U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

Hagerman Fossil Beds National Monument

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Hagerman Fossil Beds National Monument

hafo_geology.pdf

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Geologic Resources Inventory Map Document for Hagerman Fossil Beds National Monument

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Geologic Resources Inventory Map Document

Hagerman Fossil Beds National Monument, Idaho

Document to Accompany Digital Geologic-GIS Data

hafo_geology.pdf

Version: 7/30/2019

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Hagerman Fossil Beds National Monument, Idaho (HAFO).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

This document contains the following information:

1) **About the NPS Geologic Resources Inventory Program** – A brief summary of the Geologic Resources Inventory (GRI) Program and its products. Included are web links to the GRI GIS data model, and to the GRI products page where digital geologic-GIS datasets, scoping reports and geology reports are available for download. In addition, web links to the NPS Data Store and GRI program home page, as well as contact information for the GRI coordinator, are also present.

2) **GRI Digital Maps and Source Map Citations** – A listing of all GRI digital geologic-GIS maps produced for this project along with sources used in their completion. In addition, a brief explanation of how each source map was used is provided.

3) **Digital Geologic-GIS Map of Hagerman Fossil Beds National Monument and Vicinity**

   3a) **Map Unit List** – A listing of all geologic map units present on this map, listed from youngest to oldest.

   3b) **Map Unit Descriptions** – Descriptions for all geologic map units present on this map. If a unit's source map symbol, name and/or age differ from its assigned GRI unit symbol, name and/or age then these are listed before the unit's description.

   3c) **Geologic Cross Section** – The cross section graphic present on the source map within the extent of the GRI digital geologic-GIS data.

   3d) **Ancillary Source Map Information** – Additional source map information presented for the source map. This includes a correlation of map units, map symbols and an embedded PDF booklet.

4) **Digital Geologic-GIS Map of the Hagerman Fossil Beds National Monument Area**

4a) **Map Unit List** – A listing of all geologic map units present on this map, listed from youngest to oldest.

4b) **Map Unit Descriptions** – Descriptions for all geologic map units present on this map. If a unit's source map symbol, name and/or age differ from its assigned GRI unit symbol, name and/or age then these are listed before the unit's description.

4c) **Ancillary Source Map Information** – Additional source map information presented for the source map. This includes an explanation of map units, map symbols, index maps, table of pebble count information and references.

5) **GRI Digital Data Credits** – GRI digital geologic-GIS data and ancillary map information document production credits.

For information about using GRI digital geologic-GIS data contact:

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About the NPS Geologic Resources Inventory Program

Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: https://www.nps.gov/articles/gri-geodatabase-model.htm

Geologic Reports: Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage: http://go.nps.gov/gri_products

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: http://irma.nps.gov/App/Reference/Search. To find GRI data for a specific park or parks select the appropriate park(s), enter "GRI" as a Search Text term, and then select the Search Button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: https://www.nps.gov/subjects/geology/gri.htm, or contact:

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The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division.

GRI Digital Maps and Source Map Citations

The GRI digital geologic-GIS maps and their source maps for Hagerman Fossil Beds National Monument, Idaho (HAFO):

Digital Geologic-GIS Map of Hagerman Fossil Beds National Monument and Vicinity, Idaho (*GRI MapCode HAFO*)

> Othberg, Kurt L., Kauffman, John D., Gillerman, Virginia S., and Garwood, Dean L., 2012, Geologic Map of the Twin Falls 30 x 60 Quadrangle, Idaho: Idaho Geological Survey, Geologic Map, GM-49, scale 1:100,000 (digital data scale 1:24,000) (Twin Falls 30' x 60'). (*GRI Source Map ID 75638*).

The GRI used a partial extent of the source digital data and map, however, all geologic features within this extent were captured. This partial extent is defined by the following 7.5' quadrangles: Bliss, Gooding Butte, Hagerman, Tuttle, Yahoo Creek and Thousand Springs. The GRI also incorporated prominent components of the source map and related report (e.g., unit colors and unit descriptions) into the GRI digital geologic-GIS dataset and product.

Of note, numerous discrepancies were observed with unit symbols, unit names and/or unit ages between the published map and the map booklet and GIS data. It was decided by the GRI in most cases to use the unit symbol, unit name and unit age from the map booklet and GIS data as these were in agreement, and the map booklet seemed to be a more Idaho Geological Survey reviewed document than the map.

Digital Geologic-GIS Map of the Hagerman Fossil Beds National Monument Area, Idaho (*GRI MapCode HFBA*)

> Malde, Harold E., and Powers, Howard A., 1972, Geologic Map of the Glenns Ferry-Hagerman Area, West-Central Snake River Plain, Idaho: U.S. Geological Survey, Miscellaneous Geologic Investigations Map I-696 (Sheets 1 and 2 of 2), scale 1:48,000 (Glenns Ferry-Hagerman Area). (*GRI Source Map ID 1242*).

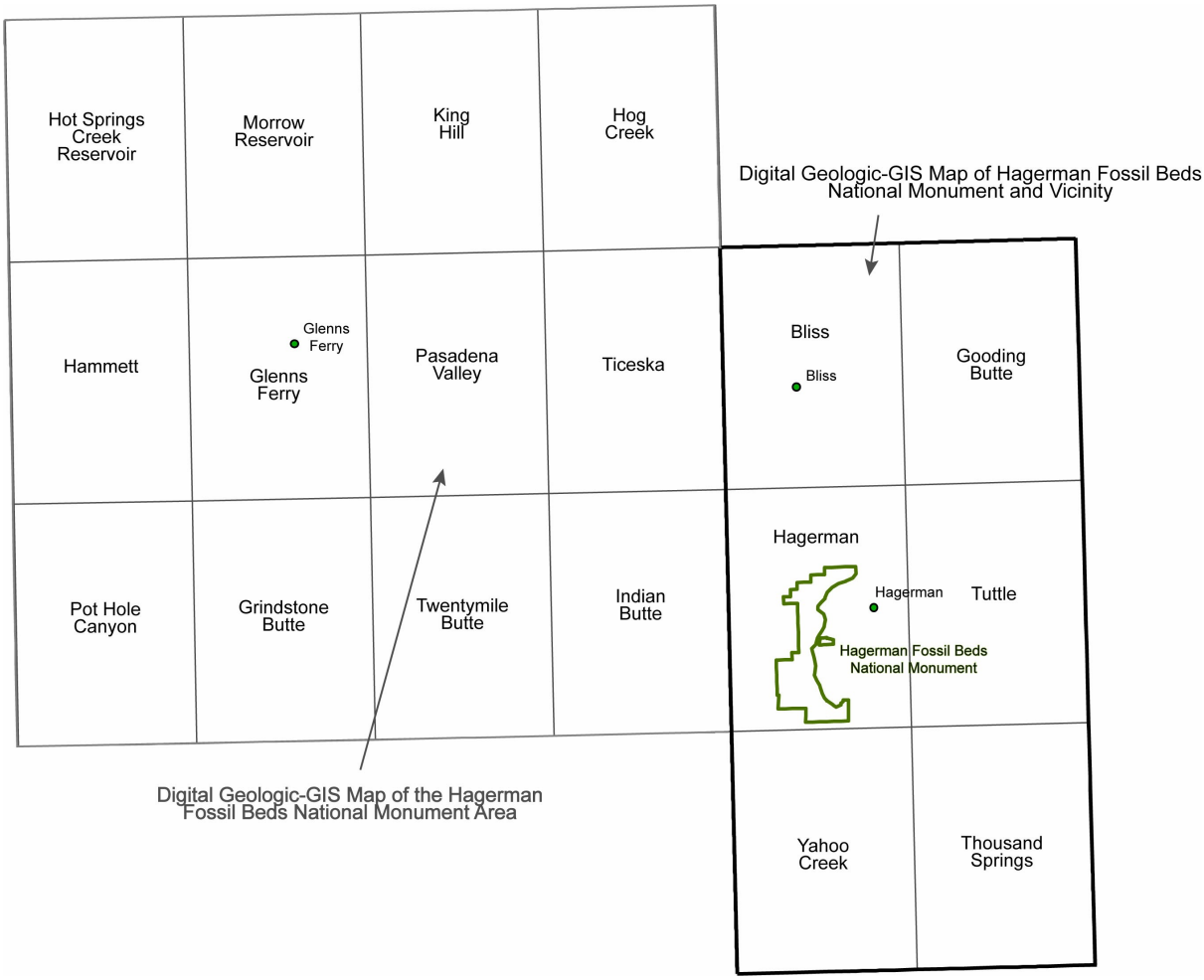
The GRI used the full extent of the source map, and incorporated prominent components of the source map (e.g., unit colors and unit descriptions) into the GRI digital geologic-GIS dataset and product.

Of note, the Digital Geologic-GIS Map of the Hagerman Fossil Beds Area (GRI MapCode HFBA) was previously released with the GRI MapCode of HAFO. However, as the new Digital Geologic-GIS Map of Hagerman Fossil Beds National Monument and Vicinity is based on more detailed larger-scale data and mapping, the latter area map now has the GRI MapCode of HFBA (GRI abbreviation for Hagerman Fossil Beds Area). The GRI report for Hagerman Fossil Beds National Monument was written for this area map, and again now uses a GRI MapCode of HFBA.

Additional information pertaining to each source map is also presented in the GRI Source Map Information (HAFOMAP) table included with the GRI geologic-GIS data.

Index Map

The following index map displays the extent of the GRI digital geologic-GIS data for Hagerman Fossil Beds National Monument. The extent of the GRI Digital Geologic-GIS Map of Hagerman Fossil Beds National Monument and Vicinity (*GRI MapCode HAFO*) is displayed in black, whereas the extent of the GRI Digital Geologic-GIS Map of the Hagerman Fossil Beds National Monument Area (*GRI MapCode HFBA*) is displayed in dark gray. Of note, the extent of the latter area map does include the full extent of the monument and vicinity map, and thus the area map is really defined by the full extent of all 7.5' quadrangles (internal boundaries shown in light gray). The monument boundary (as of July, 2019) is shown in green. Prominent towns are also shown.



Index map produced by Stephanie O'Meara (Colorado State University).

Digital Geologic-GIS Map of Hagerman Fossil Beds National Monument and Vicinity

Map Unit List

The geologic units present on the Digital Geologic-GIS Map of Hagerman Fossil Beds National Monument and Vicinity (*GRI MapCode HAFO*) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qm - Made ground). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (HAFOUNIT) table included with the GRI geologic-GIS data. Some source unit symbols, names and/or ages may have been changed in this document and in the GRI digital geologic-GIS data. This was done if a unit was considered to be the same unit as one or more units on other source maps used for this project, and these unit symbols, names and/or ages differed. In this case a single unit symbol and name, and the unit's now recognized age, was adopted. Unit symbols, names and/or ages in a unit descriptions, or on a correlation of map units or other source map figure were not edited. If a unit symbol, name or age was changed by the GRI the unit's source map symbol, name and/or age appears with the unit's source map description.

Cenozoic Era

Quaternary Period
Qm - Made ground
Qlsa - Deposits of active landslides
Qed - Dune sand
Qt - Talus
Qaf - Alluvial-fan deposits
Qam - Alluvium of mainstreams
Qes - Eolian sand of the Snake River Canyon
Qas - Alluvium of side streams
Qoam - Older alluvium of mainstreams
Qoas - Older alluvium of side streams
Qoab - Older alluvium of Big Wood River, undivided
Qoab1 - Older alluvium of Big Wood River, terrace 1
Qoab2 - Older alluvium of Big Wood River, terrace 2
Qoab3 - Older alluvium of Big Wood River, terrace 3
Qoab4 - Older alluvium of Big Wood River, terrace 4
Qass - Scoured flood pathways of side streams
Qlp - Playa deposits
Qls - Landslide deposits
Qabs - Bonneville Flood Deposits, scabland of flood pathways
Qabg - Bonneville Flood Deposits, sand and gravel in giant flood bars
Qabgl - Bonneville Flood Deposits, sand and gravel in eddy deposits and low-energy bars
Qcg - Crowsnest Gravel
Qy - Yahoo Clay
Qmk - Basalt of McKinney Butte
Qmkv - Volcaniclastic deposits of McKinney Butte
Qnb - Basalt of Notch Butte
Qbby - Basalt of Bacon Butte, younger unit
Qbbo - Basalt of Bacon Butte, older unit
Qftb - Basalt of Flat Top Butte
Qgb - Basalt of Gooding Butte
Qbu - Basalt flows, undivided
Qma - Basalt of Madson Spring

Quaternary and Tertiary Periods
QTt - Tuana Gravel

Tertiary Period
Tb - Younger Tertiary basalt flows, undivided
Tbrg - Basalt of Berger Butte
Tsh - Basalt of Shoestring Road
Tshv - Basalt and vent material, basalt of Shoestring Road?
Tbp - Basalt of Bliss Point
Tsb - Basalt of Sunset Butte
Tsgf - Glenns Ferry Formation
Tmbr - Basalt of Melon Valley, reverse polarity
Tos - Basalt of Oyster Lakes
Tub - Basalt of Hub Butte
Tms - Sediment of Melon Valley
Tmb - Basalt of Melon Valley, undivided
Tmbn - Basalt of Melon Valley, normal polarity
Tvp - Vent deposits, proximal facies
Tvd - Vent deposits, distal facies
Tbo - Older Tertiary basalt flows, undivided, upstream from Thousand Springs
Teh - Basalt of Elmas Hill
Tsfr - Rhyolite of Salmon Falls Creek, undivided

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below. All unit descriptions were taken from the source map, Twin Falls 30' x 60'. Additional information pertaining to map units, as well as the map unit descriptions themselves, can be found in the map booklet associated with the source map.

Of added note, numerous discrepancies were observed with unit symbols, unit names and/or unit ages between the published map and the map booklet and GIS data. It was decided by the GRI to use unit symbols, unit names and unit ages from the map booklet and GIS data as these were in agreement, and the map booklet seemed to be a more Idaho Geological Survey reviewed document than the map.

Qm - Made ground (Holocene)

m - Made ground (Holocene)
Artificial fills composed of excavated, transported, and emplaced construction materials typically derived locally. Primarily highway fills, railroad beds, and areas modified for settling ponds and fish ponds.

Qlsa - Deposits of active landslides (Holocene)

Primarily unsorted and unstratified silt and clay in slumps, slides, and debris flows that have been recently active. Aerial photographs flown in 1972, 1998, and 2004 were used to identify and map active landslides. There are three main areas of active landslides. In Snake River bluffs west of Hagerman, new landslides have activated or old landslides have reactivated since 1979 (Hagerman Fossil Beds National Monument, 2004). The recent failure of slopes on Glenns Ferry Formation correlates with irrigated farming on the adjacent upland west of bluffs of the Snake River valley. Near Bliss, a large, multi-aged landslide complex in both Glenns Ferry Formation and Yahoo Clay reactivated in 1993 (Gillerman, 1993). In Salmon Falls Creek canyon, the 1937 Sinking Canyon movements and the 1998-1999 Bluegill landslide (Ellis and others, 2004; Glenn and others, 2006) are shown as one polygon on the map. In addition to the landslide deposit, the map may also show the landslide scarp and the headwall (steep area adjacent to and below the landslide scarp) from which material broke away (see Symbols).

Qed - Dune sand (Holocene)

Thin, stratified fine sand of stabilized wind dunes. Shown only where identified on aerial photographs.

Qt - Talus (Holocene)

Angular pebble-, cobble-, and boulder-size fragments of basalt that have broken off nearly vertical rock walls and accumulated below. Deposits are characterized by a steeply sloping surface that is at or near the angle of repose. Not mapped where thin talus partially covers units.

Qaf - Alluvial-fan deposits (Holocene)

Stratified silt, sand, and gravel that form small fans. Merges and is interstratified with alluvium of side streams (Qas) or mainstreams (Qam). Thickness varies, but typically ranges ~1-10 m (5-30 feet).

Qam - Alluvium of mainstreams (Holocene)

Channel and flood-plain deposits of the Snake River, Big Wood and Little Wood rivers, and Salmon Falls Creek. Channel deposits are primarily stratified sand and pebble gravel; coarser gravel is present in thicker deposits. Flood-plain deposits are primarily stratified sand along the Big Wood River and silt in the Little Wood River. Basalt outcrop is common in channels during low water. Thickness of the alluvium is <1-6 m (1-20 feet).

Qes - Eolian sand of the Snake River Canyon (Holocene)

Uncompacted fine sand deposited by wind along the base of canyon walls. Locally reworked by water, possibly irrigation-return water from the canyon rim.

Qas - Alluvium of side streams (Holocene)

Silt and sand flood-plain and sheet-wash deposits in the drainage systems formed between older and younger basalt units.

Qoam - Older alluvium of mainstreams (Holocene)

Coarse sand and pebble to cobble gravel deposited by previous river regimes.

Qoas - Older alluvium of side streams (Holocene)

Channel, flood-plain, and alluvial-fan deposits of ancestral Yahoo Creek and minor tributaries to the Snake River. Primarily stratified silt, sand, and minor pebble gravel. Gravel clast lithologies suggest reworking of eroded Tuana Gravel (QTt). Includes debris-flow deposits on steep, alluvial-fan slopes west of the Snake River.

Qoab - Older alluvium of Big Wood River, undivided (Holocene)

Cobble and boulder gravel deposited by high-energy floods of the Big Wood River (Malad River). Gravel forms four terraces that are 3 m (Qoab1), 8 m (Qoab2), 16 m (Qoab3), and 30 m (Qoab4) (10 feet, 25 feet, 50 feet, and 100 feet), respectively, above the present Snake River level near the mouth of Malad Canyon.

Qoab1 - Older alluvium of Big Wood River, terrace 1 (Holocene)

Terrace 3 m (10 feet) above the present Snake River level near the mouth of Malad Canyon. See Qoab for unit description.

Qoab2 - Older alluvium of Big Wood River, terrace 2 (Holocene)

Terrace 8 m (25 feet) above the present Snake River level near the mouth of Malad Canyon. See Qoab for unit description.

Qoab3 - Older alluvium of Big Wood River, terrace 3 (Holocene)

Terrace 16 m (50 feet) above the present Snake River level near the mouth of Malad Canyon. See Qoab for unit description.

Qoab4 - Older alluvium of Big Wood River, terrace 4 (Holocene)

Terrace 30 m (100 feet) above the present Snake River level near the mouth of Malad Canyon. See Qoab for unit description.

Qass - Scoured flood pathways of side streams (Holocene)

Surface scoured by one or more floods of the Big Wood River (Malad River) that were primarily responsible for eroding Malad Gorge. Common small scour marks on basalt surfaces are aligned with the direction of water flow. Surface is mantled with thin and discontinuous sand and gravel deposits.

Qlp - Playa deposits (Holocene and Pleistocene)

Fine sand, silt, and clay sorted into thin beds and laminae. Sediments largely derived from erosion of loess or Glenns Ferry Formation (Tsgf) and washed into areas of internal drainage or nearly flat slopes primarily between basalt flows. 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.

Qls - Landslide deposits (Holocene and Pleistocene)

Unsorted and unstratified deposits composed of clasts of sediments and basalt. On the map, landslides are restricted to the canyons west of Melon Valley. In Salmon Falls Creek canyon, large slump complexes like the Bluegill landslide (see Qlsa) are associated with Tertiary sediments and basaltic tephra. From Thousand Springs to Bliss, canyon slopes of the Snake River, Billingsley Creek, and Malad Gorge have common slumps, slides, and debris flows that originated in the Glenns Ferry Formation and Yahoo Clay. In addition to the landslide deposit, the map may also show the landslide scarp and the headwall (steep area adjacent to and below the landslide scarp) from which material broke away (see Symbols).

Qabs - Bonneville Flood Deposits, scabland of flood pathways (Pleistocene)

Flood-scoured basalt surface. Loess stripped, basin and butte topography is common. Unit adapted from Scott (1982) and O'Connor (1993). Original basalt morphology stripped of pre-flood loess and soils in contrast with area north of maximum flood extent but in same basalt unit. Includes patchy sheets and bars of thin sand and gravel that are not mapped, but have been locally used for gravel (see Symbols).

Qabg - Bonneville Flood Deposits, sand and gravel in giant flood bars (Pleistocene)

Stratified, giant cross-bedded deposits of boulders, cobbles, and pebbles of basalt in a coarse sand matrix. Forms streamlined expansion bars in the Hagerman Valley. Deposited during highest-energy, maximum stage of flood. Similar to Melon Gravel (Malde and Powers, 1962; Malde and others, 1963; and Covington and Weaver, 1991), but restricted to Bonneville Flood constructional forms and deposits.

Qabgl - Bonneville Flood Deposits, sand and gravel in eddy deposits and low-energy bars (Pleistocene)

Stratified coarse sand and pebble-cobble gravel deposited in side channel positions and in lower-energy, waning-stage flood channels. Mantled with thin loess and minor fine-grained alluvium and slope wash.

Qcg - Crowsnest Gravel (Pleistocene)

Stratified sand and pebble gravel. At exposures along Crowsnest Road, the unit overlies well-bedded clay, silt, and rippled sand deposits. Gravel clasts composed of felsic volcanic rocks, quartzite, and chert. Original thickness and extent unknown owing to streamlined erosion by Bonneville Flood. Location suggests possible ancestral Yahoo Creek channel deposits. Thickness about 2 m (6 feet).

Qy - Yahoo Clay (Pleistocene)

Laminated to thinbedded clay and silty clay. Pinkish white to light yellowish brown and conchoidal fracture when dry. Common partings along bedding and vertical joints produces small blocks when exposed. Malde (1982) described the type locality near the mouth of Yahoo Creek, the lavadam origin, and the distribution of the clay in the Snake River canyon from near Bliss to the Melon Valley. Stratigraphic evidence demonstrates the Yahoo Clay is younger than the basalt of Notch Butte (Qnb), but older than the Bonneville Flood. Malde (1982) attributes the clay to McKinney Lake, a temporary lake formed by damming of the Snake River by basalt of McKinney Butte (Qmk and Qmkv units). Malde's interpretation of the lake is compelling and his stratigraphic evidence was confirmed in field mapping. East and south of Hagerman, Malde and Powers (1972) and Covington and Weaver (1990a; 1991) show the Yahoo Clay buried by Crowsnest Gravel except where dissected. Our field mapping and the soil survey by Johnson (2002) suggest the Yahoo Clay is the primary mappable unit in those areas. Sandy soils on the nearly flat surfaces are similar to that described by Malde (1982) in the Yahoo Creek area, and the sands likely have their origin as wind-reworked Bonneville Flood sands. Yahoo Clay was scoured by the maximum stage of the Bonneville Flood.

Qmk - Basalt of McKinney Butte (Pleistocene)

Dark gray, fine-grained basalt with very abundant plagioclase phenocrysts as crisscrossed interlocking crystals as large as 1 cm, or as glomerocrysts commonly with olivine grains and clots. Voids are common among the interlocking crystals. The abundance of phenocrysts and the voids gives the rock a coarse-textured appearance. Equivalent to McKinney Basalt of Malde and Powers (1972). Remanent magnetic polarity is normal (Malde, 1971). Forms a thin capping unit along the Snake River canyon north of Malad Gorge. Farther to the north, the McKinney basalt surface is characterized by youthful flow features such as lava channels and tubes, collapse pits, and pressure ridges. Tauxe and others (2004) report an 40Ar/39Ar weighted mean plateau age of 0.052 Ma for this unit (their sample sr16, McKinney Basalt).

Qmkv - Volcaniclastic deposits of McKinney Butte (Pleistocene)

Black glassy spatter, phyric to glomerophyric pillows, and tephra deposited where flows from McKinney Butte entered and dammed the Snake River and flowed into the resulting lake. Forms thick tephra deposits in the Snake River canyon west of Bliss and pillow deltas south of Bliss to Malad Gorge. Crude layering and foreset bedding is common.

Qnb - Basalt of Notch Butte (Pleistocene)

Dark gray, fine-grained, basalt, similar in hand specimen to basalt of Black Butte Crater but not as glassy; contains a few scattered clusters of plagioclase and olivine 2-3 mm, and scattered plagioclase phenocrysts 1-2 mm in length. Moderately to very vesicular. More carbonate lining and filling in voids than Qblb. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Source is Notch Butte located about 5 km (3 miles) south of Shoshone. Surface not as youthful in appearance as Qblb, but fairly irregular with pressure ridges, locally with sand and loess deposits in depressions. Vegetation characterized by sagebrush and grasses, or rarely farmed on flatter, soil-covered areas. Equivalent to Qwg (Wendell Grade Basalt) of Malde and others (1963).

Qbby - Basalt of Bacon Butte, younger unit (Pleistocene)

Dark gray, fine- to medium-grained basalt with common to abundant olivine as grains and clots as large as 3 mm and scattered small plagioclase laths. Similar in texture and appearance to basalt of Notch Butte, although slightly coarser grained overall. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Forms a raised, hilly surface of partly exposed pressure ridges where it overlies Qbbo in the vicinity of Wendell and extends southwestward to the Snake River canyon in the Sand Springs Creek area, where Malde and others (1963) mapped it as Sand Springs Basalt, which they correlated with Rocky Butte basalt. However, we interpret the unit at Sand Springs Creek, on the basis of paleomagnetic direction and chemical composition, as a younger flow or series of flows erupted from Bacon Butte, which is considerably older than Rocky Butte. Stream drainage is poorly developed. Discontinuous loess and eolian sand deposits cover less than 50 percent of the surface and are <1-3 m (1-10 feet) thick. Soil caliche (duripan) is commonly well developed within the soil profile (Johnson, 2002) and at the soil-basalt contact, but the thickness of caliche varies considerably. Some of the land is cultivatable and some is used as pasture.

Qbbo - Basalt of Bacon Butte, older unit (Pleistocene)

Dark gray, fine-grained basalt with common to abundant plagioclase laths as much as 5 mm in length and common olivine grains and clots; olivine commonly forms intergrowths with plagioclase. Locally diktytaxitic. Locally contains abundant carbonate accumulation in vesicles and fractures. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Also erupted from Bacon Butte shield volcano northeast of Jerome. Age not determined, but geomorphology is similar to that of Flat Top Butte. Included in Thousand Springs Basalt (Qtt) by Malde and others (1963) and mapped as West Basalt by Gillerman and Schiappa (1994; 2001). Topography contrasts with area of basalt of Notch Butte (Qnb) to the northeast and the basalt of Bacon Butte, younger unit (Qbby). Almost no basalt pressure ridges rise above a nearly complete mantle of loess and dune sand. Surface drainage is moderately developed. Thickness of mantle ranges from 1 to 8 m (3 to 25 feet); commonly 1-4 m (3 -12 feet) thick. Soil caliche (duripan) is typically well developed within the soil profile (Johnson, 2002) and at the soil-basalt contact, but the thickness of caliche varies considerably. Most of the land is cultivatable.

Qftb - Basalt of Flat Top Butte (Pleistocene)

Medium gray, fine-grained basalt with scattered to very abundant plagioclase-olivine intergrowths 4-7 mm across and olivine grains and clots 1-4 mm in diameter. Flows typically vesicular near the top and more dense in the center, but diktytaxitic throughout with abundant fine-grained plagioclase laths.

Carbonate coatings and fillings common in voids. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Erupted from the Flat Top Butte shield volcano east of Jerome. Equivalent to part of Thousand Springs Basalt of Malde and Powers (1962), Malde and others (1963), and Gillerman and Schiappa (1994, 2001). Tauxe and others (2004) report an 40Ar/39Ar weighted mean plateau age of 0.395 Ma for this unit (their sample sr09, Thousand Springs Basalt). A sample we dated produced an 40Ar/39Ar weighted mean plateau age of 0.33 ± 0.08 Ma (R. P. Esser, written commun., 2003). Topography contrasts with surface of younger basalt flows to the east. Almost no basalt pressure ridges rise above a nearly complete mantle of loess. Surface drainage is moderately developed. Thickness of mantle ranges 1 to 8 m (3 to 25 feet); commonly 1-4 m (3-12 feet) thick. Soil caliche (duripan) is typically well developed within the soil profile (Ames, 2003) and at the soil-basalt contact, but the thickness of caliche varies considerably. Most of the land is cultivatable.

Qgb - Basalt of Gooding Butte (Pleistocene)

Medium to dark gray, fine-grained basalt with scattered to abundant plagioclase phenocrysts as large as 1 cm in length, and plagioclase-olivine intergrowths as much as 1 cm in diameter; olivine olive-greenish-brown in color; olivine mostly as clusters; diktytaxitic and vesicular; vesicles small and circular to large and irregular. Common carbonate filling and coating in voids. Remanent magnetic polarity normal as determined in the field. Source is Gooding Butte, 3 km (2 miles) southwest of Gooding. Surface subdued, soil covered, and generally farmed. Outcrops uncommon. Equivalent to Qtm (Thousand Springs Basalt, Malad Member) of Malde and others (1963). Tauxe and others (2004) report an 40Ar/39Ar weighted mean plateau age of 0.373 Ma for this unit (their sample sr11, Malad Basalt).

Qbu - Basalt flows, undivided (Pleistocene)

Medium to dark gray, fine- to medium-grained basalt. Some units have common plagioclase phenocrysts 1-3 mm and olivine mostly as individual grains in the groundmass or as small scattered clusters. Commonly diktytaxitic and vesicular. Source(s) undetermined. Mapped along part of the northern edge of the map. The source or sources were probably from the Mount Bennett Hills area to the north and may include flows from several unnamed buttes. Both normal and reverse polarity readings were noted in the field, also indicating several sources. Equivalent to Qbb (Bruneau Formation, basaltic lava flows) of Malde and others (1963). Surface topography is subdued and outcrops are uncommon. A mantle of loess nearly completely covers original basalt surface. Stream drainage is moderately developed. Loess ranges 1 to 3 m (3 to 10 feet) thick. Soil caliche (duripan) is commonly well developed within the soil profile (Johnson, 2002) and at the soil-basalt contact, but the thickness of caliche is highly variable. Most of the land is cultivatable.

Qma - Basalt of Madson Spring (Pleistocene)

Dark gray, fine- to medium-grained basalt with very abundant olivine grains and clots as much as 4 mm in diameter. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Exposed on U.S. Highway 30 grade north of Hagerman. Equivalent to the Madson Basalt of Malde and Powers (1972). Source undetermined, but Malde (1971) suggests the source was likely to the east. It may represent early eruptions from Gooding Butte. Tauxe and others (2004) report an 40Ar/39Ar weighted mean plateau age of 0.404 Ma for this unit (their sample sr12, Madson Basalt).

QTt - Tuana Gravel (Pleistocene or Pliocene)

Well-bedded and sorted gravel, sand, and subordinate silt. Gravel clasts of pebbles and cobbles are well rounded and commonly disc shaped. Imbrication of clasts is common. Tuana Gravel contains distinctive zircon assemblages derived from northern Nevada (Link and others, 2002). South of the Snake River, gravelclast lithologies and imbrication directions suggest the gravel was deposited by north-flowing branches of the ancestral Salmon Falls Creek that prograded braidedstream deposits across a high, nearly flat plain formed on the Glenns Ferry Formation. Imbrication exposed in gravel-

pits near Bliss suggest northwest stream flow. Original extent unknown owing to erosion. Highest erosion remnants are mantled by 3-8 m (10-25 feet) of loess with several buried soils. A thick duripan in the loess often forms an erosion-resistant cap. In addition, late Pleistocene loess with a weakly developed soil commonly mantles Tuana Gravel and forms gently sloping surfaces of irrigated farmland. Named by Malde and Powers (1962). Sadler and Link (1996) and Sadler and others (1997) describe lithofacies and interpret provenance, paleocurrents, and age of the Tuana Gravel, which largely corroborate the descriptions of Malde and Powers (1962). Tuana Gravel overlies upper Glenns Ferry Formation and is therefore younger than 3.11 Ma. The age of Tuana Gravel remains poorly constrained, but Malde (1991) and Othberg (1994) suggest the Tuana Gravel and the Tenmile Gravel near Boise, apparently graded to the same base level, are correlative. A minimum age for Tuana Gravel mapped to the northwest is 1.92 ± 0.16 Ma (Malde, 1991). A minimum age for the Tenmile Gravel is 1.58 ± 0.085 (Othberg, 1994). These gravels represent fluvial and glacial regimes driven by a cooler climate in the late Pliocene but before Pleistocene incision of the western SRP (Othberg, 1994).

Tb - Younger Tertiary basalt flows, undivided (late Miocene? to Pliocene)

Tb - Basalt flows, undivided (Pliocene-late Miocene?)
Fine- to coarse-grained, unaltered to altered undivided basalt flows exposed in the Snake River canyon. Stratigraphically above Tbo unit and commonly separated from it by a thin orange baked soil or sediment horizon <1 m (1-2 feet) thick. Source(s) unknown, but probably consists of flows from different sources of different ages. Includes some basalt mapped as “Sucker Flat basalt, altered” by Bonnichsen and Godchaux (1995a, 1997b). Near Melon Valley, may be equivalent in part to Tmbr or to Tmb.

Tbrg - Basalt of Berger Butte (Pliocene)

Medium to dark gray, fine- to medium-grained basalt generally with abundant plagioclase phenocrysts as large as 5 mm and olivine phenocrysts about 1 mm in diameter. Remanent magnetic polarity is reverse as determined in the field and through laboratory analysis. Source is Berger Butte and associated satellite vents. Most of the unit is equivalent to the “basalt of Sucker Flat” unit of Bonnichsen and Godchaux (1995a, 1996, and 1997b), although we include their Lucerne School basalt (Lucerne Basalt of Malde and Powers, 1972), which Bonnichsen and Godchaux considered to be from Sunset Butte. We include it in Tbrg rather than in the Sunset Butte unit (Tsb) because paleomagnetic directions for Lucerne School basalt more closely match those from Berger Butte than those from Sunset Butte. Two samples were submitted for 40Ar/39Ar dating, one from Bonnichsen and Godchaux’s Lucerne School basalt (sample 03P015) and one from the east flank of Berger Butte (sample 04P008). Average weighted mean plateau ages for two runs of each sample were 3.14 ± 0.17 Ma and 2.91 ± 0.37 Ma, respectively (Paul Layer and Jeff Drake, written commun., 2006).

Tsh - Basalt of Shoestring Road (Pliocene)

Gray to gray-brown, medium-grained basalt with common to abundant plagioclase laths as long as 1 cm and weathered olivine crystals. Remanent magnetic polarity is reverse, as determined in the field and as reported by Neville and others (1979). Forms a thin layer 10-15 m (30-50) feet thick within the Glenns Ferry sediments on the west side of the Snake River from the Hagerman Horse Quarry (fossil-collection site within the Hagerman Fossil Beds National Monument) northward and thins and pinches out locally or is replaced by layered volcaniclastic deposits. A thicker sequence of basalt is exposed in the northwest part of the quadrangle. Source may be vent of Tshv unit, or may be unidentified source to the north. Equivalent to the Shoestring Basalt of Malde and Powers (1972). May include the Deer Gulch basalt of Hart and Brueseke (1999) who dated the Shoestring basalt at 3.68 Ma and the Deer Gulch basalt at 3.40 Ma, although they report that both units occupy the same stratigraphic horizon in the Glenns Ferry Formation, and chemical compositions of the two units are very similar (Hart and Brueseke, 1999). Their Deer Gulch basalt sample 94HA-5 was collected from the Hagerman Fossil Beds National Monument. Similar in stratigraphic position and chemical composition to Tbp unit below.

Tshv - Basalt and vent material, basalt of Shoestring Road? (Pliocene)

Basalt and vent-derived scoriaceous and ropy rubble, spatter, and basalt fragments. Basalt is fine grained and glassy in places with abundant plagioclase laths and glomerocrysts as large as 1 cm, and common to abundant olivine grains and clots 0.5-3 mm in diameter. Some olivine and plagioclase intergrowths. Invasive into Glenns Ferry Formation sediments, which are baked for several centimeters at the basalt-sediment contact. Malde and Powers (1972) considered this a vent for the Shoestring Basalt, but we did not confirm that correlation in the field and therefore have mapped it as a separate unit. Its position within the Glenns Ferry sediments, however, gives credence to their interpretation.

Tbp - Basalt of Bliss Point (Pliocene)

Gray to graybrown, fine-grained, aphyric to slightly plagioclasephyric basalt within Glenns Ferry Formation sediments in the northwest corner of the map. Consists of one flow 15 m (50 feet) or less thick that thins and pinches out locally. Field magnetometer gave conflicting normal and reverse polarity readings from the same outcrop, but polarity is probably reverse. Mapped as Shoestring Basalt (our Tsh unit) by Malde and Powers (1972). Chemical composition indistinguishable from Tsh and may be same unit. Unit has slight dip to the south, indicating the source area may be to the north, or it may be structurally tilted.

Tsb - Basalt of Sunset Butte (Pliocene)

Medium to dark gray, fine-grained basalt with common to abundant plagioclase phenocrysts 4-8 mm in length. Remanent magnetic polarity is reverse as determined in the field and through laboratory analysis. Source is Sunset Butte shield volcano. Vesicular pahoehoe basalt exposed on the rim of Salmon Falls Creek canyon northwest of the butte abruptly changes to massive columnar basalt. Malde and Powers (1972) and Bonnichsen and Godchaux (1997a, 1997b) identify the source for the Lucerne basalt (or Lucerne School basalt) as Sunset Butte. However, as noted above in the basalt of Berger Butte description, we believe the source for the Lucerne basalt may have been Berger Butte. Tmbr flows beneath the basalt of Sunset Butte in Salmon Falls Creek canyon and the western part of Melon Valley may also have originated from Sunset Butte. A sample submitted for 40Ar/39Ar dating resulted in a weighted mean plateau age of 3.68 ± 0.17 Ma (Paul Layer and Jeff Drake, written commun., 2006).

Tsgf - Glenns Ferry Formation (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. To the west and northwest, 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 SRP. The basin-filling contribution of the Glenns Ferry Formation to the western SRP's tectonic subsidence is described by Wood and Clemens (2002). Mammalian fossils in deposits at the Hagerman Fossil Beds National Monument are middle Blancan (Pliocene) in age (Repenning and others, 1995). Hart and Brueseke (1999) corroborate the Pliocene age with 40Ar/39Ar dates on basalt ranging from 3.4 to 3.8 Ma. Two magnetic polarity events recorded in the formation provide an estimate of the total age range: Near the base is the 4.18 to 4.29 Ma Cochiti, and near the top the beginning of the Kaena at 3.11 Ma (Neville and others, 1979; Hart and Brueseke, 1999). For most of the formation, detrital zircon populations indicate south-flowing drainage into the basin from the ancestral Big and Little Wood rivers. However, detrital zircons near the top of the formation indicate the drainage reversed to north-flowing (Link and others, 2002).

Tmbr - Basalt of Melon Valley, reverse polarity (Pliocene or Miocene?)

Brownish-weathering, fresh to altered aphyric to phyric, olivine-plagioclase and olivine basalt. Remanent magnetic polarity is reverse based on field and laboratory analysis. In the field, a few flows have weak normal or conflicting polarity. Columnar flows are as thick as 15 m (50 feet) and thinner vesicular flows are about 5 m (15 feet) thick. Normally overlies Tms unit but may locally lie directly on Tmb or Tmbn flows. At least four flows are present beneath a basalt of Sunset Butte flow in Salmon Falls Creek canyon and may be a series of early flows erupted from Sunset Butte. Other flows may be from shield volcanoes south of the quadrangle. Includes some water-affected basalt (Sucker Flat basalt, altered facies) of Bonnichsen and Godchaux (1996) in the Melon Valley area. Malde and Powers (1972) mapped much of this basalt as Tbu, “Banbury Basalt, basalt of upper part.”

Tos - Basalt of Oyster Lakes (early Pliocene)

Grainy, fine- to medium-grained but coarse-textured vesicular basalt. Dark gray to brownish gray or brick colored with a light purplish hue in places. Abundant plagioclase phenocrysts as long as 5 mm; groundmass is glassy in places. Unit is subaerial and quite fresh where exposed near the fish hatcheries at Oster Lakes. Includes some sedimentary interbeds in the Thousand Springs quadrangle. Remanent magnetic polarity is normal, as determined in the field and through laboratory analysis. Field relations suggest it stratigraphically and probably unconformably overlies the Tvd vent tephras and the altered or water-affected basalt flows, assigned here to Tmbr, which have reverse polarity where analyzed. Source or sources undetermined, but may be to the west or southwest. Previously mapped as “Banbury Basalt, basalt of upper part” by Malde and Powers (1972) and Covington and Weaver (1991). A K-Ar date by Armstrong and others (1975) on this unit resulted in an age of 4.4 ± 0.6 Ma. An 40Ar/39Ar date on a sample collected during this mapping project resulted in a similar age of 4.46 ± 0.39 Ma.

Tub - Basalt of Hub Butte (late Miocene to early Pliocene)

Tub - Older basalt flows, undivided, downstream from Thousand Springs (early Pliocene to late Miocene?)
Gray to gray-brown, medium- to coarsegrained, dense to altered or weathered basalt flows exposed in the lower part of the Snake River canyon from just north of Thousand Springs to west of Bliss. Includes fine-grained sediments either intercalated with or underlying the basalt near the mouth of Big Wood River (Malad River). Source(s) unknown but may be from the south and southwest. Age is poorly constrained, but underlies sediment of the Glenns Ferry Formation (Tsgf). May be equivalent in part to Tbo or Tmbr. All flows in this unit that were analyzed for remanent magnetism have reverse polarity, although all may not be age-equivalent and not all flows were analyzed. Malde and Powers (1972) included most of these flows in their “Banbury Basalt, basalt of upper part.” Stearns and others (1938) included them in the Banbury volcanics.

Of note, "Basalt of Hub Butte" was the name assigned to unit Tub on the source published map (TwinFalls_GM-49-m.pdf), and has this is a shorter name it was adopted over the longer unit name present in the source booklet (TwinFalls_GM-49-B.pdf) and the source GIS data.

Tms - Sediment of Melon Valley (Pliocene or Miocene?)

Light tan to white, pale greenish, or pinkish, fine- to medium-grained, bedded lake and stream deposits with tephra beds and rare, glassy plagioclaseolivine phyric, valley-filling basalt flows. Typically very fine-grained, nondescript sediments, but greenish-gray and local conglomeratic beds with rounded quartzite cobbles were noted at several localities. At one locality, a buried soil horizon was exposed suggesting an intermittent erosional unconformity within the unit. Malde and Powers (1972) mapped the unit as Tbs (Sedimentary deposits of the middle part of the Banbury Basalt) and noted brownish channel sands and pebble gravels as well as the lake deposits with local diatomite and silicic ash beds. They ascribe a thickness of as much as 70 m (100 feet) to the unit, which seems reasonable for the exposed part of the section. However, driller’s logs from water wells drilled in the Melon Valley area

suggest there may be as much as 100 m (several hundred feet) of interbedded lava flows and sediments below the current exposure level.

Tmb - Basalt of Melon Valley, undivided (Pliocene or Miocene?)

Brownish-weathering, fresh to altered aphyric to phyric, olivine-plagioclase and olivine basalt. Probably contains normal and reverse polarity flows. Within Melon Valley, may be equivalent in part to either Tmbr or Tmbn, or may be unrelated sequence of basalt flows. Equivalent in part to undivided basalt flows (Tb) east of Melon Valley.

Tmbn - Basalt of Melon Valley, normal polarity (Pliocene or Miocene?)

Brownish-weathering, weakly altered aphyric to very phyric, olivine-plagioclase and olivine basalt. Remanent magnetic polarity is normal based on field and laboratory analysis. Forms subdued, columnar lava flows as thick as 15 m (50 feet) and thinner vesicular flows 5 m (15 feet) thick. Alteration includes trace chlorite and clay and may be due to combinations of saprolitic spheroidal weathering, to effects of water (water-affected basalt, or WAB, of Godchaux and Bonnichsen, 2002) where flow may have been emplaced underwater or into wet sediments, or to very weak hydrothermal effects of geothermal system. Minor sedimentary interbeds include light-colored clay, silt, sand, and pebble gravel. Reed casts in lacustrine clay beds immediately under the basalt were noted in two localities. An 40Ar/39Ar date on a sample collected during this mapping project resulted in a weighted mean plateau age of 6.90 ± 0.46 Ma (Esser, 2005). Chemical similarities to basalts in upper Salmon Falls Creek canyon south of the Twin Falls 30 x 60 minute quadrangle indicate the source(s) for the Tmbn flows may be from that area. Malde and Powers (1972) mapped these as Tbl, “Banbury Basalt, basalt of lower part.”

Tvp - Vent deposits, proximal facies (late Miocene to Pliocene)

Coarse tuff breccias (blocks to 1-meter diameter), thick air fall tuffs, probable base surge deposits, cinders, and spatter-laden deposits in local phreatomagmatic vent complexes that include the prominent Riverside cone of Stearns and others (1939) and the “Thousand” vent, located in sec. 29 and secs.18 and 19 respectively, T. 8 S., R. 14 E. Includes sequences of explosively erupted layers of ash- to block-sized juvenile tephra and accidental fragments, locally tilted in the vent complex. Proximal facies were mapped by Malde and Powers (1972) who assigned them to the lower Banbury Basalt. Proximal facies are called “tuff of Blue Heart Springs” by Bonnichsen and Godchaux (2002), named for a spring near the Riverside cone. Small stream pebbles and blocks of coherent bedded clay, as well as spatter and blocks of older coarse-grained basalt, are present in the vent deposits. Small exposure of basalt flow over the Riverside cone is included in Tvp but may be equivalent to Tmbr unit. Age poorly constrained. Both vents appear to be unconformably overlain by Tos, Tmbr, or Tb, but the exact nature of the contact with Tbo (lower Banbury Basalt unit of Malde and Powers, 1972) is problematic.

Tvd - Vent deposits, distal facies (late Miocene? to Pliocene)

Variably colored, tan to orangish brown, crudely layered, pyroclastic and volcaniclastic deposits poorly exposed along the eastern Snake River canyon wall near Thousand Springs and Banbury Springs. Correlative to parts of the Banbury volcanics of Stearns and others (1938) and the Tbls and Tbu units mapped by Malde and Powers (1972). Distal facies tuffaceous and volcaniclastic deposits appear to grade laterally into more proximal facies (Tvp) where several vents occur along the Snake River. Unit includes cyclically repeated air fall tuff, local spatter, pebbly gravel deposits suggestive of reworking, and locally palagonitized tuff. Locally unconformably overlain by baked sediments under Tos.

Tbo - Older Tertiary basalt flows, undivided, upstream from Thousand Springs (Miocene to early Pliocene)

Tbo - Older basalt flows, undivided, upstream from Thousand Springs (early Pliocene to Miocene)
Gray to gray-brown, medium- to coarse-grained, mostly altered or weathered basalt flows exposed in the lower part Snake River canyon from south of Thousand Springs to just west of Twin Falls. Source (s) unknown but probably erupted from the south and southeast. Age poorly constrained but probably includes flows from different sources of different ages. One K-Ar date on this unit by Armstrong and others (1975), from an outcrop at the base of Clear Lakes grade, resulted in an age of 4.9 ± 0.6 Ma, indicating it is younger than our Tmbn unit at that location. May be equivalent in part to Tub or Tmbr. All flows included in this unit that were analyzed for remanent magnetism have reverse polarity, although all may not be age-equivalent and not all flows were analyzed. Malde and Powers (1972) included most of these flows in their “Banbury Basalt, basalt of lower part.”

Teh - Basalt of Elmas Hill (late Miocene to Pliocene)

Medium to dark gray, medium-grained, abundantly plagioclase-phyric to dense, fine-grained aphyric basalt. Plagioclase-phyric basalt is very vesicular with a significant amount of caliche coating or filling in the vesicles. Some outcrops appear fresh while others are altered or degraded. Remanent magnetic polarity is reverse as determined in the field and from laboratory analysis. Named for butte just west of the map with a survey point “Elmas” noted on the Crows Nest NE 7.5-minute topographic map. In upper Yahoo Creek, where Teh rests directly on Salmon Falls Creek rhyolite unit (Tsfr), the basalt is abundantly plagioclase phyric and vesicular. In the lower part of Yahoo Creek, Teh forms a gentle dip slope to about Crows Nest Road, where the unit steepens to about 15 degrees and dips beneath Glenns Ferry Formation sediments (Tsgf). Two flows are present in the gully where the dip steepens. The upper flow is dense, fine-grained and aphyric, but the older flow is degraded with gray-brown weathering and a grainy texture. The chemical compositions of the two flows are dissimilar, indicating either chemical changes in the erupting magma or possibly different sources. Textural differences between plagioclase-phyric and aphyric exposures may be due to distance from the source or to separate eruptive events from one or more sources.

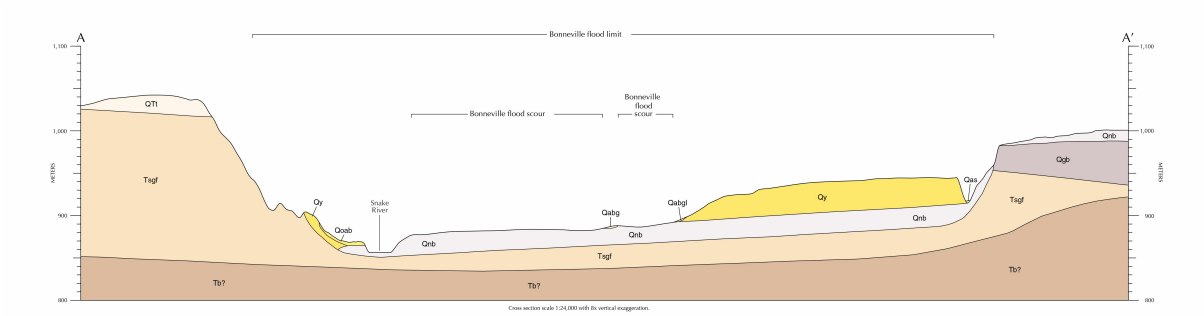
Tsfr - Rhyolite of Salmon Falls Creek, undivided (Miocene)

Physical characteristics and chemical composition indistinguishable from Castleford Crossing (Tcc) and Balanced Rock (Tbr) rhyolites. Most is probably equivalent to the normal polarity Tcc unit but a few locations which gave reverse polarity readings in the field may be equivalent to Tbr unit or perhaps to a younger reverse polarity rhyolite. An 40Ar/39Ar date on a normal polarity unit sampled during this mapping project near the mouth of Salmon Falls Creek canyon resulted in a poorly constrained age of younger than approximately 10 Ma (Esser, 2005).

Geologic Cross Section

The geologic cross section graphic for the one cross section line (A-A') within the extent of the Digital Geologic-GIS Map of Hagerman Fossil Beds National Monument and Vicinity, Idaho (*GRI MapCode HAFO*) is presented below. The cross section graphic was scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document).

Cross Section A-A'



Graphic from source map: Twin Falls 30' x 60'. 8x vertical exaggeration indicated on source map.

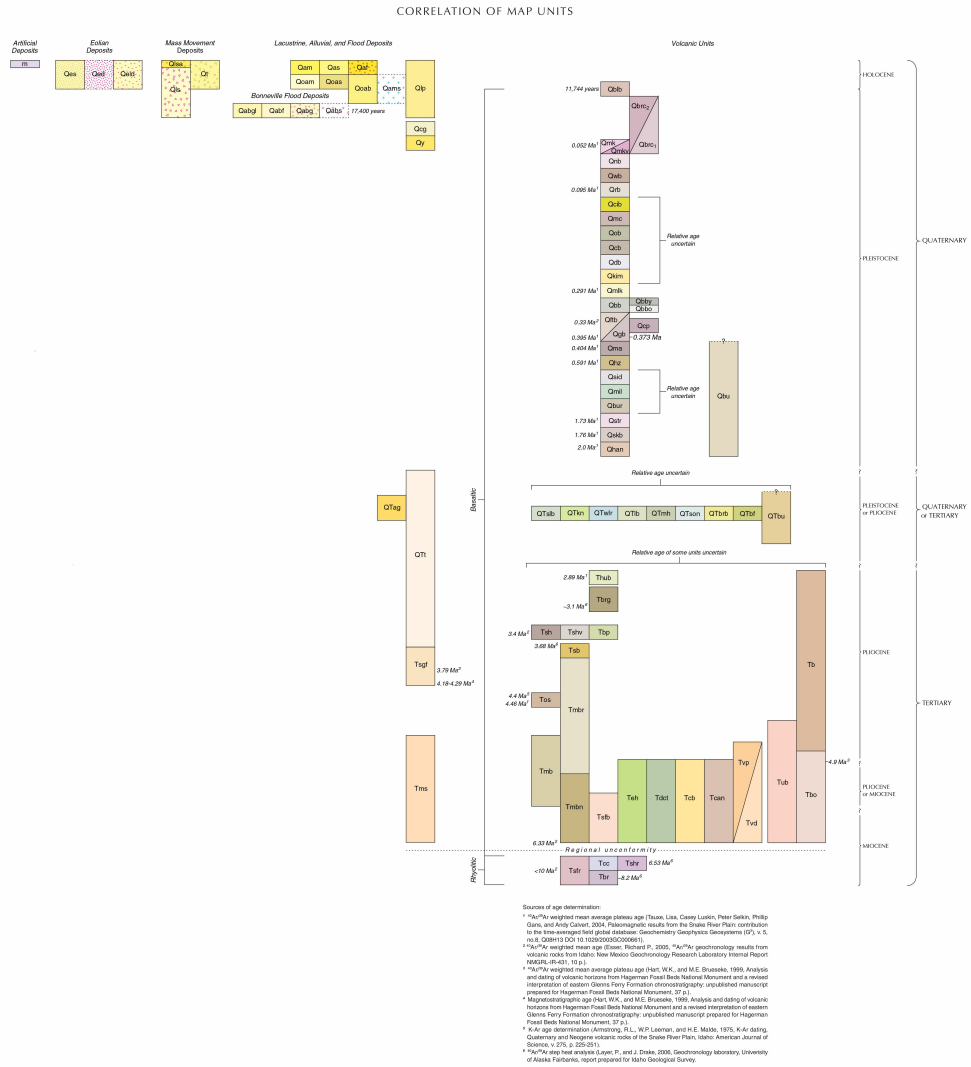
Ancillary Source Map Information

The formal citation for this source.

Othberg, Kurt L., Kauffman, John D., Gillerman, Virginia S., and Garwood, Dean L., 2012, Geologic Map of the Twin Falls 30 x 60 Quadrangle, Idaho: Idaho Geological Survey, Geologic Map, GM-49, scale 1:100,000 (digital data scale 1:24,000) (*GRI Source Map ID 75638*).

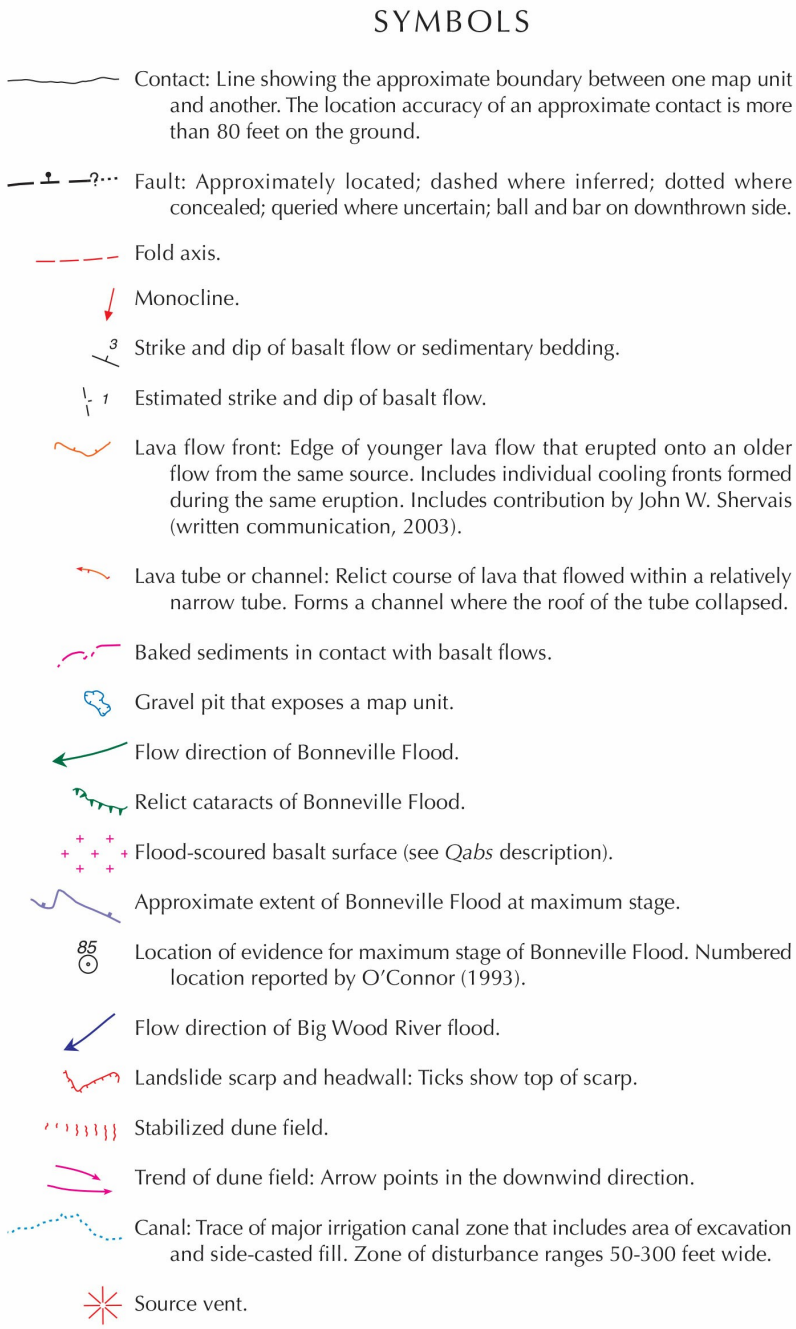
Prominent graphics and text associated with this source.

Correlation of Map Units



Graphic from source map: Twin Falls 30' x 60'. The graphic was scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document).

Map Symbols



Graphic from source map: Twin Falls 30' x 60'

Booklet

An embedded PDF document of the source map booklet can be accessed by double-clicking the following document link.

Twin_Falls_GM-49-B.pdf

The major sections of the report associated with the source map are presented below.

Introduction
Chronology
Description of Map Units
Windblown Deposits and Soils
Bonneville Flood
Structure
Geologic History
Acknowledgements
References
Appendix: Paleomagnetism

Digital Geologic-GIS Map of the Hagerman Fossil Beds National Monument Area

Map Unit List

The geologic units present on the Digital Geologic-GIS Map of the Hagerman Fossil Beds National Monument Area (*GRI MapCode HFBA*) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qal - Stream alluvium). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (HFBAUNIT) table included with the GRI geologic-GIS data. Some source unit symbols, names and/or ages may have been changed in this document and in the GRI digital geologic-GIS data. This was done if a unit was considered to be the same unit as one or more units on other source maps used for this project, and these unit symbols, names and/or ages differed. In this case a single unit symbol and name, and the unit's now recognized age, was adopted. Unit symbols, names and/or ages in a unit descriptions, or on a correlation of map units or other source map figure were not edited. If a unit symbol, name or age was changed by the GRI the unit's source map symbol, name and/or age appears with the unit's source map description.

Cenozoic Era

Quaternary Period
Qal - Stream alluvium
Qtl - Talus
Qls - Landslide debris
Qoa - Older alluvium
Qfg - Alluvial fan deposits
Qm - Melon Gravel
Qmk - McKinney Basalt
Qmk1 - McKinney Basalt, pillow basalt
Qwg - Wendell Grade Basalt
Qss - Sand Spring Basalt
Qcg - Crowsnest Gravel
Qcg1 - Crowsnest Gravel, erosion surface cut on older rocks
Qtt - Thousand Springs Basalt, younger lava flows
Qtm - Thousand Springs Basalt, Malad Member
Qsb - Sugar Bowl Gravel
Qma - Madson Basalt
Qbm - Black Mesa Gravel
Qbs - Bruneau Formation, sedimentary material
Qbf - Bruneau Formation, fan gravel
Qbu - Bruneau Formation, basaltic lava flows
Qbb - Bruneau Formation, subunit V, Berry Ranch lava flow
Qbk - Bruneau Formation, subunit V, King Hill lava flows
Qbr - Bruneau Formation, subunit IV, Morrow Reservoir lava flow
Qbc - Bruneau Formation, subunit IV, Cold Springs Creek lava flow
Qbh - Bruneau Formation, subunit III, Hammett lava flows
Qbg - Bruneau Formation, pebble gravel
Qbd - Bruneau Formation, subunit II, Deadman Canyon lava flow
Qt - Tuana Gravel

Quaternary and Tertiary Periods
QTg - Glenns Ferry Formation, lake and stream deposits
QTgl - Glenns Ferry Formation, Lucerne School lava flow
QTgp - Glenns Ferry Formation, basaltic tuff bed
QTgd - Glenns Ferry Formation, Deer Gulch lava flow
QTgs - Glenns Ferry Formation, Shoestring Road lava flow

QTgc - Glenns Ferry Formation, Clover Creek lava flow
QTgz - Glenns Ferry Formation, Devils Playground lava flow

Tertiary Period
Tbu - Branbury Basalt, basalt of upper part
Tbs - Branbury Basalt, sedimentary deposits of middle part
Tbl - Branbury Basalt, basalt of lower part
Tblp - Branbury Basalt, basalt of lower part, vent deposits
Tbls - Branbury Basalt, stream deposits
Tiv - Idavada Volcanics

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below. All unit descriptions were taken from the source map, Glenns Ferry-Hagerman Area.

Qal - Stream alluvium (Holocene)

Unconsolidated detritus conforming to present topography. Widespread mantle of windblown silt and local dunes of shifting sand not shown.

Qtl - Talus (Holocene)

Unconsolidated detritus conforming to present topography. Widespread mantle of windblown silt and local dunes of shifting sand not shown.

Qls - Landslide debris (Holocene)

Unconsolidated detritus conforming to present topography. Widespread mantle of windblown silt and local dunes of shifting sand not shown.

Qoa - Older alluvium (upper Pleistocene)

Along Snake River consists of pebble and cobble gravel in terraces 25 to 100 feet above present stream grade. In tributary valleys consists of fine-grained stratified deposits in terraces 5 to 10 feet above flood plains. Supports moderately developed calcareous soil.

Qfg - Alluvial fan deposits (upper Pleistocene)

Sand and gravel washed from nearby uplands and graded in some places to deposits of Melon Gravel. Relation to Melon Gravel of deposits mapped in uplands cannot be demonstrated, and these may include material contemporaneous with Crowsnest Gravel. Locally contains old talus debris in upper reaches.

Qm - Melon Gravel (upper Pleistocene)

Boulders and cobbles of basalt in matrix of basaltic sand arranged in giant crossbeds. Boulders commonly 3 feet in diameter; some as large as 10 feet. Forms constructional bars that rise as high as 300 feet above the Snake River, generally downstream from canyon constrictions.

Qmk - McKinney Basalt (upper Pleistocene)

Lava flow of porphyritic plagioclase-olivine basalt from McKinney Butte 9 miles northeast of Bliss. Includes Bliss Basalt (Stearns and others, 1938) of former usage. Fills a canyon as much as 500 feet deep 2 miles west of Bliss and 300 feet deep at Bancroft Springs. Terminus at level of Snake River near King Hill where the thickness is about 20 feet.

Qmk1 - McKinney Basalt, pillow basalt (upper Pleistocene)

Pillow lava facies. See Qmk for unit description.

Qwg - Wendell Grade Basalt (upper Pleistocene)

Lava flow of olivine basalt from Notch Butte 25 miles east of Hagerman. Terminus overlaps talus and landslide debris at canyon wall near Hagerman where the thickness does not exceed 20 feet.

Qss - Sand Spring Basalt (upper Pleistocene)

Lava flow of olivine basalt from vent 42 miles east of Hagerman. Fills a canyon exposed in cross section near mouth of Sand Springs Creek (thickness 225 feet), as well as at several places farther upstream. Surface south of Sand Springs Creek scoured and covered by patches of Melon Gravel too small to show on map. Surface elsewhere in this area largely mantled by eolian sand and silt.

Qcg - Crowsnest Gravel (upper Pleistocene)

Upstream from Hagerman composed mostly of silicic volcanic pebbles distributed chiefly as terrace deposits 250 feet above Snake River (altitude 3,100 feet), but partly as scattered knobs as much as 150 feet higher. Downstream from Pasadena Valley has abundant quartzite and porphyry cobbles in terrace deposits 200 feet above Snake River (altitude 2,700 feet), but includes locally at the top as much as 75 feet of poorly stratified colluvial silt and clay. Deposits on terraces generally 25 to 50 feet thick.

Qcg1 - Crowsnest Gravel, erosion surface cut on older rocks (upper Pleistocene)

Erosion surface cut on older rocks. See Qcg for unit description.

Qtt - Thousand Springs Basalt, younger lava flows (upper Pleistocene)

Qtt - Thousand Springs Basalt, lava flows of porphyritic plagioclase-olivine basalt (Upper Pleistocene)

Lava flows of porphyritic plagioclase-olivine basalt as thick as 75 feet that form canyon fill younger than Malad Member near Thousand Springs, and undivided lava flows farther east.

Qtm - Thousand Springs Basalt, Malad Member (upper Pleistocene)

Lava flows of porphyritic plagioclase-olivine basalt, capped locally with olivine basalt, from Gooding Butte. Fills a canyon 200 feet deep 2½ miles north of Hagerman.

Qsb - Sugar Bowl Gravel (upper Pleistocene)

Pebble gravel rich in quartzite and porphyry. Dissected remnants define a terrace deposit 25 feet thick and 400 feet above Snake River parallel to present stream gradient between Swiss Valley and

Hammett and lying within alcoves developed at tributary junctions.

Qma - Madson Basalt (upper Pleistocene)

Lava flow of olivine basalt probably from a vent east of map area. Fills a canyon discontinuously exposed in cross section from Tuttle westward to Swiss Valley.

Qbm - Black Mesa Gravel (middle Pleistocene)

Gravel and some sand as much as 25 feet thick on Black Mesa and related remnants of a widely preserved pediment surface south of the Snake River and 550 feet higher. Largely reworked from gravel beds of older formations. Capped by caliche layer about 5 feet thick.

Bruneau Formation

Canyon fill of undeformed, unconsolidated sedimentary material and basaltic lava flows. Base of filled canyon about 200 feet above Snake River at Rosevear Gulch (altitude 2,700 feet) but lies near river level at mouth of Bruneau River (altitude 2,375 feet), 40 miles downstream. Thickness of fill about 800 feet near Bruneau, 25 miles west of Glenns Ferry.

Qbs - Sedimentary material
Qbf - Fan gravel
Qbg - Pebble gravel
Qbu - basaltic lava flows

Stratigraphy of lava flows and the presence of several disconformities caused by dissection of lava dams downstream indicate at least five subunits of the canyon fill. These subunits include both sedimentary deposits and basaltic lava flows, as identified below. Vertebrate fossils (Malde and Powers, 1962, p. 1211) and a K-Ar date (Evernden and others, 1964, p. 191) are here assigned to the pertinent subunits because these stratigraphic details are significant for North American mammalian chronology.

Subunit V:
Alluvial deposits: extending from altitude of 3,200 feet to 3,325 feet in upland northwest of Glenns Ferry. Grade into still higher fan gravel and rest on Berry Ranch (Qbb) and King Hill (Qbk) lava flows.
Qbb - Berry Ranch lava flow
Qbk - King Hill lava flows

Subunit IV:
Lake beds: extending form altitude of 2,950 feet to 3,180 feet. Weathering profile at top as much as 5 feet thick yields spruce pollen. Rest on Morrow Reservoir (Qbr) and Cold Springs Creek (Qbc) lava flows.
Qbr - Morrow Reservoir lava flow
Qbc - Cold Springs Creek lava flow

Subunit III:
Lake beds: extending from altitude of 2,850 feet to 3,200 feet. Include six beds of beach gravel indicative of temporary stillstands during rise of lake level. Lowest gravel yields Mammuthus sp. (loc. D234) and Gigantocamelus sp. (loc. D233). Overlie the Hammett lava flows.
Qbh - Hammett lava flows

Subunit II:
Lake beds: extending from altitude of 2,450 feet at mouth of Bruneau River 23 miles west of map edge eastward to 2,950 feet at Deer Gulch. Include a distinctive marker bed of basaltic tuff in lower part. Beach gravel at base in Sailor Creek yields Equus sp. indet., ?Sangamona sp. and ?Odocoileus sp. (loc. D377). Diatomite more than 25 feet thick immediately above the basaltic tuff marker extends from

Sailor Creek to Deer Gulch. Overlie the Deadman Canyon lava flow.
Qbd - Deadman Canyon lava flow

Subunit I:
Lake beds: extending from altitude of 2,775 feet to 2,900 feet. Indicated chiefly by drilling but exposed 1 mile north of Deadman Falls.

Qbs - Bruneau Formation, sedimentary material (middle Pleistocene)

Sedimentary material dominated by massive lake beds of white-weathering fine silt, clay, and diatomite in layers 50 feet or more thick, with minor amounts of alluvial silt and sand. Lake deposits rise to altitude of 3,200 feet and are overlain by mixed alluvial and colluvial deposits of sand, clay, and gravel that rise nearly 300 feet higher.

Qbf - Bruneau Formation, fan gravel (middle Pleistocene)

Fan gravel, cobbly to pebbly. Deposits north of Snake River merge with sedimentary deposits and lava flows in the canyon fill.

Qbu - Bruneau Formation, basaltic lava flows (middle Pleistocene)

Basaltic lava flows that erupted from several vent areas at various times so as to form a series of lava plateaus and canyon-filling volcanic dams. Lavas locally stained brown and yellow but not generally softened by decomposition.

Qbb - Bruneau Formation, subunit V, Berry Ranch lava flow (middle Pleistocene)

Olivine-plagioclase basalt of coarse texture from two vents about 9 miles north of Glenns Ferry. About 25 feet thick on west side of canyon of King Hill Creek, locality of sample KA1188, which is dated at 1.36 m.y. (million years) by Evernden and others (1964, p. 191).

Qbk - Bruneau Formation, subunit V, King Hill lava flows (middle Pleistocene)

Dense lava of glassy texture and gray color in three flows from a vent 16 miles north of King Hill near Deer Heaven Mountain (Malde and others, 1963). Poor in olivine but contains scattered plagioclase crystals more than 1cm long. Commonly vesicular. Chemical composition approximates the average alkali andesite (Powers, 196)and reflects contamination. About 75 feet thick north of King Hill.

Qbr - Bruneau Formation, subunit IV, Morrow Reservoir lava flow (middle Pleistocene)

Basalt of moderately coarse texture containing a few visible olivine crystals; probably from concealed vents about 9 miles north of Glenns Ferry. About 40 feet thick along middle reach of Alkali Creek.

Qbc - Bruneau Formation, subunit IV, Cold Springs Creek lava flow (middle Pleistocene)

Dense lava of glassy texture and of gray to black color from a vent 21 miles north-northwest of Glenns Ferry near the head of West Fork Cold Springs Creek east of Bennett Mountain (Malde and others, 1963). Contains a few small olivine crystals and sparse plagioclase crystals more than 1 cm long. Commonly vesicular. Overlies dissected fan gravel 12 miles north-northwest of Glenns Ferry where the flow is about 40 feet thick.

Qbh - Bruneau Formation, subunit III, Hammett lava flows (middle Pleistocene)

Plagioclase-olivine basalt of coarse texture in at least two flows of medium-grained and relatively nonporphyritic basalt from a group of vents about 20 miles northwest of Glenns Ferry near Mountain Home (Malde and other, 1963). Descend from plateau between Mountain Home and Glenns Ferry onto stream-cut terraces, the lowest being 450 feet above Snake River 4 miles west of Glenns Ferry at The Narrows where the lava is about 40 feet thick.

Qbg - Bruneau Formation, pebble gravel (middle Pleistocene)

Pebble gravel in conspicuous iron-stained beds as much as 25 feet thick in lake deposits. Reworked as beach deposits from contiguous older gravels.

Qbd - Bruneau Formation, subunit II, Deadman Canyon lava flow (middle Pleistocene)

Deadman Canyon lava flow: plagioclase-olivine basalt of dense to medium-grained texture probably from vents near Mountain Home. More than 200 feet thick at Deadman Falls, 5 miles southwest of Glenns Ferry.

Qt - Tuana Gravel (lower Pleistocene)

Pebble and cobble gravel interbedded with layers of massive brown to gray sand and silt. Along Tuana Gulch and Salmon Falls Creek composed dominantly of silicic volcanic debris that covers an erosion surface 600-800 feet above the Snake River. Capped by massive caliche layer several feet thick. Top eroded. About 200 feet thick at Indian Butte, 10 miles southwest of Hagerman.

QTg - Glenns Ferry Formation, lake and stream deposits (lower Pleistocene and upper Pliocene)

Lake and stream deposits characterized by abrupt lateral changes in facies between neighboring sequences several hundred feet thick. Facies include: (1) silt in massive layers marked with faint banding; (2) sand in evenly layered thick beds cemented locally to flaggy sandstone; (3) thinly bedded dark clay, olive silt, and carbonaceous shale; (4) ripple-marked sand and silt; (5) granitic sand and fine pebble gravel; and (6) quartzitic cobble gravel. With these facies are several thin beds of silicic volcanic ash and thicker beds of basaltic tuff, QTgp. Volcanic ash samples KA831 and KA832 are respectively dated at 3.3 m.y. and 3.2 by Evernden and others (1964, p.184).

QTgl - Glenns Ferry Formation, Lucerne School lava flow (lower Pleistocene and upper Pliocene)

Lucerne School lava flow: plagioclase-olivine basalt of coarse texture from vents about 7 miles south of Lucerne School. About 60 feet thick on east side of canyon of Salmon Falls Creek.

QTgp - Glenns Ferry Formation, basaltic tuff bed (lower Pleistocene and upper Pliocene)

Lake and stream deposits characterized by abrupt lateral changes in facies between neighboring sequences several hundred feet thick. Facies include: (1) silt in massive layers marked with faint banding; (2) sand in evenly layered thick beds cemented locally to flaggy sandstone; (3) thinly bedded dark clay, olive silt, and carbonaceous shale; (4) ripple-marked sand and silt; (5) granitic sand and fine pebble gravel; and (6) quartzitic cobble gravel. With these facies are several thin beds of silicic volcanic ash and thicker beds of basaltic tuff, QTgp. Volcanic ash samples KA831 and KA832 are respectively dated at 3.3 m.y. and 3.2 by Evernden and others (1964, p.184).

QTgd - Glenns Ferry Formation, Deer Gulch lava flow (lower Pleistocene and upper Pliocene)

Deer Gulch lava flow: olivine basalt of fine texture from vent about 3 miles southeast of mouth of Deer Gulch. Includes a contemporaneous underlying sill and is laterally equal to a conspicuous bed of basaltic tuff north of King Hill. About 100 feet thick at Deer Gulch. Sample KA1173 from Big Pilgrim Gulch at canal road is dated at 3.48 m.y. by Evernden and others (1964, p. 191).

QTgs - Glenns Ferry Formation, Shoestring Road lava flow (lower Pleistocene and upper Pliocene)

Shoestring Road lava flow: porphyritic plagioclase-olivine basalt of coarse texture from vent 3 miles south of Bliss. About 100 feet thick at mouth of Tuana Gulch.

QTgc - Glenns Ferry Formation, Clover Creek lava flow (lower Pleistocene and upper Pliocene)

Clover Creek lava flow: plagioclase-olivine basalt of fine texture. Source unknown. Thickness exceeds 100 feet near mouth of Clover Creek.

QTgz - Glenns Ferry Formation, Devils Playground lava flow (lower Pleistocene and upper Pliocene)

Devils Playground lava flow: dense basalt finely crystalline to glassy texture and gray color. Locally vesicular. Pillow lava in lower part. Source unknown. As much as 50 feet thick in canyon of King Hill Creek.

Tbu - Branbury Basalt, basalt of upper part (middle Pliocene)

Basalt of upper part: olivine basalt and some porphyritic plagioclase-olivine basalt generally in columnar lava flows as thick as 50 feet, but also in vesicular lava flows seldom more than 15 feet think. In Melon Valley includes a few interbedded sedimentary layers. About 500 feet thick at Dry Creek and 350 feet thick at Melon Valley.

Tbs - Branbury Basalt, sedimentary deposits of middle part (middle Pliocene)

Sedimentary deposits of middle part: largely brownish sand and pebble gravel in lenticular channel deposits, but includes light-colored silt, clay, and diatomite in massive lake deposits, as well as beds of silicic volcanic ash. Thickness variable, but averages 100 feet.

Tbl - Branbury Basalt, basalt of lower part (middle Pliocene)

Basalt of lower part: olivine basalt usually in vesicular lava flows less than 15 feet thick, but contains some columnar lava flows about 30 feet thick. Vesicles commonly filled with zeolites and calcite. Thickness exceeds 400 feet at Dry Creek and 200 feet at Melon Valley.

Tblp - Branbury Basalt, basalt of lower part, vent deposits (middle Pliocene)

Vent deposits of basaltic pyroclastic material**.** See Tbl for unit description.

Tbls - Branbury Basalt, stream deposits (middle Pliocene)

Stream deposits of brownish sand and fine gravel.

Tiv - Idavada Volcanics (Pliocene)

Silicic latite; thick layers of devitrified welded tuff, but includes some bedded vitric tuff and lava flows. Rhyolitic rocks occur in minor amounts, mainly as vitric tuff. Predominantly porphyritic with phenocrysts of andesine, clinopyroxene, hypersthene, and magnetite, but with no quartz, sanidine, hornblende, or biotite. Thickness exceeds 600 feet in canyon of Salmon Falls Creek south of map area near Castleford, and elsewhere exceeds 2,000 feet.

Ancillary Source Map Information

The formal citation for this source.

Malde, Harold E., and Powers, Howard A., 1972, Geologic Map of the Glenns Ferry-Hagerman Area, West-Central Snake River Plain, Idaho: U.S. Geological Survey, Miscellaneous Geologic Investigations Map I-696 (Sheets 1 and 2 of 2), scale 1:48,000 (*GRI Source Map ID 1242*).

Prominent graphics and text associated with this source.

Explanation of Map Units

The map explanation graphics were scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document).

Holocene

Qal | Qtl | Qls

Surficial deposits

Unconsolidated detritus conforming to present topography. Widespread mantle of windblown silt and local dunes of shifting sand not shown

Qal, *stream alluvium*

Qtl, *talus*

Qls, *landslide debris. Includes local deposits older than Melon Gravel* (Qm)

CUTTING OF PRESENT RIVER CHANNEL

Upper Pleistocene

Qoa

Older alluvium

Along Snake River consists of pebble and cobble gravel in terraces 25 to 100 feet above present stream grade. In tributary valleys consists of fine-grained stratified deposits in terraces 5 to 10 feet above flood plains. Supports moderately developed calcareous soil

TERRACE CUTTING

Qfg

Alluvial fan deposits

Sand and gravel washed from nearby uplands and graded in some places to deposits of Melon Gravel. Relation to Melon Gravel of deposits mapped in uplands cannot be demonstrated, and these may include material contemporaneous with Crowsnest Gravel. Locally contains old talus debris in upper reaches

Snake River Group

Qm

Melon Gravel

Boulders and cobbles of basalt in matrix of basaltic sand arranged in giant crossbeds. Boulders commonly 3 feet in diameter; some as large as 10 feet. Forms constructional bars that rise as high as 300 feet above the Snake River, generally downstream from canyon constrictions

CUTTING OF PRESENT CANYON

Qmk

McKinney Basalt

Lava flow of porphyritic plagioclase-olivine basalt from McKinney Butte 9 miles northeast of Bliss. Includes Bliss Basalt (Stearns and others, 1938) of former usage. Fills a canyon as much as 500 feet deep 2 miles west of Bliss and 300 feet deep at Bancroft Springs. Terminus at level of Snake River near King Hill where the thickness is about 20 feet

Pillow lava facies shown by pattern

CONFORMABLE CONTACT

Qwg

Wendell Grade Basalt

Lava flow of olivine basalt from Notch Butte 25 miles east of Hagerman. Terminus overlaps talus and landslide debris at canyon wall near Hagerman where the thickness does not exceed 20 feet

CANYON CUTTING; REMOVAL OF LAVA DAM

Qss

Sand Springs Basalt

Lava flow of olivine basalt from vent 4½ miles east of Hagerman. Fills a canyon exposed in cross section near mouth of Sand Springs Creek (thickness 225 feet), as well as at several places farther upstream. Surface south of Sand Springs Creek scoured and covered by patches of Melon Gravel too small to show on map. Surface elsewhere in this area largely mantled by eolian sand and silt

CANYON CUTTING TO PRESENT DEPTH

Qcg

Crowsnest Gravel

Upstream from Hagerman composed mostly of silicic volcanic pebbles distributed chiefly as terrace deposits 250 feet above Snake River (altitude 3,100 feet), but partly as scattered knobs as much as 150 feet higher. Downstream from Pasadena Valley has abundant quartzite and porphyry cobbles in terrace deposits 200 feet above Snake River (altitude 2,700 feet), but includes locally at the top as much as 75 feet of poorly stratified colluvial silt and clay. Deposits on terraces generally 25 to 50 feet thick

Related erosion surface cut on older rocks shown by pattern

TERRACE CUTTING

Qtt | Qtm

Thousand Springs Basalt

Lava flows of porphyritic plagioclase-olivine basalt and some olivine basalt from Gooding Butte and vents farther east. Includes Malad Basalt and Thousand Springs Basalt as well as parts of Sand Springs Basalt as these three were mapped by Stearns and others (1938). Smoothly mantled with gravel, sand, and silt in alluvial and eolian deposits as much as 50 feet thick. In Hagerman Valley consists of two parts separated by an unconformity with at least 150 feet of relief as a result of canyon cutting between eruptive episodes

Qtt, *lava flows of porphyritic plagioclase-olivine basalt as thick as 75 feet that form canyon fill younger than Malad Member near Thousand Springs, and undivided lava flows farther east*

Qtm, *Malad Member: lava flows of porphyritic plagioclase-olivine basalt, capped locally with olivine basalt, from Gooding Butte. Fills a canyon 200 feet deep 2½ miles north of Hagerman*

UNCONFORMABLE ON MADSON BASALT; OCCUPIES CANYON CUT BELOW SUGAR BOWL GRAVEL

Qsb

Sugar Bowl Gravel

Pebble gravel rich in quartzite and porphyry. Dissected remnants define a terrace deposit 25 feet thick and 400 feet above Snake River parallel to present stream gradient between Swiss Valley and Hammett and lying within alcoves developed at tributary junctions

TERRACE CUTTING

Qma

Madson Basalt

Lava flow of olivine basalt probably from a vent east of map area. Fills a canyon discontinuously exposed in cross section from Tuttle westward to Swiss Valley

QUATERNARY

Pleistocene

Middle Pleistocene

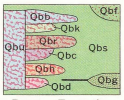
Idaho Group

Qbm

Black Mesa Gravel

Gravel and some sand as much as 25 feet thick on Black Mesa and related remnants of a widely preserved pediment surface south of the Snake River and 550 feet higher. Largely reworked from gravel beds of older formations. Capped by caliche layer about 5 feet thick

BROAD VALLEY EROSION



Bruneau Formation

Canyon fill of undeformed, unconsolidated sedimentary material and basaltic lava flows. Base of filled canyon about 200 feet above Snake River at Rosecear Gulch (altitude 2,700 feet), but lies near river level at mouth of Bruneau River (altitude 2,375 feet), 46 miles downstream. Thickness of fill about 800 feet near Bruneau, 25 miles west of Glenns Ferry

Qbs, *sedimentary material dominated by massive lake beds of white-weathering fine silt, clay, and diatomite in layers 50 feet or more thick, with minor amounts of alluvial silt and sand. Lake deposits rise to altitude of 3,200 feet and are overlain by mixed alluvial and colluvial deposits of sand, clay, and gravel that rise nearly 300 feet higher*

Qbf, *fan gravel, cobbly to pebbly. Deposits north of Snake River merge with sedimentary deposits and lava flows in the canyon fill*

Qbg, *pebble gravel in conspicuous iron-stained beds as much as 25 feet thick in lake deposits. Reworked as beach deposits from contiguous older gravels*

Qbu, *basaltic lava flows that erupted from several vent areas at various times so as to form a series of lava plateaus and canyon-filling volcanic dams. Lavas locally stained brown and yellow but not generally softened by decomposition*

Stratigraphy of lava flows and the presence of several disconformities caused by dissection of lava dams downstream indicate at least five subunits of the canyon fill. These subunits include both sedimentary deposits and basaltic lava flows, as identified below. Vertebrate fossils (Malde and Powers, 1962, p. 1211) and a K-Ar date (Evernden and others, 1964, p. 191) are here assigned to the pertinent subunits because these stratigraphic details are significant for North American mammalian chronology

Subunit V:

Alluvial deposits: extending from altitude of 3,200 feet to 3,325 feet in upland northwest of Glenns Ferry. Grade into still higher fan gravel and rest on Berry Ranch (Qbb) *and King Hill* (Qbk) *lava flows*

Qbb, *Berry Ranch lava flow: olivine-plagioclase basalt of coarse texture from two vents about 9 miles north of Glenns Ferry. About 25 feet thick on west side of canyon of King Hill Creek, locality of sample KA1188, which is dated at 1.36 m.y. (million years) by Evernden and others (1964, p. 191)*

Qbk, *King Hill lava flows: dense lava of glassy texture and gray color in three flows from a vent 16 miles north of King Hill near Deer Heaven Mountain (Malde and others, 1963). Poor in olivine but contains scattered plagioclase crystals more than 1 cm long. Commonly vesicular. Chemical composition approximates the average alkali andesite (Powers, 1960) and reflects contamination. About 75 feet thick north of King Hill*

Subunit IV:

Lake beds: extending from altitude of 2,950 feet to 3,180 feet. Weathering profile at top as much as 5 feet thick yields spruce pollen. Rest on Morrow Reservoir (Qbr) *and Cold Springs Creek* (Qbc) *lava flows*

Qbr, *Morrow Reservoir lava flow: basalt of moderately coarse texture containing a few visible olivine crystals; probably from concealed vents about 9 miles north of Glenns Ferry. About 40 feet thick along middle reach of Alkali Creek*

Qbc, *Cold Springs Creek lava flow: dense lava of glassy texture and of gray to black color from a vent 21 miles north-northwest of Glenns Ferry near the head of West Fork Cold Springs Creek east of Bennett Mountain (Malde and others, 1963). Contains a few small olivine crystals and sparse plagioclase crystals more than 1 cm long. Commonly vesicular. Overlies dissected fan gravel 12 miles north-northwest of Glenns Ferry where the flow is about 40 feet thick*

Subunit III:

Lake beds: extending from altitude of 2,850 feet to 3,200 feet. Include six beds of beach gravel indicative of temporary stillstands during rise of lake level. Lowest gravel yields Mammuthus *sp. (loc. D234) and* Gigantocamelus *sp. (loc. D233). Overlie the Hammett lava flows*

Qbh, *Hammett lava flows: plagioclase-olivine basalt of coarse texture in at least two flows of medium-grained and relatively nonporphyritic basalt from a group of vents about 20 miles northwest of Glenns Ferry near Mountain Home (Malde and others, 1963). Descend from plateau between Mountain Home and Glenns Ferry onto stream-cut terraces, the lowest being 450 feet above Snake River 4 miles west of Glenns Ferry at The Narrows where the lava is about 40 feet thick*

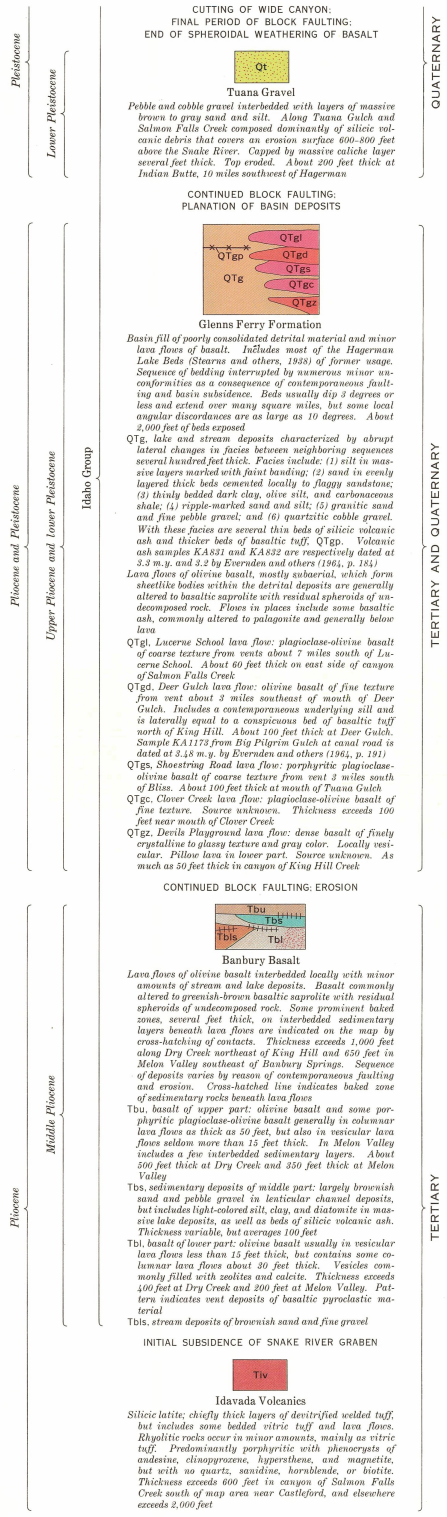
Subunit II:

Lake beds: extending from altitude of 2,450 feet at mouth of Bruneau River 23 miles west of map edge eastward to 2,950 feet at Deer Gulch. Include a distinctive marker bed of basaltic tuff in lower part. Beach gravel at base in Sailor Creek yields Equus *sp. indet.,* ?Sangamona *sp., and* ?Odocoileus *sp. (loc. D377). Diatomite more than 25 feet thick immediately above the basaltic tuff marker extends from Sailor Creek to Deer Gulch. Overlie the Deadman Canyon lava flow*

Qbd, *Deadman Canyon lava flow: plagioclase-olivine basalt of dense to medium-grained texture probably from vents near Mountain Home. More than 200 feet thick at Deadman Falls, 5 miles southwest of Glenns Ferry*

Subunit I:

Lake beds: extending from altitude of 2,775 feet to 2,900 feet. Indicated chiefly by drilling but exposed 1 mile north of Deadman Falls



Graphics from source map: Glenns Ferry-Hagerman Area.

Map Symbols

Contact

Dashed where approximately located; cross-hatching indicates baked zone of sedimentary rocks beneath lava flows of Banbury Basalt

Fault

Dashed where approximately located; dotted where concealed; queried where doubtful. U, *upthrown side;* D, *downthrown side. Hachures indicate fault scarp against which younger rocks were deposited; hachures on side of younger deposit*

Dry hole

×538

Pebble-count locality

Showing locality number used on accompanying table

●20410

Fossil mollusk locality

Showing USGS Washington Cenozoic catalog number

●D1123

Fossil vertebrate locality

Showing USGS Denver catalog number

●F182

Fossil locality

Showing author's field number

●4169*

Fossil diatom locality

Showing USGS Washington diatom catalog number

●D1690-1

Fossil pollen locality

Showing USGS Denver catalog number

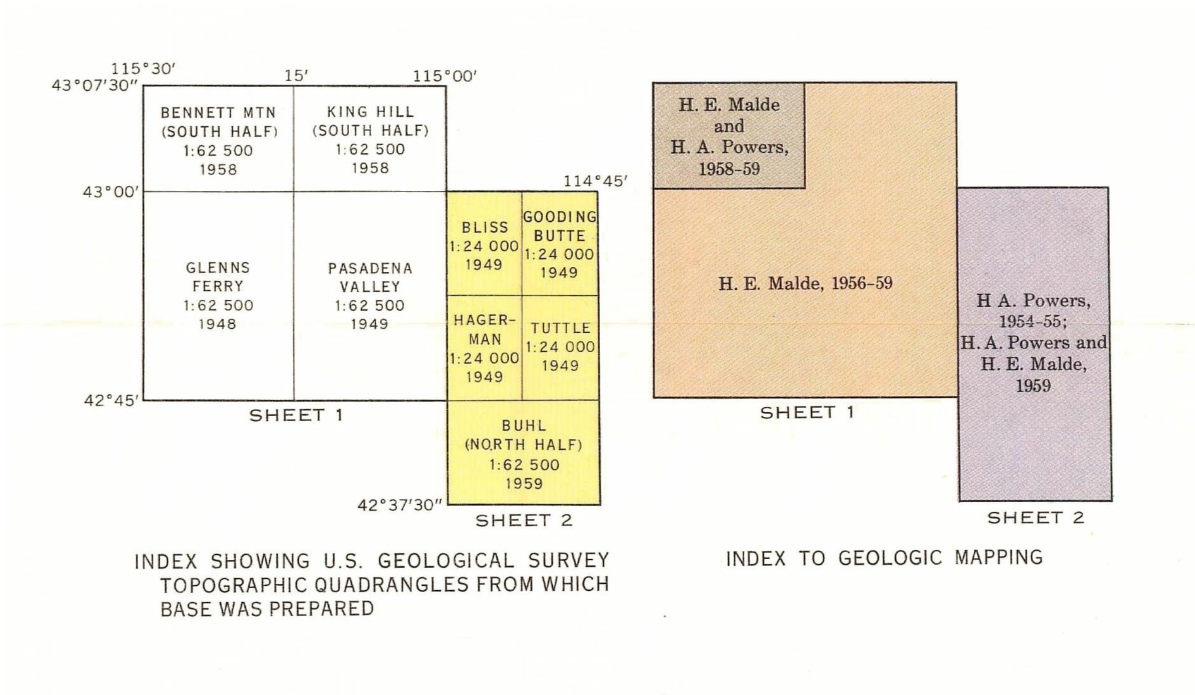
*KA832

Sample locality for potassium-argon age determinations

Showing sample number of Evernden and others (1964)

Graphic from source map: Glenns Ferry-Hagerman Area

Index Maps



Graphics from source map: Glenns Ferry-Hagerman Area

Table of Selected Pebble Counts in Percent

Localities of selected pebble counts, present on the table below (listed by locality number), are present in the GRI digital geologic-GIS data in the Geologic Observation Localities (GOL) data layer. Locality numbers are present in the Locality ID field in the data. The graphic was scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document).

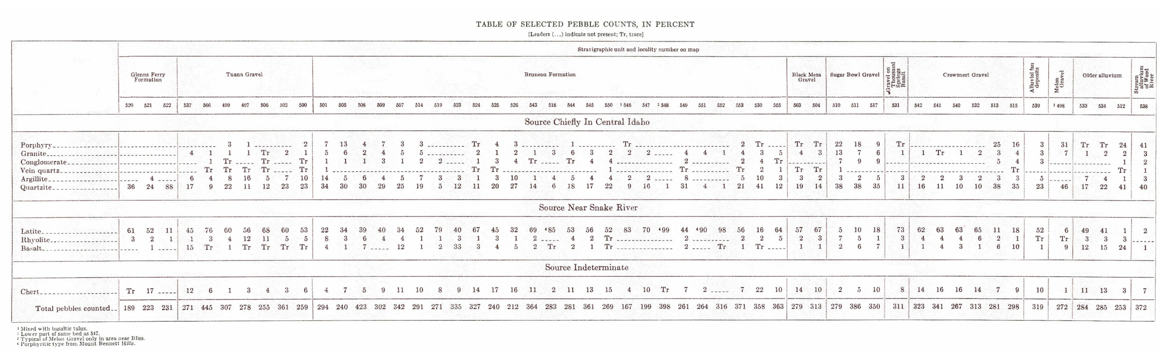


TABLE OF SELECTED PEBBLE COUNTS, IN PERCENT

[Leaders (...) indicate not present; Tr, trace]

Stratigraphic unit and locality number on map

	Glenns Ferry Formation			Tuana Gravel						
	520	521	522	537	566	499	497	506	502	500
Source Chiefly In Central Idaho										
Porphyry	...	...	...	...	...	3	1	...	...	2
Granite	...	...	...	4	1	1	1	Tr	2	1
Conglomerate	...	...	...	...	1	Tr	...	Tr	...	Tr
Vein quartz	...	...	...	...	Tr	Tr	Tr	Tr	...	Tr
Argillite	...	4	...	6	4	8	16	5	7	10
Quartzite	36	24	88	17	9	22	11	12	23	23
Source Near Snake River										
Latite	61	52	11	45	76	60	56	68	60	53
Rhyolite	3	2	1	1	3	4	12	11	5	5
Basalt	...	1	...	15	Tr	1	Tr	Tr	Tr	Tr
Source Indeterminate										
Chert	Tr	17	...	12	6	1	3	4	3	6
Total pebbles counted	189	223	231	271	445	307	278	255	361	259

	Bruneau Formation											
	501	505	508	509	507	514	519	523	524	525	526	543
Source Chiefly In Central Idaho												
Porphyry	7	13	4	7	3	3	...	...	Tr	4	3	...
Granite	5	6	2	4	5	5	...	...	2	1	2	1
Conglomerate	1	1	1	3	1	2	2	...	1	3	4	Tr
Vein quartz	1	...	...	...	...	...	...	...	Tr	Tr	...	...
Argillite	14	5	6	4	5	7	3	3	1	3	10	1
Quartzite	34	30	30	29	25	19	5	12	11	20	27	14
Source Near Snake River												
Latite	22	34	39	40	34	52	79	40	67	45	32	69
Rhyolite	8	3	6	4	4	1	1	3	1	3	1	2
Basalt	4	1	7	...	12	1	2	33	3	4	5	2
Source Indeterminate												
Chert	4	7	5	9	11	10	8	9	14	17	16	11
Total pebbles counted	294	240	423	302	342	291	271	335	327	240	212	364

	Bruneau Formation (continued)												
	518	544	545	550	[1] 546	547	[2] 548	549	551	552	553	530	555
Source Chiefly In Central Idaho													
Porphyry	...	1	...	...	Tr	...	...	...	...	...	2	Tr	...
Granite	3	6	3	2	2	2	...	4	4	1	4	3	5
Conglomerate	...	Tr	4	4	...	...	...	2	...	...	2	4	Tr
Vein quartz	...	...	...	1	...	...	...	Tr	...	...	Tr	2	1
Argillite	4	5	4	4	2	2	...	8	...	...	5	10	3
Quartzite	6	18	17	22	9	16	1	31	4	1	21	41	12
Source Near Snake River													
Latite	[4] 85	53	56	52	83	70	[4] 99	44	[4] 90	98	56	16	64
Rhyolite	...	4	2	Tr	...	...	...	2	...	...	2	2	5
Basalt	Tr	2	1	Tr	...	...	...	2	...	Tr	1	Tr	...
Source Indeterminate													
Chert	2	11	13	15	4	10	Tr	7	2	...	7	22	10
Total pebbles counted	283	281	361	269	167	199	398	261	264	316	371	358	363

	Black Mesa Gravel		Sugar Bowl Gravel			Gravel on Thousand Springs Basalt	Crowsnest Gravel						Alluvial fan deposits	Melon Gravel	Older alluvium			Stream alluvium of Wood River
	503	504	510	511	517	531	542	541	540	532	513	515	539	[3] 498	533	534	512	538
Source Chiefly In Central Idaho																		
Porphyry	Tr	Tr	22	18	9	Tr	...	...	...	...	25	16	3	31	Tr	Tr	24	41
Granite	4	3	13	7	6	1	1	Tr	1	2	3	4	3	7	1	2	2	3
Conglomerate	...	...	7	9	9	...	...	...	...	...	5	4	3	...	...	...	1	2
Vein quartz	Tr	Tr	1	...	...	...	...	...	...	...	...	Tr	...	...	...	...	Tr	1
Argillite	3	2	3	2	5	3	2	2	3	2	3	3	5	...	7	4	1	3
Quartzite	19	14	38	38	35	11	16	11	10	10	38	35	23	46	17	22	41	40
Source Near Snake River																		
Latite	57	67	5	10	18	73	62	63	63	65	11	18	52	6	49	41	1	2
Rhyolite	2	3	7	5	1	3	4	4	4	6	2	1	Tr	Tr	3	3	3	...
Basalt	1	1	2	6	7	1	1	4	3	1	6	10	1	9	12	15	24	1
Source Indeterminate																		
Chert	14	10	2	5	10	8	14	16	16	14	7	9	10	1	11	13	3	7
Total pebbles counted	279	313	279	386	350	311	323	341	267	313	281	298	319	272	284	285	253	372

[1] Mixed with basaltic talus.
[2] Lower part of same bed as 547.
[3] Typical of Melon Gravel only in area near Bliss.
[4] Porphyritic type from Mount Bennett Hills.

Graphic from source map: Glenns Ferry-Hagerman Area.

References

Evernden, J.F., Savage, D.E., Curtis, G.H., and James, G.T., 1964, Potassium-argon dates and the Cenozoic mammalian chronology of North America: Am. Jour. Sci., v. 262, p. 145-198.

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Stearns, H.T., Crandall, Lynn, and Steward, W.G., 1938, Geology and ground-water resources of the Snake River Plain in southeastern Idaho: U.S. Geol. Survey Water-Supply Paper 774, 268 p. (1939)

Text from source map: Glenns Ferry-Hagerman Area

GRI Digital Data Credits

This document was developed and completed by Stephanie O'Meara and Sarah Lowe (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory(GRI) Program. Quality control of this document by Stephanie O'Meara and James Winter (Colorado State University).

The information in this document was compiled from GRI source maps, and is intended to accompany the digital geologic-GIS maps and other digital data for Hagerman Fossil Beds National Monument, Idaho (HAFO) developed by Stephanie O'Meara and James Winter (see the GRI Digital Maps and Source Map Citations section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS maps). Anne Poole and Georgia Hybels (NPS GRD) initially digitized and developed the Monument Area map.

GRI finalization by Stephanie O'Meara.

GRI program coordination and scoping provided by Bruce Heise, Jason Kenworthy and Tim Connors (NPS GRD, Lakewood, Colorado).