Geologic Map of the Fairfield 30 x 60 Minute Quadrangle, Idaho

Mapped and Compiled by
Dean L. Garwood, John D. Kauffman,
Kurt L. Othberg, and Reed S. Lewis

2014

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INTRODUCTION

The geologic map of the Fairfield 30′ x 60′ quadrangle identifies rock units exposed at the surface or underlying thin surficial cover of soil and colluvium. The map is the result of field work conducted in 2013 and compilation of previous mapping by the authors. Mapping by previous workers, noted below, was field checked and incorporated where appropriate. Soils information is from Case (1981). Major oxide and trace element analyses of samples in the quadrangle were done at Washington State University's GeoAnalytical Laboratory in Pullman, Washington; analytical results are available for download from the IGS website.

Previous mapping in the area includes that of Schmidt (1961), Malde and others (1963), Smith (1966), Worl and others (1991), Link and others (1995), and Oakley and Link (2006). Malde and others conducted regional reconnaissance mapping and established a regional stratigraphy. Smith mapped part of the eastern Mount Bennett Hills, and Schmidt mapped the Bellevue area with a focus on Quaternary units and stream diversions by basalt flows. Worl and others mapped and compiled the geology of the Hailey 1°x 2°quadrangle, which also includes the quadrangle. Link and others mapped and compiled strata in the northeast part of the quadrangle. Oakley and Link mapped the Davis Mountain 7.5′ quadrangle near the western map border.

The northeast part of the quadrangle is underlain by Devonian, Permian, and Pennsylvanian strata (Mahoney and others, 1991). Cretaceous and Eocene intrusive rocks crop out extensively north of the Prairie (Lewis and Kiilsgaard, 1991; Kiilsgaard and others, 2001) and many of the hills both north and south of the Prairie and east of the Big Wood River are composed of Eocene Challis Volcanic Group, andesitic and dacitic to rhyolitic rocks and associated sedimentary units (Sanford, 2005). The Eocene rocks are locally capped with Miocene basalt and rhyolite tuff. The rhyolite tuff is considered part of the Miocene Idavada Volcanics of Malde and Powers (1962). Younger rhyolite in the Magic Reservoir area has been studied by Leeman (1982), Struhsacker and others (1982), and Honjo (1986).

The area includes the Camas Prairie, an extensional graben that is probably related to formation of the Snake River Plain (Kirkham, 1931; Cluer and Cluer, 1986). Pleistocene basalt flows erupted from local vents and flowed onto the Camas Prairie and across large areas of the southeastern part of the map. During these eruptions, Camas Creek and the Big Wood and Little Wood rivers were periodically dammed and diverted by the basalt flows. Sources for these streams include high glaciated mountains, and during the Pleistocene outwash gravel was deposited in their valleys. At the same time, alluvial-fan gravels were deposited in tributary valleys and spread across the Camas Prairie.

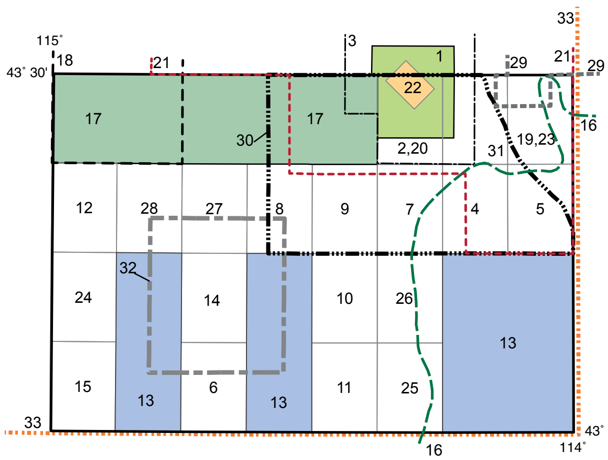

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Figure 1. *Sources of geologic mapping*

DESCRIPTION OF MAP UNITS

ARTIFICIAL DEPOSITS

m—Man-made ground (Holocene)—Artificial fills composed of excavated, transported, and emplaced construction materials typically derived locally. Includes fills for highways, railroad grades, levees, reservoir dams, mine tailings, and berms and small dams for artificial ponds and lakes.

ALLUVIAL AND LACUSTRINE DEPOSITS

Qam—Alluvium of mainstreams (Holocene)—Channel and flood-plain deposits of the Big Wood and Little Wood rivers. Stratified coarse sand and pebble to cobble gravel in channel deposits. Stratified silty sand and sandy pebble gravel in flood-plain deposits. Gravel mostly rounded clasts of Paleozoic sedimentary and metamorphic rocks, granitic rocks, felsic volcanic rocks, and minor amounts of basalt. Bedrock may be exposed in channels during low water. Deposits are 0.3-3 m (1-10 feet) thick. Soils undeveloped.

Qas—Alluvium of side streams and local drainages (Holocene and Late Pleistocene)—Channel and flood-plain deposits of creeks tributary to the Big and Little Wood rivers, and smaller creeks draining local valleys. Channel deposits are moderately sorted pebble to boulder gravel. Flood-plain deposits are clay, silt, sand, and fine gravel. Includes small areas of sheet-wash and alluvial-fan deposits. Gravel clast lithology mostly local bedrock. Thickness of deposits varies greatly, ranging from 1 to 9 m (3 to 30 ft). Soils undeveloped to weakly developed.

Qtg—Gravel terrace deposits of Big Wood River, undivided (Pleistocene)—Moderate- to well-sorted gray sandy pebble and cobble gravel deposited by the ancestral of Big Wood River. Gravel clasts subrounded to rounded. Probably equivalent to Qtg_2 or Qtg_3.

Qtg_1—Gravel terrace deposits, 1st terrace of Big and Little Wood rivers (early Holocene and Late Pleistocene)—Sandy pebble-cobble gravel; sorted and coarsely bedded. Terrace is 3-6 m (10-20 feet) above present Big Wood River flood plain. Soils weakly developed.

Qtg_2—Gravel terrace deposits, 2nd terrace of Big Wood River (Pleistocene)—Sandy pebble to boulder gravel. Mostly rounded clasts; moderate sorting; thick bedded with some cross bedding. Terrace is 3-9 m (10-30 feet) above present Big Wood River flood plain. Deposits are outwash gravels from late Wisconsin alpine glaciers in headwaters of adjacent Boulder and Pioneer mountains. Equivalent to Pinedale gravels of Schmidt (1962) and the Boulder Creek outwash gravels of Pearce and others (1988). Soils moderately developed.

Qtg_3—Gravel terrace deposits, 3rd terrace of Big Wood River (Pleistocene)—Sandy pebble and cobble gravel; mostly rounded clasts. Moderate sorting; mostly thick bedded with some cross bedding. Terrace is 12-24 m (40-80 feet) above present Big Wood River flood plain. In the Wood River Valley, unit characterized by a 1-2 m (3-7 feet) gray clay capping the gravel. Downstream of Mahoney Flat correlation inferred from longitudinal profile of terrace remnants. Deposits are outwash gravels from alpine glaciers in headwaters of adjacent Boulder and Pioneer mountains. Equivalent to Bull Lake gravels of Schmidt (1962). Soils well developed.

Qtg_4—Gravel terrace deposits, 4th terrace of Big Wood River (Pleistocene)—Moderate- to well-sorted and stratified gray sandy pebble gravel to pebbly sand. Pebbles primarily subrounded to rounded. Forms highest terrace above Magic Reservoir; height above maximum pool ranges from approximately 164 m (50 feet) near Metcalf Spring to approximately 66 m (20 feet) near Myrtle Point. Buries and thins against gentle westward-rising slope of basalt of Macon (*Qmab*); thickness variable over basalt of Macon, ranging 66-131 m (20-40 feet) thick near Magic City. Deposits weathered reddish-brown. Well-developed soils indicated by clay-rich B horizons with indurated layers and nodules of silica. Based on stratigraphy and geomorphic position, probably equivalent in age to high-position alluvial fan gravel (Qafh).

Qtgs—Gravel terrace deposits of side streams, undivided (Pleistocene)—Moderate- to well-sorted stratified coarse sand, pebbly sand, and pebble-cobble gravel. Forms terraces mostly 33-66 m (10-20 feet) above present streams. Thickness of deposits is 33-164 m (10-50 feet). Soils vary from weakly to moderately developed.

Qago—Alluvial gravel deposits, older undivided (Pleistocene)—Shown only in cross section. Coarse to fine gravel. May include beds of sand, silt, and clay.

Qaf—Alluvial-fan deposits (Holocene and Pleistocene)—Unit primarily comprises two forms: (1) Coalesced alluvial fans that emanate from the mountains and cover the western half of the Camas Prairie. Composed of moderately sorted and stratified pebbly coarse sand grading southward and westward into sand, silt, and clay. Thickness of deposits 3-30 m (10-100 feet). Overlies older Pleistocene alluvial-fan and lake deposits, and bedrock. (2) Local alluvial fans that form aprons along valley borders variously composed, depending on local bedrock, of poorly sorted silty, clayey sand and angular gravel, to poorly sorted silty sand and granules of reworked grus. Thickness of deposits varies greatly, typically ranging from 3-24 m (10-80 feet), but 30-122 m (100-400 feet) thick near Gannett and Picabo. Soils vary from weakly developed to moderately developed.

Qafo—Older alluvial-fan deposits (Pleistocene)—Primarily poorly sorted silty, clayey sand and pebble-cobble gravel. Forms dissected alluvial-fan remnants deposited by ancestral streams graded to base levels at least 40 feet above present streams. Includes small areas of younger deposits. Large areas of older coalesced fans border and interfinger with terrace gravel *Qtg_3*. Unit includes areas of high-elevation alluvial and alluvial-fan remnants that are probably older than *Qtg_3*. Thickness of deposits varies greatly, ranging from 3 to 30 m (10 to 100 feet). Soils well developed.

Qafh—Alluvial-fan deposits, high position (Pleistocene)—Moderately sorted and stratified coarse sand and pebbly coarse sand in remnants of formerly more extensive coalesced alluvial fans graded to ancestral Camas Creek. Deposited following emplacement of basalt of Macon (*Qmab*), but prior to incision of basalt of Macon and cutting of Camas Creek canyon. Thickness of deposits range from 24-30 m (80-100 feet) north of Camas Creek where they overlie older sediments or bedrock, and 3-6 m (10-20 feet) where they overlie basalt. Deposits weathered reddish-brown. Well-developed soils indicated by clay-rich B horizons with indurated layers and nodules of silica.

Qlp—Deposits of lakes and playas (Holocene and Pleistocene)—Thin-bedded to massive clay, silt, and sand; includes layers with common pebble- and cobble-sized clasts of basalt and tuff. Derived from erosion of loess and fine-grained soil washed into areas of internal drainage or nearly flat slopes. Deposited during periodic floods, especially during periods of heavy rains and times of rapid snow melt, which may have been more prevalent during the Pleistocene.

Qlm—Lacustrine deposits of Metcalf Spring (Pleistocene)—Laminated silt and clay to layered fine sand and silt exposed in cliffs for at least 2.4 km (1.5 miles) along the west shore of Magic Reservoir near Metcalf Spring. Capped by basalt of Macon, the base of which is locally hyaloclastic and pillowed in contact with the sediments. Includes a section of fluvial and deltaic facies exposed opposite the mouth of Poison Creek that includes pebbly coarse sand, thin-bedded silt and fine sand, lenses of fine gravel, and cross-bedded sand near the contact with basalt of Macon.

QTac—Alluvial and colluvial deposits (Pleistocene and Pliocene)—Remnant alluvial and colluvial deposits on the eastern edge of Mount Bennett Hills and the flanks of Rattlesnake Butte. Mostly subangular to subrounded pebbles in a silt and clay matrix.

Idaho Group

QTbl—Gravel of Bray Lake (Pleistocene and Pliocene)—Poorly consolidated, generally well-bedded and well-sorted gravel and sand; typically poorly exposed. Clasts of pebbles and cobbles are well rounded. Gravel-clast lithologies indicate a northeast source suggesting drainage of the ancestral Big and Little Wood rivers. Probable braided stream deposits from erosional remnants of an alluvial plain spread across a flat basin-fill of Glenns Ferry Formation. With the exception of clast lithology, deposit is similar to the Tuana Gravel that caps the Glenns Ferry Formation in the adjacent Twin Falls 30′ x 60′ quadrangle (Othberg and Kauffman, 2005; Othberg and others, 2012). Age is younger than the 3.11 Ma upper Glenns Ferry Formation and probably older than about 2 Ma (Othberg and others, 2012). Locally has been excavated as a gravel source.

Tsgf—Glenns Ferry Formation sediments (Pliocene)—Poorly consolidated, bedded lake and stream deposits characterized by several facies and lithologies including silt, sand, clay, and subordinate gravel. See Malde and Powers (1962), Malde and Powers (1972), and Malde (1972; 1991) for detailed descriptions and mappable extent. Exposed only in the southwest corner of the map where the depositional environment was probably near-shore lake and lake-margin fluvial. The formation includes intercalated but laterally discontinuous basalt flows and beds of tephra. Repenning and others (1995) interpret the ages of various localities included in the Glenns Ferry Formation and present a paleogeographic history of Pliocene to early Pleistocene lake and stream deposits in the western Snake River Plain (SRP). The basin-filling contribution of the Glenns Ferry Formation to the western SRP's tectonic subsidence is described by Wood and Clemens (2002). Fossil ages are middle Blancan (Pliocene) in age (Repenning and others, 1995). $^{40}Ar/^{39}Ar$ dates on intercalated basalt range from 3.4 to 3.8 Ma (Hart and Brueseke, 1999). Magnetic polarity confirms the Pliocene age.

Idavada Group

Thsg—Gravel of Hash Spring (Miocene)—Silt, sand, and gravel irregularly overlying Gwin Spring tuff and unconformably overlain by McHan basalt. Thickens and thins, possibly on irregular surface of the tuff and also possibly partly eroded prior to emplacement of the basalt. Maximum thickness is about 60 m (200 feet). Includes a thin sandy interbed between two flows of McHan basalt at one location. Gravels are subangular to well-rounded and include Challis volcanics, granitic, Gwin Spring tuff, and Paleozoic sedimentary rock clasts in a sand and silt matrix. Deposits are typically poorly to moderately sorted. Many of the landslides mapped along the north face of the Mt. Bennett Hills originate in these deposits. Equivalent to Hash Spring Formation of Smith (1966). In upper Black Canyon Creek and Burnt Willow Canyon, may include reworked sediments younger than the City of Rocks tuff eroded from nearby Hash Spring gravel deposits.

Tcd—Diatomite of Clover Creek (Miocene)—Very light gray to white diatomaceous sediments. Locally has pebble to cobble gravel at top beneath younger capping basalt flows. Oakley (2006, p. 39) reports "…coarse- and fine-grained fluvial siliciclastic layers and lenses, fine-grained lacustrine deposits with diatoms, limestone pods and lenses, and beds of volcanic shards." Maximum thickness is about 120 m (400 feet). Forms an angular unconformity with underlying McHan basalt and pinches out northward. The unit was deeply eroded prior to emplacement of the overlying City of Rocks tuff. Where not covered by the tuff, the unit is capped by flows of the basalt of Burnt Willow. The unit has been prospected for diatomaceous earth, although none of the prospects showed evidence of recent activity.

Tpcg—Gravel of Pole Corral (Miocene)—Poorly sorted, angular to subrounded pebbles and cobbles in a mostly coarse granitic sand matrix. Underlies the tuff of Gwin Springs along the north face of the Mt. Bennett Hills; base and underlying units are not exposed. Locally may overlie the Fir Grove tuff. Pebble to cobble clasts are composed mostly of granitic rock and subordinate Challis volcanics fragments. Equivalent to Pole Corral gravel of Smith (1966). In places, the tuff of Gwin Springs may be absent and this gravel unit may be continuous with the Hash Springs gravel unit. There was likely continuous erosion of the basement highlands to the north and west, and south-flowing streams deposited sediments as the volcanic units were being emplaced, probably from the south.

Sediments of Uncertain Affiliation

QTs—Alluvial sediments of Camas Prairie basin (Pleistocene to Pliocene)—Shown in cross section only. Alternating thin to thick beds of clay, sand, and gravel described in water well logs. Clay beds may be lacustrine. Total thickness exceeds 144 m (474 feet).

Ts—Sediments, undivided (Pliocene and Miocene)—Primarily alluvium of highly variable grain size ranging from silt to cobble gravel. Beds of sand and pebble-cobble gravel common in the Bennett Hills where sediments are interbedded with or overlie late Miocene to Pliocene flows of the basalt of Burnt Willow (stratigraphic equivalents of the Hash Spring and Pole Corral gravels in the McHan Reservoir 7.5′ quadrangle), or lie between Miocene basalt and tuff units. In the eastern part of the quadrangle, mostly coarse sand and pebble to cobble gravel with some fine-grained sediment and volcanic ash-rich beds. Occurs both beneath and on Picabo tuff. Where it underlies the tuff, contains mostly well-rounded pebbles derived from older rocks (*Tcv*, *Kgdh*, or *PIPs*). Sediments above the tuff contain similar well-rounded pebbles and cobbles, but also include clasts of the tuff. Stratigraphic position is commonly uncertain and the units are discontinuous and possibly faulted. Some of the younger gravels may be reworked from the older ones. Poorly exposed, but commonly forms sandy to pebbly colluvium in the soils. These sediments were likely deposited in response to displacement and repositioning of paleostreams by the eruption of the tuffs.

MASS MOVEMENT DEPOSITS

Qlsa—Deposits of active landslides (Holocene)—Slumps and slides that have been active within the last several decades.

Qls—Landslide deposits (Holocene and Pleistocene)—Unsorted and unstratified angular cobbles and boulders mixed with silt and clay. Deposited by slumps, slides, and debris flows.

Qc—Colluvium (Holocene and Pleistocene)—Primarily unsorted and unstratified silty to clayey sand and gravelly sand with few to common boulders. Forms foot slopes of large, steep escarpments stabilized by vegetation. Deposited by sheet wash, creep, and rock fall. Mostly relic judging by well-developed soils.

GLACIAL DEPOSITS

Qalc—Fine-grained deposits in glaciated uplands (Holocene and Late Pleistocene)—Silt and sand deposited in closed depressions of cirques and glaciated valleys.

Qmg—Mass movement and glacial deposits undifferentiated (Holocene and Late Pleistocene)—Angular unsorted to poorly sorted boulder gravel. Forms protalus ramparts and slumps derived from moraine remnants and frost-wedged debris on high, glaciated valley walls. Includes some alluvial-fan gravel, and Holocene glacial and periglacial deposits.

Qgo—Outwash gravels of last local glacial maximum (Late Pleistocene)—Subrounded to rounded, well-sorted sandy cobble and boulder gravel. Late Pinedale glaciation equivalent.

Qgt—Till deposits of last local glacial maximum (Late Pleistocene)—Poorly sorted clayey to sandy boulder till. Clasts subangular to subrounded. Forms moraines. Late Pinedale glaciation equivalent.

VOLCANIC ROCKS

Snake River Group

The relative ages of some Quaternary basalt units are uncertain because they are either not in direct contact or their contacts are obscured and subdued by soils. We present the units in the order we believe best approximates their relative ages, from youngest to oldest, based on geomorphological characteristics.

Qblb—Basalt of Black Butte Crater (Pleistocene)—Fine-grained, dark gray, glassy basalt with common to abundant olivine as individual grains and clots as large as 1-2 mm, and abundant small plagioclase crystals 0.5-1 mm that give the basalt a sparkly character in sunlight; diktytaxitic and vesicular; vesicles circular to irregular and tubular. Minor carbonate lining in some voids. Remanent magnetic polarity is normal, as determined in the field and in the laboratory. Source is Black Butte Crater shield volcano. Probably consists of several flow units or lobes. Youthful surface characterized by very irregular topography of pressure ridges and collapse features. Rough aa surfaces common near the vent; pahoehoe surfaces elsewhere. These flows host the tourist attraction of Shoshone Ice Caves. Surficial deposits are mostly restricted to relict stream channels where transported sand and pebbly sand accumulated as thin deposits; vegetation restricted to sagebrush and scattered grass. Equivalent to Ql (lava flows) of Malde and others (1963), and to Shoshone flow of Cooke (1999) and of Kuntz and others (1986) who reported a radiocarbon age of 10,130 ± 350 years B.P. from charred sediment at base of the lava flow. Calibrated age is 11,744 ± 5011 (Stuiver and Reimer, 2005).

Qmk—Basalt of McKinney Butte (Pleistocene)—Dark gray, coarse-textured basalt with very abundant plagioclase phenocrysts as crisscrossed interlocking crystals as large as 1 cm, or as glomerocrysts, commonly with olivine grains and clots; groundmass is fine grained. Voids are common among the interlocking crystals. Equivalent to McKinney Basalt of Malde and Powers (1972). Remanent magnetic polarity is normal (Malde, 1971). Source is McKinney Butte. Surface is characterized by youthful flow features, such as lava channels and tubes, collapse pits, and pressure ridges. Tauxe and others (2004) report an $^{40}Ar/^{39}Ar$ weighted mean plateau age of 0.052 Ma for this unit (their sample sr16, McKinney Basalt).

Qllb—Basalt of Lye Lake (Pleistocene)—Dark gray, fine-grained basalt with abundant plagioclase crystals 1-3 mm and fresh olivine grains and clots as large as 2 mm; scattered glomerocrysts of plagioclase and olivine as large as 8 mm. Lye Lake is the source vent; spatter and agglutinate rim the circular lake, which is a small lake in the Clover Creek flood plain in the southwest corner of the map. The small-volume flow terminates about 4 km (2.5 miles) west of the lake in the Clover Creek valley. Pressure ridges and collapse features indicate a relatively young event, possibly related to the McKinney Butte eruption.

Qnb—Basalt of Notch Butte (Pleistocene)—Fine-grained, dark gray basalt with common to abundant olivine as individual grains 1-2 mm and clots as large as 3 mm, and abundant small plagioclase crystals 0.5-1 mm that give the basalt a felty texture. Moderately to very vesicular and diktytaxitic. Vent is 13 km (8 miles) south of the map along State Highway 75/US 93 in the adjoining Twin Falls quadrangle.

Qsch—Basalt of Schooler Creek (Pleistocene)—Fine-grained, dark gray, vesicular to diktytaxitic basalt with a microfelty texture of small placioclase crystals and scattered to abundant fresh olivine grains <1-4 mm. Remanent magnetic polarity normal, as determined in the field. Shallow circular depression near the junction of State Highway 46 and Thorn Creek Reservoir Road is likely the source. Flowed south down Schooler Creek drainage and extends well beyond the south edge of the map. Stream drainage is moderately well developed. Remnants of pressure ridges and variations in soil characteristics form a pattern of mounds visible on air photos. The mounds are composed of silty clay 1.2-1.8 m (4-6 feet) thick that buries a well-developed soil caliche (duripan). Between mounds, the basalt is at or near of the surface. Some of *Qbu* unit may be from this source.

Qbu—Basalt flows, undivided (Pleistocene)—Basalt flows and vent materials from undetermined sources. Age uncertain. Northwest of Mormon Reservoir unit includes dark gray, vesicular, diktytaxitic olivine-bearing basalt flows; some flows plagioclase phyric. Remanent magnetic polarity of flows examined there is normal, as determined in the field. Also includes basalt flows at the southern edge of the map that may include basalt of Schooler Creek (*Qsch*), but may also include flows from the south. Thickness not determined. Most of the surface there is farmed and covered with thin to thick soils. Also includes basalt flows from several unnamed buttes southeast of Magic Reservoir. An $^{40}Ar/^{39}Ar$ date on a sample from one of the flows has a plateau age of 0.98 ± 0.27 Ma and an inverse isochron age of 0.79 ± 0.29 Ma (R.P. Esser, written commun., 2005). Remnant magnetic polarity of this sample was normal, as determined in the field.

Qbc—Basalt of Carey (Pleistocene)—Medium to dark gray pahoehoe basalt-hawaiite flows (Kuntz, 2007). Rock is hypocrystalline, medium to fine grained (mostly <0.2 mm), diktytaxitic, and microporphyritic (Kuntz, 2007). In typical samples, crystals of euhedral olivine (about $Fa_{40–50}$), laths of plagioclase ($An_{40–50}$), and equant, skeletal magnetite are as large as 0.8 mm (Kuntz, 2007). Phenocrysts are set in a matrix of same minerals plus feathery, bladed ilmenite, blades and patches of spindly, subophitic clinopyroxene, and granules of equant magnetite, all 0.05–0.2 mm, and opaque-charged, brown glass (Kuntz, 2007). Equivalent to Kuntz's (2007) $Qcfg_2$ unit (Carey pahoehoe and slab-pahoehoe basalt-hawaiite flows). Carey is 6.4 km (4 miles) beyond the east edge of the map on US20 in the adjoining Craters of the Moon 30′ x 60′ quadrangle.

Qdrb—Basalt of Darrah Reservoir (Pleistocene)—Fine to medium grained basalt with phenocrysts of plagioclase 2-4 mm long, olivine grains about 1 mm in diameter, and glomerocrysts of plagioclase and olivine 5-10 mm in diameter. Remanent magnetic polarity is normal, as determined in the field. Originates from a vent in sec. 31, T. 2 S, R. 17 E near the center of the map and close to the boundary of Camas and Lincoln counties. Smoother surfaces have clayey, stony soils generally less than 0.6 m (2 feet) thick.

Qbrc—Basalt of Black Ridge Crater (Pleistocene)—Fine-grained, aphyric to olivine-phyric basalt (Cooke and others, 2006). Glomerocrysts of plagioclase and olivine are present in some samples. Remanent magnetic polarity not determined. Possibly erupted from small, unnamed shield volcano located about 1.6 km (1 mile) south of Richfield. Flow surface retains youthful features such as pressure ridges, flow fronts, collapsed lava tubes, lava channels, and thin soil restricted to isolated low areas.

Qpdb—Basalt of Picabo Desert (Pleistocene)—Medium-grained basalt with scattered small plagioclase phenocrysts 2-4 mm in length and olivine grains 0.5-2 mm; occasionally glomerophyric with intergrowths of plagioclase and olivine as large as 8 mm; vesicular. Remanent magnetic polarity is normal, as determined in the field. Erupted from vents 3.2 km (2 miles) south of Picabo. Surface morphology characterized by pressure ridges, collapsed pits, and absence of stream drainage; some flat areas are covered with loess as much as 2 m (6 feet) thick. Cinders on the west flank of the vent were quarried for road material. An $^{40}Ar/^{39}Ar$ date on a sample from the vent gave a plateau age of 0.46 ± 0.11 Ma (R.P. Esser, written commun., 2005). Formerly named the Priest member of the Bellevue basalt by Schmidt (1961) for a now-abandoned railroad siding.

Qpcb—Basalt of Portuguese Creek (Pleistocene)—Undescribed basalt, subdivided based on geomorphic expression.

Qslb—Basalt of Sheep Lake (Pleistocene)—Dark gray, fine-grained basalt with abundant glomerocrysts of plagioclase and olivine. Individual plagioclase phenocrysts 2-5 mm in length and olivine grains up to 1 mm are common. Reverse remanent magnetic polarity, as determined in the field. Source probably near Sheep Lake. Major oxide and trace element chemistry indistinguishable from basalt of Buckbrush Reservoir (*Qbrb*) and basalt of Lone Rock Reservoir (*Qlrb*).

Qbrb—Basalt of Buckbrush Reservoir (Pleistocene)—Fine-grained, dark gray vesicular basalt with scattered plagioclase laths 1-3 mm in length and plagioclase clusters as large as 1 cm. Remanent magnetic polarity reverse, as determined in the field. Calcium carbonate coating or filling in some vesicles. Overlies *Trd* unit in a small area 8 km (5 miles) southwest of Magic Dam. Spatter and agglutinate on a small knoll indicate possible vent. Maximum thickness is about 164 m (50 feet). Major oxide and trace element chemistry indistinguishable from basalt of Sheep Lake (*Qslb)* and basalt of Lone Rock Reservoir (*Qlrb*).

Qbcr—Basalt of Campbell Reservoir (Pleistocene)—Medium gray, intracanyon, pahoehoe basalt flows (Kuntz, 2007). Vent area unknown. Flows fill broad, low area near Campbell Reservoir, Muldoon Creek, and Little Wood River valley. Kuntz (2007) reports a K-Ar age of 433±78 ka. Equivalent to Kuntz's (2007) $Qsbd_1$ unit (Basaltic pahoehoe flows of Campbell Reservoir–South Fork Muldoon Creek area).

Qmc—Basalt of Mammoth Cave (Pleistocene)—Coarse-grained basalt with abundant plagioclase laths 5-7 mm long and common to abundant olivine grains and clots. Source is unnamed butte located 7.5 km (4.7

miles) northwest of Kinzie Butte and 6 km (3.7 miles) southwest of Shoshone Ice Cave. Remanent magnetic polarity is normal, as determined in the field. Between pressure ridges loess is 0.6-1.8 m (2-6 feet) thick and includes a well-developed soil caliche (duripan). Variations in soil characteristics and vegetation form a patterned ground between pressure ridges which is visible on aerial photographs. Included in Qlo unit (older lava flows) by Malde and others (1963). Flows of this basalt host the tourist attraction of Mammoth Cave.

Qhay—Basalt of Hay (Pleistocene)—Fine- to medium-grained, medium to dark gray basalt with common plagioclase phenocrysts 1-3 mm; olivine mostly as individual grains in groundmass; diktytaxitic and vesicular. Breckenridge and others (2003) report an $^{40}Ar/^{39}Ar$ age of 0.515 ± 0.063 Ma. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Discontinuously covered with loess as much as 2 m (6 feet) thick.

Qmbb—Basalt of Monument Butte (Pleistocene)—Surface-, channel-, and tube-fed, dark gray to medium gray, pahoehoe basalt flows, and shelly-pahoehoe flows (Kuntz, 2007). Rock examined is relatively coarse, containing phenocrysts of plagioclase ≤ 2.5 mm and euhedral to subhedral, mostly equant olivine that are ≤ 1.5 mm (Kuntz, 2007). Cumulophyric clots of as many as 5 olivine crystals ≤ 1.75 mm and as many as 10 plagioclase crystals ≤ 2.5 mm are common, as is waist texture. Matrix is olivine and plagioclase crystals ≤ 0.5 mm, and elongated, intergranular crystals of clinopyroxene ≤ 0.25 mm (Kuntz, 2007). Elongated crystals of ilmenite ≤ 0.15 mm exceed equant crystals of magnetite ≤ 0.25 mm in volume. Flows are mantled by loess and eolian sand ≤ 1 m (Kuntz, 2007). Equivalent to Kuntz's (2007) $Qsbb_9$ unit (Basaltic pahoehoe flows and near-vent pyroclastic deposits of Monument Butte lava field). Monument Butte is 11.3 km (7 miles) northeast of Pagari in the adjoining Craters of the Moon 30′ x 60′ quadrangle.

Qcrb—Basalt of Crater Reservoir (Pleistocene)—Medium- to coarse-grained basalt with abundant phenocrysts of placioclase and olivine. Normal remanent magnetic polarity, as determined in the field. Source is the small butte marked with elevation "1709" that is 8 km (5 miles) east of Thorn Creek Reservoir. Vesicular, frothy, crudely layered agglutinate(?) on northeast side of summit crater; blocky basalt mounds on south rim.

Qsfb—Basalt of Sonners Flat (Pleistocene)—Fine- to medium-grained, dense to coarsely diktytaxitic, plagioclase-phyric, olivine basalt flows. Some flows have interlocking plagioclase phenocrysts 5-7 mm in length and scattered small olivine crystals. Other flows are finer grained with glomerocrysts of plagioclase and olivine as large as 1 cm. Some olivine is altered to amber iddingsite. Remanent magnetic polarity is normal, as determined in the field. Probably erupted from ridge extending north from Wedge Butte, although spatter and other vent-related deposits were not found. Interpreted to have flowed through the narrow gap on Dinosaur Ridge and probably surrounded the rhyolite dome that forms the south end of the ridge. Stream drainage is moderately well developed. Basalt surface covered by loess up to 1.8 m (6 feet) thick and includes a well-developed soil caliche (duripan). Variations in soil characteristics and vegetation form a patterned ground visible on aerial photographs.

Qphb—Basalt of southern Picabo Hills (Pleistocene)— Medium gray, fine- to medium grained basalt flow with scattered small plagioclase phenocrysts 3-7 mm in length and olivine grains 0.5-2 mm. Remnant magnetic polarity of this unit was normal, as determined in the field. Probably erupted from a vent located at the northernmost exposure of the unit.

Qkb—Basalt of Kinzie Butte (Pleistocene)—Fine- to medium-grained basalt with scattered olivine clots 2-4 mm and clusters of intergrown plagioclase and olivine crystals as large as 1.5 cm. Source is Kinzie Butte. Remanent magnetic polarity as determined in the field inconclusive but probably normal. Almost no pressure ridges remain and stream drainage is well developed. Basalt outcrops are common only in the upper areas of the butte where loess and soil is 0.3-0.6 m (1-2 feet) thick. Loess has accumulated to more than 1.5 m (5 feet) thick on lower slopes of the butte where variations in soil characteristics and vegetation form a patterned ground visible on aerial photographs. Included in Qbb (basalt flows of the Bruneau Formation) by Malde and others (1963).

Qlrb—Basalt of Lone Rock Reservoir (Pleistocene)—Fine-grained basalt with rare to common glomerocrysts of plagioclase and olivine as large as 1 cm. Reverse magnetic polarity, as determined in the laboratory. An $^{40}Ar/^{39}Ar$ date on the spillway flow resulted in a plateau age of 0.59 ± 0.19 Ma and an inverse isochron age of

0.79 ± 0.16 Ma (R.P. Esser, written commun., 2005), which places the unit in the Matayuma Reverse Polarity Chron. Linear scarp features cutting this unit may be collapsed areas resulting from deflation as lava drained away; they do not appear to be fault scarps resulting from tectonic activity. Stream drainage is moderately well developed. Basalt surface covered by loess 0.6-1.8 m (2-6 feet) thick and includes a well-developed soil caliche (duripan). Variations in soil characteristics and vegetation form a patterned ground visible on aerial photographs. Vent is 4.7 km (2.9 miles) southwest of Magic Dam.

Qbp—Basalt of Pothole (Pleistocene)—Dark gray, fine-grained, vesicular, diktytaxitic olivine-bearing basalt erupted from The Pothole. The vent and associated flows are cut by a west-northwest-trending scarp; maximum offset is about 25 m (70 feet), down to the north. Part of the scarp crosses the southeast corner of the map. Remanent magnetic polarity normal (Oakley, 2006). Some basalt mapped as *Qbu* may also be from this source. Equivalent to basalt of Pothole of Oakley (2006).

Qtgl—Basalt of Tom Gooding Lake (Pleistocene)—Very coarse-grained basalt where examined on the east rim of the butte. Consists of an open network of interlocking plagioclase crystals 4-8 mm long and common altered or weathered olivine grains interspersed in the plagioclase. Remanent magnetic polarity is normal, as determined in the field. Forms 1-2 m (3.3-6.6 feet) diameter columns on the butte rim, but otherwise is poorly exposed because of soil cover. Source is the butte containing Tom Gooding Lake. Flows abutted *Trd* unit to the north and east, and flowed around several *Trd* ridges on the east and south flanks of the butte. Appears to be geomorphically older than Crater Reservoir and Darrah Reservoir basalts. Stream drainage is moderately well developed. Basalt surface mostly covered by thin loess locally as much as 1.8 m (6 feet) thick and includes a well-developed soil caliche (duripan). Variations in soil characteristics and vegetation form a patterned ground visible on aerial photographs.

Qjb—Basalt of Johnson Butte (Pleistocene)—Fine to medium grained with abundant plagioclase and olivine phenocrysts, commonly as clusters and intergrowths. Of six samples at two locations checked in the field for remanent magnetic polarity, five gave strong normal readings; the sixth gave strong reverse. Pressure ridges are still visible in many areas. Stream drainage is moderately well developed. Between pressure ridges loess is 0.6-1.6 m (2-6 feet) thick and soil caliche (duripan) is commonly well developed. Outside of farmed areas, variations in soil characteristics and vegetation form a patterned ground visible on aerial photographs. Included in Qbb (basalt flows of the Bruneau Formation) by Malde and others (1963).

Qmab—Basalt of Macon (Pleistocene)—Fine- to medium-grained basalt with scattered plagioclase phenocrysts 2-3 mm long and uncommon olivine <1 mm in diameter. Diktytaxitic and vesicular. Most vesicle walls coated with calcium carbonate. Remanent magnetic polarity normal, as measured in the field and the laboratory. Scarps in this basalt are likely extensional fractures related to late-stage development of the Camas Prairie. An $^{40}Ar/^{39}Ar$ date on this basalt resulted in a weighted mean plateau age of 1.45 ± 0.16 and an inverse isochron age of 1.25 ± 0.36 (R.P. Esser, written commun., 2005). Pressure ridges are common and stream drainage is poorly developed. Soils are thin to absent except between pressure ridges where 0.6 m (2 feet) of silt and clay overlie a silica-rich hardpan (duripan). Variations in soil characteristics and vegetation form a patterned ground visible on aerial photographs, including east-west elongate bands of thin dune sand.

Qdb—Basalt of Duro Butte (Pleistocene)—Undescribed basalt east of Richfield in the southeast part of map. Subdivided based on geomorphic expression.

Qrcb—Basalt of Richfield Canal (Pleistocene)—Basalt flows from one of several unnamed buttes southeast of Magic Reservoir. Flows examined are fine to medium grained with scattered small plagioclase phenocrysts 2-10 mm in length. Glomerophyric with intergrowths of plagioclase and olivine as large as 1 cm.

Qwrb—Basalt of Wind Ridge (Pleistocene)—Fine-grained basalt with common glomerocrysts of weathered, eroded plagioclase and olivine as large as 7 mm; olivine altered to purplish iddingsite. Fresh surfaces have a faint purplish hue. In the field, magnetic polarity was strong and very sensitive to inclination of the sample; a sample collected at the “Sheep Bridge” location, 2.5 km (1.6 miles) east of Hot Springs Landing, was reverse polarity as measured in the laboratory. In places the flow deflects a compass needle. Source is a vent about 1 mile southwest of Ditto Hill. Cinders and welded spatter occur near the vent. Spatter fragments and basalt near the vent have abundant xenocrysts of plagioclase and quartz, and some granitic xenoliths. Thickens westward from about 98 m (30 feet) near Ditto Hill to at least 230 m (70 feet) thick at Sheep Bridge where the base is not exposed. Thickening is probably due to irregularities in the preflow topography. Stream drainage is moderately well developed. Basalt surface covered by silt and clay (loess?) 0.6-1.2 m (2-4 feet) thick and includes a well-developed soil caliche (duripan). Variations in soil characteristics and vegetation form a patterned ground visible on aerial photographs. Formerly divided into "upper" and "lower" units by Schmidt (1961), and Struhsacker and others (1982) report three flows. However, we could find no conclusive evidence of separate flows, although there do appear to be several internal vesicular zones in the outcrop at Sheep Bridge. An $^{40}Ar/^{39}Ar$ date on the flow just west of Ditto Hill (Schmidt's upper flow) resulted in a plateau age of 1.54 ± 0.13 Ma and an inverse isochron age of 1.48 ± 0.22 Ma (R.P. Esser, written commun., 2005). For the flow at Sheep Bridge (Schmidt′s lower flow), an $^{40}Ar/^{39}Ar$ date resulted a plateau age of 1.17 ± 0.21 Ma and an inverse isochron age of 1.06 ± 0.19 Ma (R.P. Esser, written commun., 2005). Chemical composition of samples from the "upper" unit near Ditto Hill and the "lower"unit at Sheep Bridge is indistinguishable.

Idaho Group

Tigu—Idaho Group, undivided (Pliocene and Miocene)—This unit is shown in cross section only, includes *Tbcc*, *Tsgf*, *Ts*, and *Tbwu*.

Tbp—Basalt of Bliss Point (Pliocene)—Gray to gray-brown, fine-grained, aphyric to slightly plagioclase-phyric basalt within the upper Glenns Ferry Formation sediments. Exposed locally in the southwest corner of the map where it consists of one flow 15 m (50 feet) or less thick that thins and pinches out. Field magnetometer gave conflicting normal and reverse polarity readings from the same outcrop, but polarity is probably reverse. Mapped as Shoestring basalt by Malde and Powers (1972). Hart and Brueseke (1999) dated the Shoestring basalt at 3.68 Ma. In the adjoining Twin Falls 30′ x 60′ quadrangle, chemical composition of the Bliss Point basalt was indistinguishable from that of the Shoestring basalt and is likely the same unit (Othberg and others, 2012).

Tbbf—Basalt of Burgess Flat (Pliocene)—Dark gray to medium gray, intracanyon, pahoehoe basalt flows along Little Wood River (Kuntz, 2007). Source vents unknown, may be in Snake River Plain. Kuntz (2007) reports a K-Ar age of 3.55 ± 0.13 Ma. Equivalent to Kuntz's (2007) $Tsbf_1$ unit (Basaltic pahoehoe flows of upper Little Wood River and South Fork Muldoon Creek areas).

Tcbb—Basalt of Clay Bank Hills (Pliocene)—Fine- to medium-grained, fine- to coarse-textured basalt; texture results from abundant plagioclase phenocrysts 2-5 mm in length. Flow south of Rattlesnake Butte is fine grained and essentially aphyric. Olivine occurs in the groundmass and is altered to amber to purplish iddingsite(?). Laboratory determination of remanent magnetic polarity of the unit on the ridge above Magic City was normal; field determination on the unit south of Rattlesnake Butte gave conflicting readings. Maximum thickness is about 61 m (200 feet). Equivalent to the Clay Bank basalt of Schmidt (1961) and other previous workers. Flows north of Rattlesnake Butte are cut by west-northwest-trending down-to-the-north block faults that dip 5-7 degrees to the south. The faults predate the basalt of Sonners Flat, which is not disrupted. An $^{40}Ar/^{39}Ar$ date from the flow on the ridge above Magic City resulted in a plateau age of 4.2 ± 1.3 Ma and an inverse isochron age of 3.8 ± 1.6 Ma (R.P. Esser, written commun., 2005).

Tthb—Basalt of Turkey Head Butte (Pliocene?)—Plagioclase-phyric basalt at Turkey Head Butte, a probable vent. Age uncertain, but older than *Qsch* and most likely Pliocene. Some of *Tbu* basalt may be from this butte.

Basalt flows of Burnt Willow area

Smith (1966) used the name "Burnt Willow Basalt" for a series of flows on the south flank of the eastern Mount Bennett hills that unconformably overlie and pinch out northward against older tuffs and sediments. Previous mapping in the Fairfield and McHan Reservoir 7.5′ quadrangles (Othberg and Kauffman, 2010; Kauffman and others, 2010), and from our unpublished mapping, we divided Smith's Burnt Willow Basalt into several units on the basis of both physical characteristics and chemical composition. Age is constrained by the older 8.2 Ma City of Rocks tuff (William Leeman, written commun., 2012) and the younger 3-4.5 Ma Glenns Ferry Formation (Hart and Brueseke, 1999). To the east, the Square Mountain andesite, which is about 3.8 Ma

(William Leeman, written commun., 2012), occupies the same capping stratigraphic position as the Burnt Willow basalts, although they may not be coeval. We believe the Burnt Willow basalts were erupted over an extended period of time following significant erosion on the City of Rocks tuff and older units. We therefore estimate the basalts are about 3.8 to 6 Ma, or late Miocene to Pliocene.

Tbcc—Basalt of Black Canyon Creek (Pliocene to late Miocene)—Dark gray, plagioclase- and olivine-phyric basalt. Plagioclase phenocrysts are typically 2-5 mm in length. Glomerocrysts of plagioclase and olivine are as large as 1 cm. Thickness varies from less than 3 m (10 feet) to at least 30 m (100 feet). Age uncertain. Remanent magnetic polarity inconsistent in the field, but likely reverse for at least one flow. Named for flows in Black Canyon Creek (Kauffman, 2012). Composition characterized by moderate to high TiO_2 (2.6-3.3 wt. percent), moderate Al_2O_3 (>15.0-16.5 wt. percent), and high P_2O_5 (~0.5-0.7 wt. percent); differences in composition may reflect separate flows. Faulted down-to-the-northeast along northwest-trending faults in the vicinity of Mormon Reservoir. Tilted 3-8 degrees to the southwest. Overlies Tertiary granite (*Tg*) or local Fir Grove tuff remnants (*Tfg*). Source not determined. Unconformably overlain by Quaternary basalt (*Qbu)* west of Mormon Reservoir. Previously mapped by Smith (1966) as part of Burnt Willow basalt. Variations in soil characteristics form a pattern of mounds visible on air photos, but the patterned ground is less well developed compared to that formed on *Tsma*.

Tccb—Basalt of Catchall Creek (Pliocene to late Miocene)—Dark gray, plagioclase and olivine phyric, coarse-textured basalt with a glassy groundmass. Plagioclase phenocrysts typically 2-5 mm long; olivine occurs as grains and clots, commonly with plagioclase. Remanent magnetic polarity normal, as determined in the field. Named for exposures in the upper Catchall Creek. Composition characterized by high Al_2O_3 (~18.0 wt. percent), and low TiO_2 (~1.1 wt. percent), FeO* (~10.0-11.0 wt. percent), P_2O_5 (~0.13 wt. percent), and Zr (60-70 ppm).

Tbwu—Basalt of Burnt Willow, undivided (Pliocene to late Miocene)—Dark gray, sparsely phyric to plagioclase and olivine-phyric basalt flows that occupy similar stratigraphic positions on the south flank of the Mount Bennett Hills. The flows unconformably overlie older Miocene units and dip gently southward toward the Snake River Plain. Flows are commonly separated by southward-thickening sediments, suggesting the plain was actively subsiding during flow emplacement. The flows and sediments dip beneath the more flat-lying Glenns Ferry sediments in the southwest corner of the map. Varying chemical compositions and remanent magnetic polarities indicate they were probably erupted from multiple sources over an extended time period. Source areas uncertain, but probably erupted to the north, possibly along east-west- to northwest-trending structures.

Tbw—Basalt of Burnt Willow Canyon (Miocene)—Moderately to abundantly olivine-phyric basalt. Olivine is typically altered to amber or maroon and commonly occurs as irregular 3-8 mm clots. Physically and chemically distinct from plagioclase-rich basalt of unnamed vent (*Tbuv*) and Black Canyon Creek basalt (*Tbcc*). Characterized by low TiO_2 (~1.2 wt. %), FeO* (~10 wt. %), and P_2O_5 (<0.13 wt. %), and high MgO (>8.5 wt. %), CaO (>12.5 wt. %), and Cr (~500 ppm). Remanent magnetic polarity is reverse, as determined in the field; samples checked gave consistent moderate to strong reverse polarity readings. Source uncertain, but may have erupted along an east-west-trending fault west of Schooler Creek. Caps McHan basalt and City of Rocks tuff. Thickness varies but typically less than 15 m (50 feet). Thickens and thins locally on City of Rocks tuff, where it forms rim rock from Schooler Creek to Burnt Willow Canyon. Age uncertain but probably younger than *Tbuv* unit. Previously included in Burnt Willow basalt by Smith (1966). Stream drainage is moderately well developed. Clay-rich cobbly soils bury a well-developed soil caliche (duripan) formed on basalt. Variations in soil characteristics form a pattern of mounds visible on air photos, but the patterned ground is less well developed compared to that formed on *Tsma.*

Tbuv—Basalt of unnamed vent (Miocene)—Moderately to abundantly plagioclase-phyric basalt. Similar in appearance to Black Canyon Creek basalt and McHan basalt, but chemically distinct. Characterized by high FeO* (~18 wt %) and low SiO_2 (~45 wt %). Remanent magnetic polarity is probably reverse, although many polarity tests were inconclusive in the field. Strongly magnetic and commonly deflects a compass needle. Overlies City of Rocks tuff, Hash Spring sediments, or Gwin Spring tuff north of Burnt Willow Canyon. Source is an unnamed vent in secs. 7 and 8, T. 3 S., R. 15 E. Previously included in Burnt Willow basalt by Smith (1966).

Volcanic Rocks of Magic Reservoir Area

Trbt—Tuff of Rattlesnake Butte (Pliocene?)—Light gray to light pinkish gray rhyolite tuff(?) with scattered phenocrysts of quartz, plagioclase, and sanidine, and a few mafic crystals (hornblende?) with weathered rinds. Layering (flow layering or compaction foliation?) of cliff-forming outcrop on top of Rattlesnake Butte strikes N15°W and dips 30°W. Source unknown; possibly an extrusive unit related to rhyolite of Wedge Butte. Previously included in the Moonstone rhyolite (Schmidt,1961; Leeman, 1982) or the young domes unit (Honjo, 1986). Honjo and others (1986) obtained a K-Ar date of 2.92 ± 0.04 Ma for this unit. However, it appears that the basalt of Clay Bank Hills, which as noted below has an age of about 4.0 Ma, abuts and flanks the north and east sides of Rattlesnake Butte and therefore should be younger than the tuff. Alternatively, the unit may have been extruded through the basalt. The dates support the latter alternative. An area on the north and east flank of the butte was previously mapped as Poison Creek tuff by Schmidt (1961). Pumice fragments in the overburden are weathered light orangish-brown and resemble pumice from the Poison Creek tuff unit at the north end of Magic Reservoir. However, fresh surfaces of fragments are feathery light gray pumice with phenocrysts of quartz and sanidine, as well as minor hornblende, which resembles the tuff of Rattlesnake Butte unit (*Trbt*). A sample of the pumice fragments has chemical composition very similar to the tuff of Rattlesnake Butte and different than that of the Poison Creek tuff. We conclude, therefore, that the fragments were eroded from a pumice layer in the tuff of Rattlesnake Butte. Most fragments are subangular to subrounded and at one location overlie the basalt of Clay Bank Hills.

Twbr—Rhyolite of Wedge Butte (Pliocene?)—Pinkish gray rhyolite with abundant phenocrysts of quartz, sanidine, and plagioclase. This phenocryst abundance gives the rock a coarse-grained, granitic appearance, both in hand sample and outcrop. Previously included in Moonstone rhyolite unit (Schmidt, 1961; Leeman, 1982) or the young domes unit (Honjo, 1986). Armstrong and others (1975) report an average K-Ar date (two feldspar separates) of 3.06 ± 0.04 Ma from Wedge Butte. Honjo and others (1986) obtained a K-Ar date of 3.29 ± 0.05 Ma on the dome 3.2 km (2 miles) southwest of Wedge Butte. All of these buttes are surrounded by Quaternary basalt flows. As with the tuff of Rattlesnake Butte, stratigraphic relationship of these domes to the basalt of Clay Bank Hills is unclear, but based on the dates, the domes are younger. The dome southwest of Wedge Butte has pronounced vertical radial joints that weather to form concentric ridges, which are particularly well developed on the west side. Wedge Butte has similar jointing, although less well developed. Flanks of all of the rhyolite domes have thin to thick cover of colluvial debris, generally granular fragments or grus.

Tsma—Andesite of Square Mountain (Pliocene)—Fine-grained andesitic unit with plagioclase phenocrysts and locally common quartz and plagioclase xenocrysts; also contains a few granitic or rhyolitic xenoliths. Maximum thickness is about 100 feet. Remanent magnetic polarity inconclusive, but probably reverse; both normal and reverse readings were obtained in the field. Commonly has curving, platy jointed zone 5-20 feet thick below a stocky, crudely columnar top that is generally less than 20 feet thick. The top weathers into large subrounded blocks as much as 3-6 feet in diameter. Samples plot in the upper part of the andesite field on the total alkali-silica diagram of LeMaitre (1984). Chemical composition for several samples we collected is nearly identical to that of the Square Mountain ferrolatite reported in Honjo (1986) and Honjo and Leeman (1987), and we consider these to be equivalent units. Forms fault-block ridge and valley topography on which soils are thin to absent. Foot slopes and narrow valleys have a thin cover of colluvium and sheet wash composed of gravelly silty sand. A distinctive patterned ground characterizes the unit's gently sloping surface. The pattern of circular to elongate mounds of silty clay separated by gravelly zones is readily visible on aerial imagery. The features are identical to those described by Malde (1964) and are remnants of frost sorting and solifluction processes active in the Pleistocene.

Tmmr—Rhyolite of Moonstone Mountain (Pliocene)—Light gray to pinkish gray, coarse-textured rhyolite that forms much of Moonstone Mountain. Abundant phenocrysts of sanidine, quartz, and plagioclase, with minor mafic accessory minerals. Phenocrysts range in size from 2 mm to 1 cm. Interpreted as an endogenous dome by Schmidt (1961). Some concentric radial jointing noted on aerial photographs. Honjo and others (1986) report sanidine K-Ar ages from rhyolite at two locations on Moonstone Mountain as 3.38 ± 0.06 Ma and 3.02 ± 0.04 Ma, indicating the possibility of several episodes of dome building. Stratigraphic ambiguities with *Tsma*, as well as textural differences at several localities, also indicate the possibility of several episodes, one (or more) possibly older than *Tsma* and another younger. Soils are thin to absent on Moonstone Mountain except on the foot slopes where more than 5 feet of gravelly and sandy colluvium and sheet wash bury the rhyolite.

Tpct—Tuff of Poison Creek (Pliocene to Miocene)—In the vicinity of Hot Springs Landing, this unit consists of rhyolite tuff of varying texture that probably consists of several units, as reported by Struhsacker and others (1982). They describe three tuff units, which they name "rhyolite ash-flow tuffs of Magic Reservoir", and an associated rhyolite dome. Schmidt (1961) named these ash flows the "Poison Creek tuff" and Honjo and others (1986) named them "Young tuffs". We have lumped the tuffs and use the informal name "tuff of Poison Creek". The reader is referred to Schmidt's and Struhsacker and others' reports for detailed descriptions of the individual units. The tuffs are well exposed in the US Highway 20 road cut west of the Hot Springs Landing turnoff and in nearby pumice quarries just south of the highway. Struhsacker and others (1982) reported K-Ar dates ranging from about 4.77 to 5.64 Ma for samples from this unit. South of Macon Flat, the unit consists of light gray to light purplish gray rhyolite tuff with common phenocrysts consisting of mostly plagioclase, with a few sanidine(?) and small quartz crystals. Swirling to contorted flow foliation is common. Lithophysal cavities and voids are locally common. Weathers pinkish to brownish.

Trd—Rhyolite and dacite of eastern Mount Bennett Hills (Miocene)—Phenocryst-, xenocryst-, and locally xenolith-rich rhyolite to dacite lavas(?). Groundmass is light tan-gray in platy, interior part of flow to dark gray to black and vitrophyric at the top and possibly in zones within the interior and at the base. Small pyroxene grains are scarce to common. Many of the xenocrysts are rounded and embayed. Vesicular zones may be flow tops. Spherulites ranging from several millimeters to several centimeters are common, especially in the top part of flows, and typically are more resistant to weathering than surrounding rock and form rough, knobby rock surfaces. Remanent magnetic polarity at several locations was normal, as measured in the field. Forms a rugged topography with common ridges and knobs on which soils are thin to absent. Foot slopes and narrow valleys have a thin cover of colluvium and sheet wash composed of coarse sand and fine gravel. Included in the Moonstone rhyolite by Schmidt (1961) and Leeman (1982). Equivalent to rhyolite of Magic Reservoir (Tmr unit) of Honjo (1986) and quartz latite of Magic Reservoir (Tmq unit) of Worl and others (1991). Using the total alkali-silica classification of Le Maitre (1984), Honjo's samples plot in the dacite and rhyolite fields and several samples we analyzed also plot near the rhyolite-dacite boundary. Honjo (1986) reports a K-Ar age of 4.2 Ma for the Tmr unit. Struhsacker and others (1982) report a K-Ar age of 5.8 Ma for their "older rhyolite" unit, which we believe is equivalent to the *Trd* unit. Kauffman and Othberg (2008b) report a low confidence $^{40}Ar/^{39}Ar$ age of about 4.22 Ma. The *Trd* is clearly overlain by the tuff of Poison Creek (Kauffman and Othberg, 2008a), for which Struhsacker and others (1982) reported K-Ar dates ranging from about 4.77 to 5.64 Ma. Therefore, we believe the 5.8 Ma age for *Trd* is the more reasonable.

Volcanic Rocks of Uncertain Affiliation

QTbu—Basaltic and andesitic rocks, undivided (Pleistocene to Pliocene)—Dense, gray, fine-grained basaltic andesite with common 2-3 mm plagioclase phenocrysts and scarce olivine grains ~ 1 mm; also a few glomerocrysts of plagioclase and olivine about 5 mm in diameter. Remanent magnetic polarity not determined. Caps granitic rock, but otherwise age is poorly constrained. Other exposures include one vent east of Wedge Butte and small remnant on east flank of the butte. On the west flank of the vent, the basalt is fine grained but coarsely plagioclase phyric with intergrown phenocrysts as large as 1 cm, giving the rock a coarse overall texture; olivine is uncommon. On the southeast flank of the vent, the basalt is finer grained with common plagioclase phenocrysts 5-10 mm and clusters of plagioclase and olivine 1 cm in diameter; some coarse zones or layers, similar to the west flank variety. Remanent magnetic polarity normal as determined in the field on the southeast flank. The small basalt remnant on the east flank of Wedge Butte is fine grained with 1-2 mm plagioclase phenocrysts and 4-7 mm glomerocrysts of plagioclase and olivine; the olivine is altered to amber or purple iddingsite(?). This small remnant could be older than the rhyolite of Wedge Butte.

QTbrb—Basalt of Brown Butte (Pleistocene or Pliocene)—Black, fine-grained, vesicular to massive plagioclase- and olivine-phyric basalt (Cooke, 1999). Remanent magnetic polarity not determined. Very poorly exposed. A few exposures occur as pavement outcrops along the flanks of the volcano. Brown Butte is on the south edge of the map about 8 km (5 miles) southwest of Richfield.

Tbu—Basalt flows, undivided (Pliocene or late Miocene?)—Dark gray, typically grainy textured basalt flows from undetermined sources. Both normal and reverse polarity readings were noted in the field, suggesting multiple flows of different ages. Variable composition from several samples also indicates multiple flows.

Idavada Group

Tcort—Tuff of City of Rocks (Miocene)—Pinkish gray to brownish gray crystal-rich rhyolite tuff, typically with black vitrophyre at base and top. Remanent magnetic polarity normal, as determined in the field. Oakley (2006) also reports normal polarity. Platy subhorizontal flow foliation layering is typically several millimeters to several centimeters thick, although some massive zones are present. Isoclinal folding of the foliation occurs locally. Forms eroded and channeled cliffs and pillars. Honjo and others (1986) report a K-Ar age of 9.15 ± 0.13 Ma, but William Leeman (written commun., 2012) reports a recent $^{40}Ar/^{39}Ar$ age of about 8.2 Ma. Equivalent to City of Rocks tuff of Smith (1966) and Oakley's (2006) tuff of City of Rocks. Contact with underlying Clover Creek diatomite is highly irregular, probably the result of erosion of the diatomite. Abruptly thins and mostly terminates against the Thorn Creek fault, although thin remnants occur at a few locations north of the fault. Offset of the underlying McHan basalt in Thorn Creek is about 106 m (350 feet), down to the south. Soils are generally thin to absent.

Tpt—Picabo tuff (Miocene)—Light gray, tan, and purplish tan crystal-poor rhyolite tuff. Phenocrysts of quartz, plagioclase, and sanidine compose about 10 percent of the rock. Commonly has compaction foliation layers spaced 1-3 mm. Probably consists of several ash flows or cooling units as indicated by vitrophyric layers and associated zones with irregularly shaped lithophysal cavities from several centimeters to tens of centimeters in size. The lithophysal zones commonly form ledges 2-10 m (6-30 feet) high. The unit weathers into granular fragments. Caps ridges west of Highway 75 and composes most of the ridges of the Timmerman Hills east of State Highway 75 (Kauffman and Othberg, 2007), and caps the western part of the Picabo Hills (Garwood and others, 2010). Extruded onto irregular topography of Challis Volcanics, Cretaceous granitic rocks, or Paleozoic sedimentary rocks. Equivalent to the Picabo tuff of Schmidt (1961). Honjo and others (1986) obtained a K-Ar date on plagioclase for Picabo-B unit (Schmidt, 1961) of 8.98 ± 0.12 Ma.

Tbb—Basalt of Big Bluff (Miocene)—Medium to dark gray basalt with scattered 1-2 mm plagioclase laths, abundant olivine ≤1 mm, and scattered plagioclase + olivine clots as large as 5 mm. Caps Gwin Spring tuff on the north end of Big Bluff and on the south flank of the bluff (Othberg and Kauffman, 2010). Composition is similar to that reported for basalt of Davis Mountain (Oakley, 2006), although texture is dissimilar and stratigraphic age is younger – Davis Mountain basalt is older than Gwin Spring tuff whereas Big Bluff basalt is younger than the tuff.

Tmh—Basalt of McHan (Miocene)—Medium gray, fine- to medium-grained nearly aphyric to plagioclase-phyric basalt. Consists of one to three flows. Plagioclase phenocrysts in the more phyric flows (or parts of a flow) range from 2-7 mm in length for individual crystals and 5-10 mm for glomerocrysts. Olivine is uncommon and typically <1 mm. Remanent magentic polarity is probably reverse, although normal, reverse, inconclusive, or inclination sensitive readings were obtained in the field. Thickness ranges from less than 15 m (50 feet) to as much as 30 m (100 feet). Unconformably overlies Hash Spring sediments or Gwin Spring tuff where the sediments are absent. Underlies a thin vitrophyre cap of City of Rocks tuff north of the Thorn Creek fault and underlies City of Rocks tuff basal vitrophyre south of the fault. Equivalent to McHan basalt of Smith (1966). Oakley (2006) mapped "basalt of McHan" as equivalent to Smith's McHan basalt; however the chemical composition of samples we collected near McHan Reservoir (for which Smith named the unit) is somewhat different than that reported by Oakley. Pinches out to the south and west. Honjo and others (1986) report a K-Ar age of 9.44 ± 0.11 Ma. Forms the capping unit on much of the fault-block ridge and valley topography in the northeast part of the map.

Tbwc—Basalt of Wardrop Creek (Miocene)—Medium gray, plagioclase-phyric basalt exposed east of Soldier Creek, on the southeast flank of Cannonball Mountain, and west of Elk Creek. At least two flows present, which are separated by a diatomite bed in Brush

Canyon, a tributary of Wardrop Creek. Phenocrysts of plagioclase (10-20 percent) are as much as 4 mm long, but typically 0.2-1 mm in length and crudely aligned. Olivine phenocrysts (3-6 percent) are as much as 1.5 mm long, but typically 0.2-0.3 mm. Groundmass consists of clinopyroxene, plagioclase, and opaque minerals. Xenocrystic plagioclase crystals 1-5 mm in length are common. They have disequilibrium resorption textures and typically contain opaque minerals. Upper part of unit along Wardrop Creek is highly oxidized. In Elk Creek, unit overlies unnamed basalt that in turn overlies tuff of Gwin Spring. The unnamed basalt contains much less olivine and fewer and smaller (< 1 mm in length) crystals of plagioclase.

Tbbc—Basalt of Basalt Creek (Miocene)—Medium gray, plagioclase-phyric basalt exposed in the headwaters of Basalt Creek on the northwest flank of Cannonball Mountain. Two flows with similar major and trace element composition are present; both have high TiO_2 concentrations (2.3-2.7 percent) relative to nearby basalt units. Lower flow is reverse magnetic polarity; polarity of upper flow is unknown. Lower flow contains small phenocrysts of plagioclase typically 0.5-1 mm in length. Olivine phenocrysts are typically 0.3-0.5 mm. Groundmass consists of clinopyroxene, plagioclase, and opaque minerals. Upper flow contains small plagioclase phenocrysts (mostly 0.5-1 mm), and 0.2-0.5 mm clinopyroxene and olivine phenocrysts. This flow contains slightly more phenocrysts overall, less clinopyroxene, and more abundant opaque minerals in the groundmass than the upper flow.

Tgs—Tuff of Gwin Spring (Miocene)—Light purplish or pinkish gray to tan or brown crystal-poor rhyolite tuff. Lithophysal cavities present at one or more horizons and platy partings common. Folded flow layering locally common. Gray to black vitrophyre at top of unit is poorly exposed. Oakley (2006) reports normal remanent magnetic polarity, but Kauffman and others (2010) report conflicting field magnetometer readings. According to Oakley (2006), age is bracketed by overlying 9.4 Ma McHan basalt and underlying 10.1 Ma Thorn Creek tuff in the Davis Mountain 7.5′ quadrangle. Equivalent to Gwin Spring Formation of Smith (1966), tuff of Gwin Springs of Oakley (2006), and the tuff of Gwin Spring of Kauffman and others (2010). Appearance nearly identical to Fir Grove tuff but separable by chemical composition. Soils are generally thin to absent.

Ttct—Tuff of Thorn Creek (Miocene)—Pinkish gray, brownish gray to gray crystal-rich rhyolite tuff. In Thorn Creek, black vitrophyre at top of the unit directly underlies and appears to be conformable, or nearly so, with the Gwin Spring tuff. Thickness is at least 60 m (200 feet); base is not exposed. Equivalent to "lower welded tuff" of Smith (1966), rhyolite of Thorn Creek of Honjo (1990), and tuff of Thorn Creek of Oakley (2006). Indistinguishable in the field from tuff of Knob (*Tk*), as noted below for that unit.

Tcm—Tuff of Cannonball Mountain (Miocene)—Alkali rhyolite (comendite) tuff exposed north of Camas Prairie. Light gray, porphyritic, and in places vesicular. Unit weathers brown and forms thin soils. Nodules of obsidian are common in float, but were not observed in outcrop. Phenocrysts of sanidine and quartz, 0.2-1.5 mm in length, compose about 2-6 percent of the rock. Both minerals are embayed, and the sanidine commonly exhibits light blue chatoyancy. Rare green pyroxene (aegerine-augite?) is present near Willow Creek. The groundmass is thoroughly devitrified and is composed of spherulites or, more commonly, intergrowths of equant feldspar and quartz crystals. Small radial sprays of both opaque minerals and sodic amphibole are intergrown with the feldspar and quartz. Euhedral sodic amphibole is also present in vesicles along with quartz and zeolite. Attitudes of flow foliation are highly variable and the tuff likely remobilized after deposition. Unit is poorly exposed overall and thickness is difficult to estimate; local accumulations of 100-200 m (330-660 feet) are likely. Lewis (1990) reported a sanidine K-Ar age of 10.2 ± 0.3 Ma.

Tcml—Tuff of Cannonball Mountain, lower member (Miocene)—Alkali rhyolite (comendite) tuff with abundant flattened glassy volcanic fragments. Exposed only along Elk Creek north of Camas Prairie. Unit contains about 35 percent dark gray fragments of perlitic glass and 5 percent lighter gray volcanic lithic fragments in a light gray matrix. Glassy fragments are 1-5 cm in length; they lack vesicles and are locally devitrified. Phenocrysts of sanidine and quartz, 0.2-2 mm in length, compose about 6-10 percent of the rock. Base of unit is not exposed; minimum thickness 50 m (160 feet).

Tpv—Vitrophyre of Pole Creek (Miocene)—Orange-brown to black, crystal-poor, plagioclase-phyric, lithic-vitric rhyolitic ignimbrite with pyroxene, quartz, and magnetite. Thickness typically ranges from 6-9 meters

(Oakley, 2006). The unit overlies the basalt of Davis Mountain south of the Pole Creek fault. The unit is directly overlain by the 10.1 Ma tuff of Thorn Creek. Weathered surfaces of the vitrophyre are gray to brown color with spots of rusty color (hematite?) surrounding the oxides. The vitrophyre of Pole Creek has ~3% phenocrysts of subhedral 1 mm plagioclase grains, subhedral 0.5mm pyroxenes (pigeonite 45%, augite 50%, and orthopyroxene 5%) with minor amounts of quartz and magnetite (Oakley, 2006). Trace amounts of zircon and apatite can be seen in thin section. Similar to the tuff of Fir Grove the vitrophyre of Pole Creek has a shardy texture. Phenocryst aggregates of plagioclase, pigeonite, and augite are found in this unit. The plagioclase and pigeonite phases exhibit a sieve texture.

Tbd—Basalt of Davis Mountain (Miocene)—Medium to dark gray plagioclase-phyric and plagioclase-olivine-glomerophyric basalt. Plagioclase phenocrysts 2-8 mm in length; plagioclase-olivine glomerocrysts are as large as 1 cm. Remanent magnetic polarity not determined; Oakley (2006, p. 138) reports polarity as normal, but several of his field measurements gave reverse polarity readings.

Tk—Tuff of Knob (Miocene)—Pinkish gray, brownish gray to gray crystal-rich rhyolite tuff capped by black vitrophyre 3-6 m (10-20 feet) thick. Crops out near Fir Grove Mountain where it overlies Fir Grove tuff (*Tfg*) and appears to be unconformably overlain by Gwin Spring tuff (*Tgs*). Indistinguishable in the field from tuff of Thorn Creek (*Ttct*). Equivalent to tuff of Knob of Oakley (2006), who suggested that Smith mistakenly mapped this unit as City of Rocks tuff. We concur with Oakley from both stratigraphic evidence and chemical composition that Smith was in error. Oakley (2006) noted that the tuff of Thorn Creek and tuff of Knob are indistinguishable unless separated by a marker unit, as he had in the Davis Mountain 7.5′ quadrangle; he also noted slight chemical differences. We map the tuff of Knob on the basis of the unconformable contact with the overlying Gwin Spring tuff as opposed to the apparent conformable contact of the Thorn Creek and Gwin Spring tuffs in Thorn Creek canyon.

Tfg—Tuff of Fir Grove (Miocene)—Tan to brown crystal-poor rhyolite tuff. Lithophysal cavities present at one or more horizons, otherwise common platy weathering. Appearance in the field indistinguishable from tuff of Gwin Spring. Thickness not determined. Equivalent to Fir Grove tuff of Smith (1966) and tuff of Fir Grove of Oakley (2006), who reports reverse magnetic polarity, although our field measurements of polarity were inconclusive. An $^{40}Ar/^{39}Ar$ date on the Fir Grove tuff from the Davis Mountain 7.5′ quadrangle resulted in an age of 11.17 ± 0.08 Ma (Oakley, 2006). Although Smith (1966) mapped this unit as younger than the tuff of Gwin Spring, Oakley (2006) concluded from stratigraphic evidence that it was older. We concur with Oakley's stratigraphy on the basis of the chemical composition and our present mapping, but contact relationship with the Gwin Spring tuff is locally ambiguous. Soils are generally thin to absent.

Tds—Tuff of Deer Spring (Miocene)—Black to red crystal-rich, sanidine bearing, vitric rhyolitic ignimbrite with plagioclase, quartz, and pyroxene. Trace amounts of fayalitic olivine, zircon, apatite, and ilmenite are present. This unit was first recognized by Honjo (1990). His study suggests a tentative correlation of the rhyolite of Deer Springs with the 11.0 Ma rhyolite of Windy Gap, dated using the K-Ar method by Armstrong and others (1980). An $^{40}Ar/^{39}Ar$ date on this unit reveals an age of 11.21 ± 0.08 Ma (Oakley, 2006). This unit does stand in prominent cliffs but they are limited due to sparse exposures. Where devitrified, the unit stands in pinnacle or hoodoo-like columns. The unit consists of 20% phenocrysts. The phenocryst assemblage is dominantly sub-euhedral, 2 mm long, embayed sanidine, 30% of total phenocrysts. Plagioclase is 1.5 mm, euhedral and comprises 20% of the phenocrysts with anorthite content ~An_{30}. Broken and embayed quartz phenocrysts are <1 mm in diameter accounting for 10% of the crystals. The proportion of pyroxene is 10% (as equal amounts of augite and pigeonite). The pyroxene phenocrysts are less than 1 mm in diameter. Magnetite grains are generally subhedral grains and represent 5% of the phenocrysts. Trace mineral phases (<1%) include: fayalitic olivine, zircon, apatite, and ilmenite.

Challis Volcanic Group

Tcv—Challis Volcanic Group, undivided (Eocene)—Mostly gray, tan, pink, or purple porphyritic hornblende dacite, but may include some poorly exposed rhyolite tuff and andesite. In dacite, plagioclase phenocrysts common to abundant; hornblende phenocrysts uncommon to common and in places altered and oxidized; biotite phenocrysts absent to common. Platy partings (flow foliation?) are common in the dacite. Locally includes white to light-gray, locally trachytic, acicular hornblende-quartz-plagioclase crystal tuff. Breccias are locally common. North of Gannett unit includes uncommon hornblende andesite lava flows, vesicular hornblende plagioclase vitrophyre, pink plagioclase quartz biotite heterolithologic lithic tuff, and lahar deposits with dacite blocks in sandy matrix. Fragments of petrified wood occur in the soils near the contact with the Paleozoic rocks in the Picabo area and north of Gannett.

Tcvr—Challis Volcanic Group, rhyolitic rocks (Eocene)—Red-brown biotite rhyolite in two small exposures on north side of Camas Prairie west of Big Deer Creek. Contains 5 percent plagioclase and 2 percent biotite phenocrysts (2 mm in length and smaller) in a very fine grained to glassy groundmass.

Tcvd—Challis Volcanic Group, dacitic rocks (Eocene)—Mostly medium to dark gray, pink, or purple porphyritic biotite-hornblende dacite and rhyodacite. Plagioclase phenocrysts common to abundant; hornblende and biotite phenocrysts uncommon to common and in places altered and oxidized. Quartz is uncommon and typically resorbed. Along Soldier Creek individual flows are meters to tens of meters thick and accumulations of multiple flows locally amount to several hundred meters (Lewis, 1990). Colors there range from purple to read to green, and textures are porphyritic to nearly aphyric. Most flows are porphyritic and contain phenocrysts of andesine and hornblende; biotite and augite are present locally, as is quartz. Hornblende from rhyodacite east of Soldier Creek was dated by K-Ar methods at 49.9 ± 0.6 Ma (Lewis, 1990). Biotite from the same sample yielded an age of 47.4 ± 0.6 Ma.

Tcvdm—Challis Volcanic Group, massive dacite (Eocene)—Massive, hornblende-biotite dacite, generally more porphyritic and with larger phenocrysts than compositionally similar dacite that is thought to largely represent flows or tuffs (dacite within *Tcv* unit). Only subdivided in area northeast of Gannett. Similar dacite flow domes are reported in the area west of Little Wood River Reservoir (Sanford, 2005).

Tcvvc—Challis Volcanic Group, volcaniclastic rocks (Eocene)—Light gray to tan massive sedimentary breccia exposed east of the Wood River Valley. Very poorly sorted matrix-supported breccia containing muddy to sandy (crystal-bearing) matrix. Clasts are angular, as large as 1.5 m (5 feet), and are dominated by hornblende- and (or) biotite-bearing dacite and andesite. Unit locally attains thickness of 90 m (300 feet) and consists of multiple deposits intercalated with dacite and andesite lava flow rocks.

Tcva—Challis Volcanic Group, andesitic rocks (Eocene)—Brown-weathering dark greenish grey andesitic lava rocks and uncommon light gray tuffs. Andesitic lava rocks contain common augite phenocrysts as large as 0.25 mm and less common plagioclase and altered olivine phenocrysts. Includes Shoshonite flows. Chalcedony locally fills vesicles and fractures. Siliceous biotite quartz crystal tuff and uncommon coarse-grained pumice lithic crystal rhyolite tuff forms layers 1.2-1.5 m (4-5 feet) thick that are intercalated with andesite lava flow rocks. Some may be water lain or reworked. Unit includes part of the lower andesite unit of Sanford (2005) in the Little Wood River Reservoir area. Also includes relatively fresh, dark gray, fine- to medium-grained trachyandesite north of Gannett that contains common phenocrysts of augite and olivine as large as 0.5 cm across and less common plagioclase phenocrysts as long as 2 mm. May be a young unit of the Eocene Challis Volcanic Group or a younger Miocene flow; this trachyandesite appears to be chemically similar to andesitic flows assigned to the Challis Volcanic Group on the Buttercup Mountain 7.5′ quadrangle immediately north of the map area (O'Brien and others, 1993). Also includes dark gray, fine- to medium-grained basaltic andesite of uncertain age exposed along the crest of the Picabo Hills that contains phenocrysts of plagioclase and olivine.

Tcvsd—Challis Volcanic Group, sedimentary rocks and dacite (Eocene)—Arkosic sandstone and interlayered hornblende dacite north of Croy Creek near the northern map boundary. Basal Challis unit deposited on Pennsylvanian-Permian strata (*PlPdml*). Sandstone dips 45° to the east-southeast. Dacite is relatively fine grained and contains plagioclase, hornblende, and biotite phenocrysts. Equivalent to Tsd unit of Skipp and others (1994) in the adjoining Mahoney Butte 7.5′ quadrangle to the north.

Tcvs—Challis Volcanic Group, sedimentary rocks (Eocene)—Indurated arkosic sand, siltstone, mudstone, and locally fine ashy deposits on Johnson Hill south of Corral where they appear to overlie dacitic rocks as well as appear to be interbedded with the volcanic units, suggesting several episodes of deposition; some repetition of sediments there may be caused by unrecognized faulting. East of the Wood River Valley are poorly exposed, light gray to greenish tan pebble conglomerate, sandstone, siltstone, and claystone. Bedding varies from massive to finely laminated and graded bedding is common. Clasts are as large as 10 cm in size and are angular to subrounded, consisting of feldspar, quartz, biotite, hornblende, and volcanic and sedimentary rocks. Black chert clasts are particularly common. Pebble conglomerate is matrix supported. In outcrops located in upper Seamans Creek, unit is intercalated with andesite lava rocks of unit *Tcva*. Remnants of unit also occur locally on ridges to the west of these outcrops where black chert pebbles are found in float lying on unit *PIPwe.* Mapped as volcaniclastic sandstone and conglomerate in basal conglomerate andesite units of Sanford (2005).

INTRUSIVE ROCKS

Tb—Basalt dike rocks (Miocene)—Unit limited to three basalt dikes mapped in the northern part of the quadrangle. The dike on Smoky Dome and another west of Willow Creek have north-northwest trends, unlike the north-northeast to northeast trends typical of the Eocene dikes described below. Age of these two basalt dikes is highly uncertain. The dike cutting basalt of Wardrop Creek east of Soldier Creek has been dated by whole-rock K-Ar methods at 6.4 ± 0.2 Ma (Lewis, 1990). It contains about 40 percent phenocrysts (plagioclase, olivine, and augite), all of which are coarser than those found in the basalt of Wardrop Creek. Also, the presence of augite phenocrysts in the dike likely rules out correlation with the basalt, given that it contains only plagioclase and olivine phenocrysts.

Tr—Rhyolite dike rocks and small rhyolite stocks (Eocene)—Tan to light brownish red, weakly porphyritic rhyolite with small (<2 mm) quartz, plagioclase, and potassium feldspar phenocrysts.

Trp—Porphyritic rhyolite dike rocks (Eocene)—Pink to light gray, highly porphyritic rhyolite with quartz, potassium feldspar, and plagioclase phenocrysts. Potassium feldspar phenocrysts are as much as 15 mm in length. Groundmass is commonly characterized by granophyric intergrowths of quartz and potassium feldspar.

Trdd—Rhyodacite dike rocks (Eocene)—Pink to gray-green, moderately to highly porphyritic rhyodacite with plagioclase, hornblende, biotite, and local quartz phenocrysts. Phenocrysts typically 2 to 5 mm in length. Groundmass is commonly characterized by granophyric intergrowths of quartz and potassium feldspar.

Tda—Dacite and andesite dike rocks (Eocene)—Green to gray, weakly to moderately porphyritic dacite and andesite with plagioclase and hornblende phenocrysts typically 2 to 4 mm in length. Andesite dikes locally contain pyroxene and dacite dikes contain biotite.

Td—Dacite dike rocks (Eocene)—Green to gray, porphyritic dacite with plagioclase, hornblende, and biotite phenocrysts.

Ta—Andesite dike rocks (Eocene)—Phenocryst-poor, dark green to dark gray andesite. Phenocrysts are typically plagioclase and hornblende.

Tg—Biotite granite (Eocene)—Pink to pinkish-tan, fine- to coarse-grained, equigranular to porphyritic biotite granite. Highly perthitic alkali feldspar is the most abundant mineral in the unit. Local phenocrysts consist of equant dark quartz crystals 5-8 mm and tabular pale pink orthoclase crystals 10-20 mm long. Biotite composes about 3 to 5 percent of the rock. Easily weathers and typically poorly exposed. Smith (1966) mapped exposures of this granite east of Mormon Reservoir as Cretaceous, but Worl and others (1991) considered it Tertiary (Eocene). Quarried for road material at several locations in the reservoir area. Exposures in the vicinity of Smoky Dome at the northern map boundary include a variety of textural varieties and local occurrences of mafic inclusions and hornblende. Although included in the "pink granite suite" of Eocene intrusions by Lewis and Kiilsgaard (1991), some of the hornblende-bearing phases may instead be part of the "quartz monzodiorite suite." Exposures near Smoky Dome contain weakly to moderately zoned white oligoclase with albitic rims (Lewis, 1990). Rapakivi texture is developed locally.

Thgd—Hornblende-biotite granodiorite (Eocene)—Heterogeneous unit of equigranular to porphyritic and fine- to coarse-grained biotite-hornblende granodiorite. Also includes granite, quartz monzonite, and quartz monzodiorite (Lewis, 1990).Typically medium-grained and seriate to porphyritic. Hornblende-rich inclusions, commonly 3 to 10 cm across, are typical of this unit. More mafic phases are most common near contacts with older rocks, but not restricted to these areas. Aplite dikes are narrow and sparse, and pegmatite dikes are rare. Plagioclase is sodic oligoclase and andesine.

Potassium feldspar present as small phenocrysts and as an interstitial component. Quartz is present as small (<4 mm) equant crystals and interstitial matrix material. Pseudohexagonal books of biotite are a common feature. Hornblende is typically euhedral, acicular, and glomerocrystic. Magnetite is abundant, particularly in the glomerocrysts, and clinopyroxene is locally present as cores in hornblende.

Tfgd—Foliated hornblende-biotite granodiorite (Eocene)—Foliated, medium- to fine-grained biotite granodiorite exposed in a single small stock along lower Willow Creek. Foliation is mylonitic and characterized by grain size reduction. Mylonitic metasedimentary inclusions containing hornblende, diopside, and quartz are present locally within the unit. Biotite in excess of hornblende and some phases contain only trace amounts of hornblende. Provisional U-Pb zircon age of 47.6 ± 2.1 Ma (Richard Gaschnig, written commun., 2014).

Tdg—Diorite and gabbro (Eocene)—Medium-grained biotite-hornblende diorite and gabbro in small intrusive masses west of Willow Creek and near the western map edge. Includes some quartz diorite and quartz monzodiorite. Contains as much as 35 percent hornblende and 15 percent biotite; relict clinopyroxene present in small amounts as cores in hornblende.

TKl—Lamprophyre dikes (Eocene or Cretaceous)—Dikes of dark greenish-gray biotite lamprophyre. Poorly exposed and typically only found in float on mine dumps. Characterized by biotite phenocrysts in a groundmass rich in plagioclase and calcite. Commonly altered; abundant sericite and calcite.

Klg—Leucocratic granite (Cretaceous)—Small masses of granite containing minimal amounts of mafic minerals.

Kap—Aplite and pegmatite dikes (Cretaceous)—Fine- and coarse-grained, light-colored granitic dikes cutting *Kgdh* unit. More abundant than shown, based on presence of fragments in the overburden. Only mapped locally, but are abundant in *Kgdh* near contacts with the surrounding country rocks.

Kgd—Biotite granodiorite (Cretaceous)—Light gray, medium-grained biotite granodiorite. Equigranular to porphyritic, with potassium feldspar phenocrysts 1 to 5 cm in length present locally. Plagioclase is weakly zoned oligoclase-andesine, mostly in the An_{20-35} range (Lewis, 1990). The potassium feldspar is weakly perthitic and predominately intermediate microcline. Quartz is present as large (3-8 mm) strained crystals, or as polycrystalline aggregates resulting from recrystallization of the large crystals. Rutile is a common inclusion in the quartz. Crystals of biotite are small (0.2-2 mm) in size and anhedral to subhedral, in contrast to the large euhedral biotite in *Kgdh*. Unit is cross-cut by dikes of aplite and pegmatite, which resist weathering and form significant amounts of many of the outcrops.

Kgdh—Hornblende-biotite granodiorite (Cretaceous)—Gray, medium- to coarse-grained, equigranular to porphyritic, hornblende-biotite granodiorite. Grades to monzogranite. Biotite is in distinct books as much as 4 mm across. Plagioclase displays strong oscillatory zoning (An_{20-40}) and the potassium feldspar is microcline with well-developed grid twins. Sphene is a conspicuous accessory mineral. A mafic zone is present along southwest margin of the McCoy Mine stock west of Bellevue and there it contains clinopyroxene as cores in hornblende. Map unit includes small areas of gravelly sand in terrace remnants (Qsmr and Qsw of Schmidt, 1961). Pegmatite and aplite dikes are concentrated near contacts with wallrocks and mafic inclusions are common. Equivalent to Kgdk unit of Worl and others (1991) and Kiilsgaard and others (2001), who indicate it is a potassium-rich intrusive, having high K_2O content for a given SiO_2 content relative to other intrusives to the northwest that make up the main peraluminous phase of the Idaho batholith. Also notable for the relative abundance of gold-bearing quartz veins (Lewis, 1989, 2001; Worl and Lewis, 2001). Gaschnig and others (2010) report a 91.4 ± 2.6 Ma U-Pb age on zircon from a sample along Croy Creek west of Bellevue.

Kqd—Biotite-pyroxene quartz diorite (Cretaceous)—Medium to dark gray, medium-grained, equigranular quartz diorite of the Croesus stock. Locally has "salt-and-pepper" appearance. Conspicuous biotite persists in the soil when unit weathers (Anderson and others, 1950). Also contains hypersthene, augite, and hornblende. Plagioclase is weakly zoned. Gaschnig and others (2010) report a 98.2 ± 2.1 Ma U-Pb age on zircon from a sample collected in Croesus Gulch.

SEDIMENTARY ROCKS

PlPs—Sun Valley Group, undivided (Permian and Pennsylvanian)—Light-colored calcareous sandstone, gray siliceous sandstone, sandy limestone, dark gray siliceous argillite, dark gray carbonaceous silty argillite, quartzite, and conglomerate in the Picabo Hills. Float present along the road northwest of Skeeter Point is calcareous sandstone similar to that of the Eagle Creek member of the Wood River Formation (*PIPwe*). Exposures south of Skeeter Point are dark gray carbonaceous silty argillite similar to that found in the upper member of the Dollarhide Formation (*Pdu*). Exposures in and west of the canyon west of Skeeter Point are dark gray siliceous argillite that at least superficially resembles the Milligen Formation (*Dm*). The argillite is tentatively interpreted here, however, as contact metamorphosed or silicified Dollarhide Formation. Calc-silicate rocks are present near contacts with *Kgdh*. Conglomerate on highest point northwest of Pasco Spring is highly deformed (mylonitic) and the clasts are stretched.

This unit was previously subdivided into the lower member of the Dollarhide Formation, middle member of the Dollarhide Formation, and the Eagle Creek Member of the Wood River Formation (Mahoney and others, 1991; Worl and others, 1991; Link and others, 1995). Contacts of these subdivisions were shown in differing ways. The presence of mylonitic rocks is suggestive of structural complications not yet understood and for this reason we have shown all strata as a single unit. Additional detailed mapping is needed in this area.

Pdu—Dollarhide Formation, upper member (Permian)—Black carbonaceous argillite, subordinate dark and light gray limestone and gray siltstone, and minor dark and light gray quartzite. Weathers to a sooty dark soil. Reddish brown iron staining is present on fracture surfaces and bedding is typically centimeter scale. Blockier and darker weathering than *Dm*, which is overall more siliceous and phyllitic. Near intrusive contacts unit is hornfelsed and contains metamorphic biotite. West of Bellevue the unit contains spots of quartz, cordierite(?), and metamorphic biotite.

PlPdml—Dollarhide Formation, middle and lower members, undivided (Permian and Pennsylvanian)—Quartzite, calcareous siltstone, limestone, and rare argillite. Quartzite is typically fine to medium grained and weathers light gray, medium gray, and tan. Convolute bedding, graded bedding, flame structures, and cross-beds are common, as is a "banded" appearance. Much of unit is weakly to moderately hornfelsed and contains diopside, tremolite, and rare garnet; near contacts with intrusive rocks the clastic rocks are bleached and limestone is recrystallized to marble. Fusulinids from southwest of Bellevue indicate Wolfcampian to mid-Leonardian and Missourian to Wolfcampian ages (Mahoney and others, 1991).

Pww—Wood River Formation, Wilson Creek Member (Permian)—Light brown silty micritic limestone, light to dark gray sandy micritic limestone, and subordinate light brown, medium-bedded micritic sandstone and dark-gray carbonaceous siltstone. Includes distinctive beds of dark gray and tan, burrowed, trough cross- and convolute-laminated sandy and silty micrite grading upward to more massive tan limy siltstone. Fossils include crinoid columnals, fusulinids, corals, and the trace fossil Scalarituba. On Bell Mountain southeast of Bellevue, black argillite, light gray limestone, well-bedded micritic sandstone and siltstone, and pebble conglomerate containing quartzite, sandstone, chert, and limestone clasts were tentatively assigned to this unit. Top of unit is not exposed.

PIPwe—Wood River Formation, Eagle Creek Member (Permian and Pennsylvanian)—Light purple to tan silty micritic limestone, light brown micritic sandstone, light gray sandy micritic limestone, and subordinate light tan sandstone. Lower and upper parts consist of thin- to medium-bedded silty micritic limestone and sandy micritic limestone. In places, silty micrite is finely laminated and contains cross beds and graded beds. Locally contains distinctive beds of dark gray and tan trough cross- and convolute-laminated sandy and silty micrite grading upward to more massive tan limy siltstone. Lower part of unit contains a distinctive marker bed 0-6 m (0-20 feet) thick of thinly laminated dark gray silty micrite that was southeast of Bellevue. Middle part consists of mostly medium-bedded, fine- to medium-grained micritic sandstone and less common non-calcareous medium- to thick-bedded, fine-grained sandstone containing about 10-15 percent potassium feldspar.

IPwh—Wood River Formation, Hailey Member (Pennsylvanian)—Gray to reddish brown, conglomerate, sandstone, and bioclastic limestone. Basal conglomerate lithofacies consists of medium-bedded to massive matrix- and clast-supported pebble to cobble calcareous conglomerate intercalated with subordinate thin- to medium-bedded, poorly to moderately sorted, fine- to coarse-grained calcareous sandstone. Conglomerate clasts are subangular to rounded, and consist of light gray to tan quartzite and sandstone, dark gray to black chert, dark gray argillite and siltstone, and light gray limestone. Upper limestone facies consists of thin- to medium-bedded bioclastic grainstone, packstone, and in situ biostromes intercalated with micritic sandstone, siltstone, and thinly bedded pebble and granule conglomerate. Fossils include horn corals, tabulate corals, crinoid columnals, pelecypods, and fusulinids. The Hailey Member lies in angular unconformity on folded rocks of the underlying Milligen Formation (*Dm*) and is locally absent.

Dm —Milligen Formation (Devonian)—Dark brown to dark gray, thinly laminated to medium-bedded, chert, argillite, and phyllitic siltstone. Limestone beds occur locally. Thinly bedded black chert and argillite is typically intercalated with laminated gray to varicolored phyllite. Thinly bedded phyllitic siltstone and fine- to medium-grained sandstone is also common and is locally limy. Uncommon limestone beds as thick as 30 cm. Mine dumps of Milligen Formation are conspicuously black colored, but unit otherwise weathers brown, in contrast to the sooty, dark gray weathering features of the upper part of the Dollarhide Formation. Base of unit is not exposed. Unit contains common centimeter- to meter-scale close to isoclinal folds and a conspicuous cleavage. The age of some of the folding may predate deposition of overlying rocks of the Wood River Formation. One conodont locality northwest of Bellevue has yielded an age of latest Middle Devonian, or earliest Late Devonian and a second nearby locality yielded a late Middle Devonian age (Gary Webster, written commun. in Ratchford, 1994).

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