flattened vesicles in volcanic flows. Upright rocks of the Pocatello Formation have a weakly to more rarely moderately developed foliation. Foliation in the Blackrock Canyon Limestone is marked by parallel wavy bands oriented oblique to bedding. The Inkom Formation, although typically unfoliated in hand-specimen, contains a cleavage so strong that it commonly obscures bedding in the west-central map area. In most places foliation has a northerly strike and dips eastward, with the amount of dip somewhat less than that of bedding.

Joints

Joints are present in all Proterozoic and Paleozoic rocks and in volcanic flows of the Miocene Starlight Formation, but joint density and orientation were not measured in this study.

Faults

Pre-Quaternary rocks throughout the map area are cut by numerous faults. Faults range in length from a few meters to more than 20 kilometers, and fault offset is as much as 6,000 meters. Only faults that offset stratigraphic contacts in plan view by more than 100 meters are shown on the geologic map. The most significant of these faults are described below.

Fort Hall Canyon fault—Normal fault located along the eastern edge of the Portneuf Valley (cross section EE' and FF'). Extends southeast beyond the map area into Fort Hall Canyon (N. McQuarrie and others, unpub. mapping, 1997). Manifested by the truncation of map units, the break in metamorphic grade, the change in topographic gradient, and the brittle-ductile shear zone that extends as much as several meters away from the fault. Approximate N-S strike and dip of 25º W., as determined by its trace over rugged topography. Separates a footwall of Pocatello Formation from a hanging wall of Pocatello Formation to upper Starlight Formation, indicating a significant component of normal slip. If it is entirely a dip slip normal fault, then offset just southwest of the map area is at least 20,000 feet (Burgel and others, 1987).

Dry Creek fault—Located along Dry Creek from Gibson Jack Creek to West Fork Mink Creek. Manifested by the truncation of map units. Approximate strike of N. 20º E. and dip of 40º NW., as determined by its trace over rugged topography. Separates a footwall of Inkom Formation and Mutual Formation from a hanging wall of Elkhead Limestone and Bloomington Formation, indicating a large component of normal slip. Slip vector unknown; if it is a dip slip normal fault, then slip amount is about 6,000 feet (cross-section AA').

Slate Mountain fault—Located just north of Slate Mountain. Manifested by the truncation of map units and intensely brecciated and silicified quartzite within the Camelback Mountain Quartzite. Nonplanar, shovel-shaped fault with a basal segment that strikes N-S and dips 20º W., as determined by measurement of the fault outcrop. Separates a footwall of Camelback Mountain Quartzite from a hanging wall of Camelback Mountain Quartzite and Gibson Jack Formation. Several fault striations trend N. 90º W., indicating a dip slip normal fault. Slip is about 900 feet (cross-section AA').

Gibson Jack fault—Located along Gibson Jack Creek. Manifested by the truncation of map units and by sheared quartzite within the Camelback Mountain Quartzite and Mutual Formation. Approximate strike of N. 70º E., according to its map trace, and an assumed dip of 60º SE. Separates a footwall of Inkom Formation to Elkhead Limestone from a hanging wall of internally faulted Mutual Formation to Bloomington Formation. Overlain by Miocene Starlight Formation. Slip vector unconstrained but inferred to be varied due to scissorlike faulting (see cross-sections HH', II', and discussion below).

Campbell Creek fault—Located in Campbell Creek and Dry Creek. Manifested by the truncation of map units and by brecciated and silicified quartzite within the Mutual Formation. Approximate strike of N. 60º E. and dip of 65º SE., as determined by its trace over rugged topography. Separates a footwall of Mutual Formation to Gibson Jack Formation from a hanging wall of internally faulted Mutual Formation to Bloomington Formation, indicating a component of normal slip. Overlain by Miocene Starlight Formation. Slip vector unknown; dip slip separation is at least 1,000 feet (cross-section II').

City Creek fault—Located just south of City Creek. Manifested by the truncation of map units. Approximate strike of N. 20º E. and dip of 40º SE., as determined by its trace over rugged topography. Separates a footwall of the upper Caddy Canyon Quartzite to Mutual Formation from a hanging wall of upper Caddy Canyon Quartzite to Mutual Formation, indicating a component of normal slip. Slip vector unknown; if it is a dip slip normal fault, then slip is about 3,000 feet (cross-sections DD', HH').

Trail Creek fault—Located just north of Trail Creek. Manifested by the truncation of map units and silicified quartzite lenses. Approximate strike of N. 8º E. and assumed dip of 60º NW. Separates a footwall of upper member of the Pocatello Formation to the lower member of the Caddy Canyon Quartzite from a hanging wall of the upper member of the Starlight Formation, indicating a significant component of normal slip. Normal slip is as much as 17,000 feet (cross-sections GG', HH'), assuming the Starlight Formation overlies the Elkhead Limestone (see Trimble, 1976).

East-west fault set—Faults of this set are located throughout the map area in Proterozoic and Paleozoic rocks. Manifested by the truncation of map units and locally by brecciation and silicification of quartzite. Faults have an approximate strike of N. 90º E., according to their map traces and dips assumed to be 60º S. or more rarely north. Slip vectors unknown; if they are dip slip normal faults, then slips range from 300 feet to 5,000 feet (cross-sections GG', HH', II').

INTERPRETATION OF STRUCTURES

The style and geometry of structures, as well as cross-cutting relations, provide evidence for three pulses of deformation. The pulses most likely reflect the three regional tectonic events recognized throughout the region: the shortening in the Sevier fold and thrust belt, the extension associated with formation of the Basin and Range Province, and the subsidence of the adjacent Snake River Plain.

Shortening

Shortening in the quadrangle is represented by foliation and the Blackrock Canyon fold. These structures are present in the lowest stratigraphic units but rare to absent elsewhere, indicating that ductile deformation only affected midcrustal rocks. Upper crustal rocks of the region were apparently unstrained. The north-trending fold and generally north-striking foliation document an east-west shortening direction, with a eastward sense of shear indicated by fold vergence and the angle between bedding and foliation. The amount of shortening has not been estimated. The age of shortening is poorly constrained by cross-cutting relations as post-Cambrian to pre-Miocene, but if shortening occurred in conjunction with major thrust faults to the east of the map area, timing is more tightly bracketed as Late Jurassic to Late Cretaceous (Armstrong and Oriel, 1965), possibly Aptian to Albian in age (Heller and others, 1986).

Significant rock record is missing along the sub-Miocene unconformity. A sequence of Middle Cambrian to Permian-Triassic sedimentary rock as much as 8 kilometers thick is regionally persistent but absent in the map area. Erosion of these units most likely occurred during regional uplift associated with shortening, although some uplift associated with younger extension cannot be ruled out. The Putnam thrust is inferred to underlie the study area (Royse and others, 1975; Burgel and others, 1987; Kellogg, 1992), and uplift may have occurred in conjunction with slip along a concealed frontal thrust ramp located immediately west of the quadrangle (Rodgers and Janecke, 1992).

Extension

Extension is represented by normal or normal-oblique faults that cut across the map, but the fault history is difficult to deduce because discrete fault sets, with internally consistent attitudes, are not readily apparent. For example, faults with the same orientation include the Fort Hall Canyon fault, Dry Creek fault, and Slate Creek fault, as well as the Gibson Jack fault and Campbell Creek fault. Cross-cutting map relations, however, indicate the age progression of these faults, from oldest to youngest, is Campbell Creek fault, Dry Creek fault, Gibson Jack fault, and Fort Hall Canyon fault. These somewhat contradictory data preclude an accurate assessment of the fault history, so the following interpretation is best considered preliminary.

The fault with greatest displacement is the gently west-dipping Fort Hall Canyon fault, which separates an east-tilted footwall of Pocatello Formation from an east-tilted hanging wall of Brigham Group, Middle Cambrian limestone, and upper Starlight Formation. This range-bounding fault is interpreted to be a single surface in some places, but more commonly a number of parallel splays are present in hanging wall rocks. About 18,000 feet of dip slip along the fault resulted in the footwall uplift of ductilely deformed, upper greenschist to lower amphibolite facies rocks. Slip along the fault accomplished east-west extension as well as the initial formation of the Pocatello Range, Portneuf Valley, and Bannock Range. Slip occurred from 8.2 to 7.4 Ma, based upon the age span of the Starlight Formation in Portneuf Valley, and probably continued for some time after this.

The foothills of the Pocatello Range in the northeast corner of the map area contain a plexus of faults almost too complex to illustrate. This region is interpreted to have three major fault blocks separated by two major normal faults. The Fort Hall Canyon fault separates a footwall of west-dipping, overturned Pocatello Formation from a hanging wall of east-dipping, upright Pocatello Formation. A subhorizontal, structurally higher normal fault separates the upright Pocatello Formation from a hanging wall of medial Brigham Group and Starlight Formation. A thin sheet of Blackrock Canyon Limestone is discontinuously present along this fault. The two major faults and three fault blocks are cut by minor normal faults that strike north or east, resulting in a gridlike pattern of faults.

The Dry Creek fault, Slate Mountain fault, and other unnamed normal faults that are subparallel to the Fort Hall Canyon fault are similarly interpreted to reflect east-west extension. The Gibson Jack and Campbell Creek faults, which show mutually cross-cutting relations with north-striking normal faults, are interpreted to be tear faults coeval with extension along the north-striking normal faults. According to this interpretation, the southwest quarter of the map area consists of four major fault blocks. Block 1, the structurally lowest block, is bounded by the Campbell Creek, Dry Creek, and Gibson Jack faults as well as the Starlight Formation. Block 2 crops out south of Block 1 and is bounded by the Campbell Creek and Dry Creek faults as well as the Starlight Formation. Just south of the map area, Block 2 ends and a new fault block appears with rock units similar to Block 1 (Platt, 1995). Block 1 is interpreted to underlie Block 2. Block 3 crops out west of the Dry Creek fault and south of the Gibson Jack fault, and map relations indicate it overlies Blocks 1 and 2. Block 4 is north of the Gibson Jack fault and west of the Starlight Formation. Rock units in Block 4 are similar to those in Block 3, and the two blocks are interpreted to have been continuous prior to slip on the Gibson Jack fault. According to this interpretation, the south-dipping Gibson Jack fault is a dextral-normal fault to the west but a reverse fault to the east where Mutual Formation and Gibson Jack Formation are juxtaposed. The fault may be a "scissors" fault perhaps because Block 4 is tilted east more than Blocks 1, 2, and 3.

The uniform eastward tilt of Tertiary and pre-Tertiary rocks is interpreted to reflect "domino-style" half graben normal faulting. This fault style, common throughout the Basin and Range Province, is characterized by the tilting of fault blocks and the faults that divide them. In the Pocatello region, pre-Tertiary rocks are uniformly tilted 40º east, and several north-striking normal faults, including the Fort Hall Canyon fault, dip 20º-30º W. At the onset of extensional faulting, bedding would have been subhorizontal, and these faults would have dipped 60º-70º W., typical attitudes for these features. Furthermore, initial tilting and normal faulting apparently preceded deposition of the upper Starlight Formation, as shown by the 15º dip of the sub-Miocene angular unconformity and the apparent overlap of upper Starlight Formation on the Gibson Jack and Campbell Creek faults.

The east-west fault set records a young pulse of north-south extension. These faults are subparallel to the margin of the Snake River Plain, located a few miles north of the quadrangle, and they may have formed in association with that feature. However, because most of these faults dip south, they did not accommodate subsidence of the Snake River Plain, merely extension on its flanks similar to Snake River Plain-parallel faults elsewhere in eastern Idaho (Zentner, 1989). Extension has occurred in concert with crustal flexure, as the Snake River Plain continues to actively subside (McQuarrie and Rodgers, 1998).

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