Projection: Idaho State Plane Coordinate System, west zone, 1927 North

Base built from U.S.G.S. 1:100.000-scale Digital Line Graph and Geographic

Geology was digitized from nine 1:24,000-scale originals and then compiled

Color separations were digitally set by Optronics Specialty Company, Inc.,

for publication at 1:50,000.

Geologic map data are available in GIS format.

Name Information System data. Contours on western third of map were

GEOLOGY OF THE BOISE BASIN VICINITY, BOISE, ADA, AND ELMORE COUNTIES, IDAHO

By T. H. Kiilsgaard, T. M. Scanlan, and D. E. Stewart

Scale 1:50,000

-----This geologic map of the Boise Basin vicinity was prepared during the period 1984-1993 as part of research in the Hailey 1° x 2° quadrangle and western part of the Idaho Falls 1° x 2° quadrangle. The study was conducted by the U.S. Geological Survey in cooperation with the Idaho Geological Survey and the departments of geology at Idaho State University and the University of Idaho. The project was part of the U.S. Geological Survey's Conterminous Mineral Assessment Program (CUSMAP). Research results are published in U.S. Geological Survey Bulletin 2064, volumes 1 and 2. Most of the geologic information shown on this map has been incorporated into the 1:250,000scale geologic map of the Hailey 1° x 2° quadrangle (Worl and others,

3 Pioneerville

4 Shafer Butte

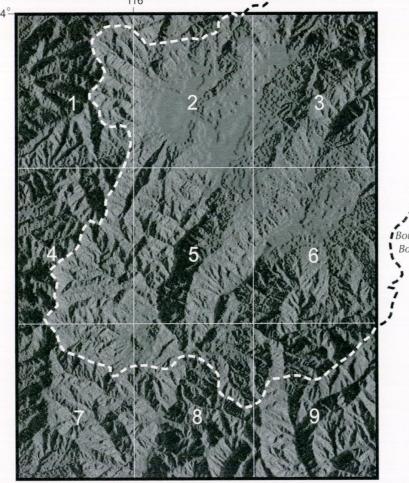
5 Warm Springs Point

present stream valleys.

The geographic term "Boise Basin" is widely used locally and in some published reports, but the boundary of the basin is not shown on topographic or other maps of the area. This probably is because former descriptions of the basin boundary have varied. As used herein, the basin covers an area of about 376 square miles, including the drainage area of Grimes and Mores Creeks upstream from the junction of those two streams. The approximate location of the basin boundary, with respect to the nine 1:24000-scale quadrangles covered by this map, is shown on the Index to 1:24,000-scale

INTRODUCTION

Index to 1:24,000-scale Topographic Maps



Intrusive into the Idaho batholith are stocks of plutonic rocks of Eocene age.

Rock types in these stocks include diorite (Td), quartz monzodiorite (Tqm),

hornblende-biotite granodiorite (Tgd), gabbro (Tgb), and biotite granite (Tg).

Intrusive into both the Cretaceous and Eocene plutonic rocks are myriad

Tertiary dikes that range from basalt to rhyolite in composition. Locally

overlying the plutonic rocks and dikes are sedimentary sandstone and shale

of the Payette Formation (Tp) of Late Miocene age in which are intermittent

interbeds of the Columbia River Basalt Group (Tcb). Resting locally on biotite

granodiorite of the Idaho batholith is volcanic rhyolite (Tv) of Oligocene

age. The youngest igneous rock in the Boise Basin is basalt of Quaternary

and which is referred to here as the Basalt of Mores Creek (Qsb).

age, which crops out along Mores Creek and the lower end of Grimes Creek

Crossing the Boise Basin is a major system of northeast-striking regional

faults. Northeast extensions of several of these faults were previously

recognized in the contiguous Challis 1° x 2° quadrangle to the north as

members of the trans-Challis fault system (Kiilsgaard and Lewis, 1985). These

northeast-striking faults have guided the emplacement of Eocene plutonic

rocks and Tertiary dikes. The locations of gold-silver veins around Quartzburg

are also controlled by the northeast-striking fault system. Also conspicuous

in the area are north-striking faults, one of which, the Boise Ridge fault,

crosscuts and offsets the northeast-striking vein system exposed near

At least three mappable units of gravel occur in the area. The oldest of these,

High gravel (Qhg) of Pleistocene age, occurs as caps on ridges and appears

to be a remnant of extensive Pleistocene deposits. Terrace (bench) gravel

(Qtg) occurs along the flanks of Grimes Creek and parts of Mores Creek and

appears to be, in part, reworked High gravel. Recent alluvium (Qal) coats

CORRELATION OF MAP UNITS

DESCRIPTION OF MAP UNITS

gravel deposits and from present valley walls and deposited along the floor

centimeters or meters deep and not much wider than the stream itself. At

other localities, however, the alluvium may be 15 m or more deep and may

gravel and Terrace gravel deposits, recent alluvium may also be gold-bearing,

particularly in deeper sections of the alluvium near underlying bedrock and

not too far downstream from the eroded source of the gold. Placer gold

tends to diminish in quantity downstream from the erosional source, eventually

becoming too scarce to be economic to mine. Alluvium is deposited at any

point along a stream where the volume of water in a stream or the stream

part of the area along both sides of Mores Creek. They are especially evident

along the western side of Mores Creek between Daggett and Robie Creeks.

The landslides are the result of slope failure caused by the movement of

unstable, sheared, altered, and deeply weathered Cretaceous biotite

Terrace or Bench Gravel (Pleistocene)—Terrace gravel occurs along Grimes

Creek, along Granite Creek downstream from Quartzburg, and along both

sides of Mores Creek near Idaho City. Tops of the terraces or benches are

as much as 24 m above the level of the nearby valley floor. Like the High

gravel, the Terrace gravel also is gold bearing, and at many localities the

original benchlike form of the deposits has been obliterated by placer mining.

Deposits of Terrace gravel have formed from the erosion of the older High

gravel, and the tops of the benches represent contiguous, former valley-floor

levels before uplift. Following uplift, accelerated erosion of the streams

transported most of the valley floor material downstream, leaving only,

remnants (terraces) of the former valley fill plastered along the sides of the

uplifted valleys. Terrace gravel is considered to be Late Pleistocene in age

and to have formed during times when abundant water from melting glacial

(1898) to describe gravel on ridges, some occurrences hundreds of meters

above stream level. We have retained that term for these unusual deposits.

High gravel was particularly significant during early settlement in the Boise

Basin as it commonly was gold bearing and was placer mined. Along the

southern side of Mores Creek opposite Idaho City, the ridges between

California Gulch on the west and Pine Creek on the east are capped by High

gravel. The base of the gravel is about 107 m above Mores Creek. It rests

lisconformably on tilted lacustrine beds of the Payette Formation and

originally (Lindgren, 1898) was as much as 15 m thick. Most of this gravel

was mined hydraulically, and the mine tails now are strewn on the hillsides

and in the gulches. Features of the original deposits are difficult to determine.

High gravel was also placer mined on East Hill, immediately east of Idaho

City, and on Gold Hill also east of Idaho City but north of Bear Gulch. The

High gravel on Gold Hill is more than 30 m thick and is well exposed in

Another High gravel deposit mined by hydraulic methods is on the ridge

southwest of Idaho City, east of Placer Creek, and about 427 m north of

Thorn Creek. The base of this deposit is 195 m above Thorn Creek. A larger

unmined deposit of High gravel is south of Thorn Creek on the ridge between

Thorn and Minneha Creeks. The base of the highest gravel on the ridge is

378 m above Thorn Creek. These High gravels probably are not gold bearing,

but parts of the depostis may not have been mined possibly because water

High gravel caps ridges between Little Muddy and Muddy Creeks northwest

of Pioneerville and near Placerville. Much of this gravel has been placed

mined. The base of the gravel in these areas ranges from 4,400 feet to 4,600

feet (1,341-1,402 m). The highest deposit found in the area is on Boise Ridge

515 m southwest of Hawley Mountain Lookout at an altitude of 2,133 m,

The High gravel consists of poorly sorted to unsorted sand, gravel, cobbles,

and boulders eroded from rocks of the Idaho batholith and from various

dikes. Cobbles and boulders as much as 1.5 m in diameter are common in

stream channels eroded into underlying rocks and indicate deposition from

high-energy streams. Resistant dike rocks, particularly aplite, rhyolite, and

rhyodacite, make up much of the deposits. Quartz fragments ranging in size

from sand to boulders are common in the deposits. Perhaps 10 to 20 percent

of the High gravel around Placerville consists of basalt pebbles and cobbles

eroded from lava flows of the Columbia River Basalt Group that had buried

for placer mining could not be brought profitably to the sites.

about 792 m above the base of High gravel near Placerville.

a pre-Late Miocene erosional surface of low relief.

Geology of the northeast-striking belt of dikes, from Quartzburg to north

Publication of this colored geologic map was made possible through funds

granted by the Boise Cascade Corporation and the Idaho Geological Survey.

Digital cartography, GIS conversion, and map production by Lori D. Snyder,

Daryle R. Faircloth, Timothy D. Funderburg, Steve F. Mulberry, Jane S. Freed

and Loudon R. Stanford at the Idaho Geological Survey's Digital Mapping

border of the map, modified from Anderson (1947).

Printed by Universal Printing Company, St. Louis, Missouri.

the face of a hydraulic pit that was mined into the 1930s.

High Gravel (Pleistocene)—High gravel is the descriptive term used by Lindgren

ice was eroding the previously deposited High gravel.

Landslide Deposits (Holocene)—Landslide deposits are common in the southern

granodiorite along or near major fault zones.

gradient is reduced and the stream no longer can transport the alluvial load.

cover the valley floor across widths of 800 m or more. Like the older High

of present streams. Along small streams the alluvium may be only a few

7 Robie Creek 8 Dunnigan Creek Payette Formation (Miocene)—Exposures of Payette Formation are scattered in the western part of the area. The most studied exposures are near Idaho City

in the northern part of the area and along Clear Creek south of the Clean Creek lodge. The most extensive exposures are west of Boise Ridge. Plutonic rocks of the Idaho batholith of Cretaceous age underlie the Boise Basin. These rocks consist chiefly of biotite granodiorite (Kgd) and muscovite-

Lindgren (1898) recognized the lacustrine beds of clay, sandstone, and grave near Idaho City to be comparable to rocks he had mapped in the foothills north of Boise, and which he named the Payette Formation. Knowlton (1898) tudied plant flora from the Payette, some of which were collected near Idaho City, and concluded the formation was Late Miocene in age. Smith (1941) and Axelrod (1964) later studied flora from an exposure of lacustrine rocks about 0.8 km upstream from the mouth of Thorn Creek. From her studies, Smith (1941) concluded the rocks were units of the Payette Formation and were Late Miocene in age. Reasons that suggest the Payette Formation might properly be mapped as units of another group of rocks are presented in USGS Bulletin 2064, Chapter BB.

The High gravel is considered to be Pleistocene in age and to have been

deposited by periglacial streams. The region was undergoing uplift during

Pleistocene time, and many of the deposits appear to have formed on a

topographic surface unrelated to the present one. The minor variance in

altitude of the bases of many deposits suggests the gravel, most of which is

walnut sized or smaller, was dumped as an alluvial fan or series of fans,

either at the foot of higher ground that extended to the north or at the edge

decrease in stream gradient caused the streams derived from melting glacial

ice to deposit their heavy loads. While the high-energy streams may have

headed well to the north of the Boise Basin, High gravel deposits north of

Boise Basin are not known to be auriferous. Thus, most of the placer gold

in the High gravel deposits in and near the Boise Basin must have originated

Glacial Deposits (Pleistocene)—Glacial deposits are rare in the area and found

only along the upper reaches of Clear Creek in the northeast corner of the

map. At that site, at an altitude near 1,768 m, are remnants of a lateral

were scoured during Pleistocene alpine glaciation from the high ridge that

extends northeast from Wilson Peak. More extensive lateral moraines are

northeast of the map area, on both sides of Grimes Creek near Summit Flat

Most of the terrain is too low in altitude to have been affected by Pleistocene

alpine glaciation. Any small moraines that may have formed at higher

Quaternary Snake River Group of Lava Flows

by young basalt, identified by Howard and others (1982) as the Basalt of

Mores Creek, a unit of the Snake River Basalt Group. The basalt extends

from the mouth of Mores Creek to about 2.4 km above the junction of Mores

and Grimes Creeks and about 1.6 km up Grimes Creek. At the junction of

Mores and Grimes Creeks, the top of the basalt is about 73 m above stream

level. The top of the basalt is almost the same distance above stream level

The basalt flowed into a pre-existing canyon cut into the Cretaceous biotite

granodiorite by ancestral Mores Creek. Mapping by Scanlan (1986) indicates

he vent for the Basalt of Mores Creek is along the south side of Corral Creek,

about 0.8 km from the mouth of the stream. At that locality a hilltop capping

of basalt, identical in physical characteristics to the Basalt of Mores Creek,

crops out 61 m above the nearby basalt that extends along Mores Creek. A

sample from the Corral Creek exposure (sample 85-145K, Table 2, map site

18) is identical in chemical composition to three samples of the Basalt of

Mores Creek (samples 85-144K, 85-146K, and 85-150K, Table 2, map sites

17, 19, and 20). Basalt from the Corral Creek vent flowed into the Mores

The Basalt of Mores Creek is dark gray, vesicular, and rich in olivine. It is

composed of lathlike crystals of plagioclase (labradorite) set in a matrix that

is chiefly augite, ilmenite, and magnetite but which also contains crystals

and granules of olivine, most of which are larger in size than the labradorite

laths. Larger crystals or granules of olivine are commonly rimmed by red-

brown iddingsite. Small specks of a red-brown, somewhat opaque mineral

The Basalt of Mores Creek is Pleistocene in age. A sample of the basalt from

Mores Creek canyon near the mouth of Rush Creek gave a potassium-argon

age of 0.44 +/- 0.20 Ma (mega-annum: million years; Howard and others,

and along the lower part of Thorn Creek about 11 km southwest of Idaho

in the basalt probably are iddingsite, although they could be limonite altered

from magnetite or ilmenite, two minerals that compose a significant part of

Creek canyon and backed up into both Mores and Grimes Creeks.

Basalt of Mores Creek (Pleistocene)—The valley of Mores Creek is dominated

altitudes have since been destroyed by stream erosion.

downstream at the junction of Mores and Robie Creeks.

moraine composed of unsorted boulders, cobbles, pebbles, and sand that

from the erosion of gold-bearing veins there.

of a large basin that extended to the south. Whatever the terrane, an abrupt

Warm Springs, about 3 km southwest of Idaho City, sandstone predominates and forms clifflike exposures, which on the northwest side of Mores Creek rise more than 122 m above the valley floor. The sandstone has been eroded from the surrounding granitic hills, and near Warm Springs it has been silicified by hot water from the springs. Silicified sandstone forms the more durable outcrops in that locality. The sandstone has been tilted since deposition and now strikes northeast and dips as much as 45 degrees to the northwest Along the northwest side of the exposure, displacement along the Elk Creek ault has placed the sandstone against Cretaceous biotite granodiorite. Southeast of Warm Springs on the southeast side of Mores Creek, a large

A variety of sedimentary rocks are included in the Payette Formation. Near

exposure of Payette Formation extends northeast about 7 km to Granite Creek. The rocks are chiefly sandstone with interbedded shale, clay, and volcanic ash. On the ridge between Bairds and Campbell Gulches, at outcrops washed clean by hydraulic placer mining, is an indurated capping unit of sandstone about 1.2 m thick. Above the sandstone is High gravel of Pleistocene age that was hydraulically placer mined. Beneath the sandstone is poorly sorted, nonindurated sand and gravel about 6 m thick. Cobbles as much as 15 cm long occur in the gravel. Beneath the sand and gravel unit is 1.8 m of dark basaltic ash, now largely altered to clay. Sandstone and shale underlie the basaltic ash. Pieces of coalified wood and unidentified plant fossils were found in black shale near the mouth of Pine Creek. Large exposures of the Payette Formation along the southeast side of Mores Creek are mantled by gravel mined hydraulically for placer gold from High gravel that overlies the Payette sediments. According to Lindgren (1898), the earlyday placer miners called the Payette lake beds "false bedrock." Very little, if any, gold was mined from the false bedrock. Olivine-rich basalt is interbedded in Payette sediments near the eastern end of the exposure. Near Idaho City, small outcrops of basalt are interbedded in the Payette lacustrine

Lacustrine rocks, chiefly sandstone, shale, and interbedded clay identical to lacustrine rocks exposed at Idaho City and at Thorn Creek, crop out on Muddy and Little Muddy Creeks, on the South Fork of Clear Creek, and on the ridge west of Hill Creek in the northwest corner of the area. Basalt is interbedded with the sedimentary rocks at the latter two areas. The rocks a all three localities have physical characteristics similar to those of the lacustrine rocks at the Idaho City and Thorn Creek exposures. Fragments of unidentified flora were found along Muddy Creek. At the Hill Creek exposure, in the NE1/4, sec. 32, T. 8 N., R. 3 E., at the border of the map, an inclined adit was driven northeast on a bed of bituminous coal 5-8 cm thick. According to Jack Frye (oral commun., 1989), coal was mined from the adit before 1926 and used at his father's farm house. Sacked coal was hauled to Bois Basin, where it was sold to different mining concerns that used it in blacksmith forges. The thickness of the Payette Formation in the Idaho City area is estimated at more than 175 m.

Columbia River Basalt Group (Miocene)—Small exposures of flows in the Columbia River Basalt Group are scattered in the area. The easternmost exposure is about 0.8 km east of Idaho City, along the northern road bank of State Highway 21 and along Forest Service Road 304, which extends south along Pine Creek. Other small exposures are scattered remnant caps on ridge tops near Placerville.

Placerville, south of the Star Ranch summer home area and south of Trail Creek along the county road leading from Placerville to Horseshoe Bend. This exposure is offset along the western side by the Boise Ridge fault. The largest exposure of Columbia River basalt is in the northwest corner of the area, extending from the top of Hawley Mountain north and west well beyond the limits of the map. Most of this large mass of basalt on the west side of Boise Ridge is essentially a dip-slope exposure, the beds of basalt dipping west at angles of inclination near those of the west-sloping hillsides. Basalt of the large northwest exposure has been offset along two large north-The other, an unnamed fault, extends along the upper reaches of Pumpkin

The basalt appears to have flowed onto an uneven, low-relief land surface

determinations) and in magnetic polarity at exposures on both sides of the

Oligocene Volcanic Rocks

rhyolite rests on an eroded surface of Cretaceous biotite granodiorite, and

only remnant masses remain, most of the rhyolite having eroded away. The

best exposure is in a quarry near the Clear Creek lodge. Rhyolite from the

quarry is used as road metal on several dirt roads in a nearby housing

development. Rhyolite crops out on a ridge at the old Davidson Ranch,

about 3/4 mile southwest of the Clear Creek lodge. The southern end of this

elongate rhyolite exposure is enclosed by lacustrine rocks of the Payette

The rhyolite is light gray, almost white, very fine-grained, and crystal poor.

It consists of a matrix of quartz and potassium feldspar in which are angular

pieces of quartz, sanidine, and oligoclase that range from 1 to 3 mm long.

Sparse biotite in the rock is somewhat altered to chlorite; dark microscopic

particles probably are glass. Accessory minerals include zircon and magnetite.

The rock shows fluidal banding that is somewhat obscured by post-

emplacement crystallization of the matrix minerals. No shards or evidence

of former shards were seen, and no pumice was found. Physical characteristics

of the rock, both those seen under the microscope and in the field, suggest

Two samples of the rhyolite were dated: one from the Clear Creek lodge

guarry and the other from an outcrop on Elk Creek about 25 km southeast

of the Clear Creek exposures. Zircon from the two samples was dated by

R.A. Zimmerman of the U.S. Geological Survey using the fission-track

exposure procedure. The two samples show good age agreement, one being

34.0 + /- 2.4 Ma and the other 32.7 + /- 2.7 Ma. So far as the authors know,

the two Oligocene dates mark the first Oligocene volcanic rhyolite found

and muscovite were not seen in thin sections of the rock.

Fracture surfaces commonly are stained by limonite. Pyroxenes, amphiboles,

Rhyolite of Clear Creek (Oligocene)—Several small exposures of volcanic

rhyolite are on the ridge north of Clear Creek in sec. 21, T. 5 N., R. 4 E. The

and Pumpkin Creeks, but rare elsewhere.

A larger exposure of Columbia River basalt is about 6 km southwest of

Basalt in the various exposures has many similar physical features. The rock is dark gray to black, fine grained—the average grain size being less than 0.5 mm, but commonly porphyritic with euhedral lathlike phenocrysts of plagioclase (andesine to labradorite) to 4 mm in length. Olivine is a common mineral in most of the samples, occurring as phenocrysts larger than the phenocrysts of plagioclase. Granular augite is a common matrix mineral. Small crystals of quartz are rare in the basalt, but magnetite is common.

dioritic suite: diorite, quartz monzodiorite, hornblende-biotite granodiorite, The base of remnant ridge caps of basalt near Placerville is about 1,372 m, and the basalt base near Idaho City and Clear Creek is about 1,219 m. Basalt on Hawley Mountain is much higher, the base at about 1,950 m. Basalt on Diorite (Eocene)—In the porphyry belt, diorite is exposed across Wolf Creek, Boise Ridge and near Placerville and to the south appears to have flowed I km north of Placerville. It is also exposed near the head of Smith Creek onto a common surface, which subsequently was displaced by fault movement east of Pioneerville and on the high ridge southwest of Mt. Heinen in the along the Boise Ridge fault, the surface east of the fault being downdropped. southern part of the area. This fault interpretation is supported by the similarities in chemical characteristics (see map for sample sites and Table 2 for analytical The diorite tends to crop out peripheral to or near the quartz monzodiorite

unit, which suggests the diorite is older than the porphyritic quartz monzodiorite, but this age distinction is not supported by dates obtained from samples of the rock. The diorite weathers easily and is commonly The rock weathers readily and forms a red, claylike soil in which are remnant exposed as flat ridge-tops or as benches. Weathered diorite also forms a somewhat rounded boulders of unweathered basalt. Only irregular, somewhat distinctive, fine-grained, dark, reddish brown soil. knobby, patchy outcrops are seen on the more gentle slopes. Cliffs of basalt are conspicuous at some northwestern exposures, particularly along Hill The diorite is dark gray, equigranular, and fine to medium grained. Clots or

large crystals of hornblende give some exposures of the rock a slightly porphyritic appearance. The rock tends to have a salt and pepper appearance Correlating the basalt with vast exposures of the Columbia River Basalt caused by lighter plagioclase crystals interstitial to darker mafic minerals, Group of Miocene age in western Idaho, Oregon, and Washington is based all of the mineral crystals being about the same size. Green hornblende is on lithologic similarities. In addition, vast areas of Columbia River basalt the principal mafic mineral and may account for as much as 40 percent of elsewhere are interbedded with fresh-water sedimentary rocks of Miocene the rock. Augite and hypersthene also are common constituents, and biotite age, as is much of the basalt in the Boise Basin vicinity. The most accessible is rare. The plagioclase minerals are andesine grading to labradorite, both interbedded exposure is about 1 mile east of Idaho City where basalt is strongly zoned. Quartz content generally is less than 5 percent, although interbedded with the Payette Formation, which Knowlton (1898) described locally there may be enough quartz to make the rock a quartz diorite as Late Miocene in age. Basalt is also interbedded with the Payette Formation Potassium feldspar content generally is less than 2 percent. Magnetite, apatite, along the South Fork of Clear Creek about 2.4 km northeast of the Clear sphene, and zircon are common accessories. Secondary minerals in the Creek Summit. Perhaps the most striking exposures of basalt interbedded in rock include epidote, sericite altered from plagioclase minerals, and chlorite the Payette Formation are along the north side of Hill Creek, NE1/4 sec. 6, altered from hornblende. T. 7 N., R. 2 E., about 0.8 km west of the west boundary of the map.

> Quartz Monzodiorite (Eocene)—A porphyritic texture is the striking characteristic of the quartz monzodiorite. Phenocrysts in the rock are chiefly strongly zoned plagioclase, although some are quartz. Another conspicuous feature is fresh-appearing, vitreous, euhedral biotite.

> The rock is dark greenish gray and commonly contains 10 to 30 percent of green hornblende, which is euhedral, acicular, and commonly glomerocrystic. Clinopyroxene is common, both as small phenocrysts and as cores of hornblende grains. Ellipsoidal inclusions of fine-grained, hornblende-rich rock are common. Strongly zoned andesine is the dominant plagioclase both in the groundmass and the phenocrysts. Quartz and potassium feldspa (chiefly intermediate microcline) are subordinate interstitial minerals. Primary muscovite was not found in the rock. Accessory minerals include magnetite apatite, sphene, allanite, zircon, and monazite. Like the diorite, quartz monzodiorite weathers readily and forms a dark reddish brown soil.

Hornblende-biotite Granodiorite (Eocene)—Hornblende-biotite granodiorite is similar to quartz monzodiorite in many respects, differing primarily in being more evenly granular in texture and much less porphyritic. It also contains more quartz and less plagioclase.

The rock also differs from quartz monzodiorite in distribution. Quartz monzodiorite is more prevalent in the western part of the area, whereas hornblende-biotite granodiorite dominates in the southeastern part and continues east. The principal exposure in the southeast corner is on the high ridge that extends along the north side of the Boise River. The rock is dark greenish black and more or less even textured but with an occasional plagioclase phenocryst. Green hornblende makes up as much as 28 percent of the rock and accounts for the dark color. Vitreous, euhedral biotite is distinctive characteristic. The quartz content ranges from 20 to 28 percent. Strongly zoned andesine is the principal plagioclase mineral. Potassium

feldspar (microcline) is present in about the same percentages as quartz.

Clinopyroxene occurs in the rock but in rather limited amounts. Primary

muscovite was not found. Accessory minerals include magnetite, zircon,

apatite, monazite, allanite, and sphene. Secondary minerals are principally

epidote, sericite altered from feldspars, and chlorite altered from biotite.

Gabbro (Eocene)—Three small stocks of gabbro crop out on Thorn Cree idge in the southeast quarter of the map. The rock is dark gray, equigranula and medium to fine grained. It is layered and consists chiefly of cumulate aggregates of labradorite grading to andesine, hypersthene, augite, and olivine. Quartz content is less than 1 percent, and fine-grained potassium the area. Although some dikes have diverse attitudes, the overwhelming feldspar is less than 10 percent. The plagioclase minerals are altered to sericite. Magnetite, zircon, apatite, and sphene are common accessories.

The dikes range from basalt to rhyolite in composition and are porphyritic

They range in width from a few centimeters to more than 91 m and in length

from a few meters to more than 914 m. The dikes cut all plutonic rocks in

majority strike northeast. Emplacement of the dikes appears to have been

guided by northeast-striking faults that are prominent throughout the Boise

Basin area. Locally, the dikes are so numerous and spaced so close to each

northeast from Quartzburg. Lindgren (1898) described this swarm as the

In the field, the dikes may be considered in two broad categories: dark green

to gray mafic dikes that range from dacite to basalt in rock type, and reddisl

weathered, felsic dikes of rhyolitic composition. In composition, the dark

green mafic dikes are similar to the dioritic, plutonic rocks with whom they

may be genetically related. By contrast, the rhyolitic dikes are compositionally

similar to Eocene biotite granite. The rhyolitic dikes are more radioactive

than other dikes, a distinctive feature that also characterizes the Eocene

The porphyritic dikes cut plutonic rocks dated as Eocene; thus, the dikes

can be no older than Eocene. Muscovite in a rhyolite dike at the Gold Hill

mine near Quartzburg (sample HN-GH-3, Table I, map locality F) has been

dated at 45.8 m.y., a date that coincides with the age of Eocene plutonic

rocks of the area and that suggests the other porphyritic dikes of the porphyry

belt may also be Eocene in age. Porphyritic dikes do, however, cut the

Eocene plutonic rock, indicating the dikes are younger. Zircon from a rhyolite

dike at the Little Falls molybdenite property north of the area yielded a

fission-track age of 29.3 +/- 1.7 Ma (Oligocene; Kiilsgaard and others, 1989)

which suggests that other rhyolitic dikes of the area may also be younger

Field relations indicate dacitic dikes of the mafic suite are older than the

rhyolitic dikes, as some rhyolite dikes cut across dacitic dikes.

Basin vicinity. East of the map area, similar basaltic dikes were found to

strike northwest and cut across older, northeast-striking porphyritic dikes.

On Boise Ridge, about 1.2 km southwest of Hawley Mountain, a basalt dike

that is about 0.61 m thick strikes north and cuts Columbia River basalt of

Late Miocene age. Farther south, along the Boise Ridge near and along the

west side of the West Fork of Clear Creek are a number of north-striking

basalt dikes that cut muscovite-biotite granite and biotite granodiorite of the

Idaho batholith. Hand specimens show the dike rock to be dark gray and

dense. The rock contains considerable magnetite but sparse amounts of

olivine and quartz. The dark dikes tend to stand out as ledges and are not

(Tdl), the distinction from basalt based on the medium-grained, ophitic to

subophitic texture. An occasional dark, mafic, porphyritic dike in which the

ferromagnesium phenocrysts were set in a dark aphanitic groundmass was

classed as lamprophyre, although these field classifications are arbitrary and

not supported by adequate laboratory work. Indeed, whether the two rock

types are separate or simply varieties of basalt is questionable.

Rhyolite (Eocene)—Rhyolite is the most common dike rock in the Boise Basir

vicinity. The dikes are rich in quartz, which makes them resistant to erosion

thus, they commonly stand above the ground surface. High points on ridge

crests commonly are exposures of rhyolite. The rock is light gray on fresh

surfaces, but on weathered surfaces most outcrops are stained reddish by

iron oxides derived from oxidized pyrite. The rhyolite may be weakly to

intensely porphyritic: the phenocrysts being quartz, potassium feldspar, or

plagioclase and ranging in length from 2 to 15 mm. The phenocrysts are set

in an aphanitic groundmass of quartz and feldspars. Rounded phenocryst

of guartz are common, some with chalcedonic rims. Plagioclase phenocrysts

are oligoclase. Spherulitic intergrowths of quartz and potassium feldspar are

common in the aphanitic groundmass. Sparse amounts of hornblende and

biotite were found in some specimens of the dikes, the biotite usually

intensely altered to chlorite. Feldspar minerals in the rock commonly are

samples of the rock, but on outcrop exposures the pyrite usually is altered

Chemical composition of the rhyolite is similar to that of biotite (pink) granite,

with which it may be genetically related. The rhyolite, like the biotite (pink)

weakly porphyritic. The phenocrysts are plagioclase and commonly 2 to 4

mm long. Biotite, various ferromagnesian minerals, and calcic plagioclase

The dikes tend to be small, commonly only a few centimeters thick but

occasionally swelling to a thickness of 3 m or more. They range in length

from a few meters to 91 m or more. The dikes tend to be wispy: one pinches

out at one locality and another starts in an en echelon location a short

In the field, andesite dikes are difficult to distinguish from dikes of basalt

or lamprophyrye. Basalt contains less silica than andesite. In the field we

used a guartz limit of 5 percent for basalt, but the guartz content in a dark,

ine-grained rock is difficult to determine. Some dikes identified as andesite

likely are basalt. Some basaltic dikes could also be lamprophyre, a dark

rock carrying only ferromagnesium phenocrysts in an aphanitic groundmass,

but an accurate field determination of such features in a weathered rock is

not easy to make. Also, some andesite dikes classed as Tertiary in age possibly

are Cretaceous. Andesite dikes weather to a dark brown soil and leave poorly

exposed outcrops from which it is difficult to establish relationships with

Quartz Monzodiorite (Eocene)—Quartz monzodiorite dikes have a composition

similar to plutonic quartz monzodiorite but differ in that the groundmass

texture of the dike rock is aphanitic and not granitic as is characteristic of

plutonic rock. The rock is highly porphyritic, the phenocrysts accounting

for as much as half of the rock mass. Phenocrysts in the rock are as much

as 1 cm long, but normally range from about 2 to 6 mm. The phenocrysts

are chiefly zoned andesine and hornblende. Magnetite is a common accessory

is almost identical to quartz monzodiorite. The dike rock differs only in

quartz content, the granodiorite containing more than 20 percent quartz.

is distinguished from plutonic granodiorite by the aphanitic texture.

Hornblende-biotite Granodiorite (Eocene)—Hornblende-biotite granodiorite

Dacite (Eocene)—Dacite dikes are dark greenish to gray and porphyritic, the

phenocrysts set in an aphanitic groundmass. Most of the phenocrysts are

plagioclase (zoned andesine), although some are quartz, which is commonly

resorbed and rounded. Small phenocrysts of hornblende and biotite are

common. The rock tends to be bimodal, with all feldspar phenocrysts about

the same size set in an aphanitic groundmass composed chiefly of feldspars

Eocene Plutonic Rocks

A belt of younger igneous rocks, extending from Quartzburg northeast to

beyond Mineral Mountain, was first recognized by Lindgren (1898), who

referred to the rocks and associated dikes as the "porphyry belt." Anderson

(1947) also used this term to describe both the plutonic and porphyritic dike

rocks in the belt. Our dating of plutonic rocks of the belt shows them to be

Three belts of Eocene plutonic rocks cross the Boise Basin area. The first bel

is more or less the porphyry belt exposures as Anderson (1947) mapped

them. The second belt extends from Boise Peak, in the southwest corner of

the map area, northeast to beyond Idaho City. The third and largest of the

belts extends from the lower reaches of Robie Creek, in the southwest corner

of the map, northeast beyond the map. Included in the third belt is the Sheep

Creek batholith of biotite granite (Lewis and Kiilsgaard, 1991), most of which

Emplacement of the Eocene plutonic rocks along the three belts appears to

have been guided by pre-existing northeast-trending faults of the trans-Challis

belt, and our mapping supports his interpretation. In the second belt,

northeast-striking faults appear not only to have controlled emplacement of

Eocene rocks, but also to have been the sites of post-Eocene fault movement.

Continuous exposure of northeast-striking faults was not found in the third

belt of plutonic rocks. In that belt, and possibly in local parts of the other

two belts as well, the guiding northeast-striking faults may have been

obliterated by the invading, younger, Eocene plutonic rocks. Eocene plutonic

Digritic Suite—The rocks of the digritic suite have similar chemical composition

and tend to grade from one type to another with little change in physical

features. They are dark and contain abundant hornblende and commonly

pyroxene. Plagioclase tends to be the most abundant mineral, and quartz

is present in relatively small amounts. Magnetite is abundant in the dioritic

suite of rocks, exposures of which commonly show as magnetic highs on

aeromagnetic maps. Soil of the decomposed rocks is even granular and dark

reddish brown in contrast to the fragmental and light-buff soil that forms

from Cretaceous igneous rocks. Four types of rocks are recognized in the

fault system. Anderson (1947) recognized the fault control of the porphyry

s northeast of the eastern boundary of the map.

and quartz. Magnetite is a common accessory mineral.

andesine-labradorite) are the principle mineral constituents. The quartz

Andesite (Eocene)—Andesite in dikes is dark gray to black, fine grained, and

granite, is more radioactive than other Tertiary dikes.

content is low, less than 20 percent.

known Tertiary dikes.

Diabase and Lamprophyre (Eocene)—A few dark dikes were mapped as diabase

Basaltic Dikes (Miocene)—Basaltic dikes are the youngest dikes in the Boise

other that they constitute a swarm or belt, an example of which extends

Biotite (Pink) Granite (Eocene)—Exposures of biotite (pink) granite in the Boise Basin area are chiefly in the southern part of the map, the westernmost being along the lower part of Robie Creek. A large exposure to the east lies along the western side of Cottonwood Creek, and still farther to the east is th western part of the Sheep Creek batholith (Lewis and Kiilsgaard, 1991). A small northeast-trending exposure in the northern part of the map is at the neads of Applejack and Little Muddy Creeks.

Coarse grains of equigranular potassium feldspar account for the striking

pink color. Subordinate variants contain phenocrysts of potassium feldspar. he potassium feldspar is intermediate microcline and is highly perthitic. Granophyric intergrowths of potassium feldspar and quartz are common. Quartz in the rock commonly is dark due to radiation damage. Radioactivity n the pink granite is two to four times greater than in the intruded Cretaceous plutonic rocks. The plagioclase is oligoclase, commonly with albitic rims. Biotite content of the rock averages less than 4 percent, and commonly the piotite is partially altered to chlorite. Occasional crystals of hornblende were found in the rock, but no primary crystals of muscovite were present. Accessory minerals include allanite, apatite, zircon, and pyrite. Small miarolitic cavities, commonly 1-3 mm long, are a distinctive characteristic of the pink granite, especially east of the map area along high ridges and peaks such as Steel Mountain.

Leucocratic Granite (Cretaceous)—Dikes of leucocratic granite crop out at few localities in the Boise Basin area and only in plutonic rocks of the Idaho patholith. The rock is light gray and fine to medium grained, and has a distinctive anhedral texture. It is similar in many respects to aplite. Quartz plagioclase (oligoclase), and potassium feldspar (chiefly microcline) are the principal minerals; the mineral grains are all about the same size and preser in about equal amounts. Both the plagioclase and potassium feldspar are moderately altered to sericite. Accessory minerals include magnetite, sphene,

Distinguishing features of the rock are the fine to medium grain size and the light color. The rock is resistant to erosion and tends to form high points or ridges. It weathers to a resistant, noticeably rubbly scree, which gives the appearance on hillsides of having originated from a much larger intrusive The dikes are considered to be Late Cretaceous in age. They cut plutonic

rocks of the Idaho batholith but were not found in the Eocene plutonic rocks

East of the Boise Basin and north of Deer Park on the North Fork of the Boise River, a stock of leucocratic granite is intruded by Eocene biotite granite, which indicates the leucocratic granite is older. Pegmatite and Aplite (Cretaceous)—Of the few pegmatite dikes in the Boise Basin area, most were small and were not mapped. Some pegmatites are 3 m (meters) or more thick and several meters long. Most of these larger

dikes are shown on the map. The most observable dike exposures are on ridge tops where their resistance to erosion causes them to stand out above Narrow dikes of light gray, fine-textured aplite, most less than 15 cm thick and only a few meters long, are common in granitic rocks of the Idaho batholith, but because of their small size and erratic distribution were not

mapped. Quartz and feldspar minerals are the principal constituents of the aplite, but the mineral crystals are so small that hand specimen identification Pegmatites are light gray to white and distinguished by the large grain size of contained minerals. Muscovite, a common mineral, may occur in sheets

15 cm or more wide. Quartz and feldspars also are common minerals, and

in many places large crystals of these minerals are graphically intergrown.

About 1.6 km southwest of Pioneerville and 914 m up Swede Creek on the south bank of the stream is a pegmatite dike that strikes N. 40 W. and is about 2 m thick. In 1990, the dike had been explored in a bulldozed trench. Large sheets of ruled muscovite littered the bulldozed area, but no other minerals of possible commercial significance were seen. Bart Curren of Boise (oral commun., 1994) did the bulldozer work in the mid-1980s. The work did not find any beryl crystals of commercial value, but according to Curren, a previous but unknown operator found some beryl crystals in the pegmatite, one of which was reported to be excellent quality.

Plutonic Rocks of the Idaho Batholith

Muscovite-Biotite Granite (Cretaceous)—A northeast-trending belt of muscovite-biotite (two-mica) granite (Kg), grading to granodiorite, crosses the Boise Basin, extending from points west of Boise Ridge to the upper reaches of Hall and Clear Creeks to the northeast. Locally, the two-mica rock is displaced by northeast-striking faults, but in a general sense, the trend of the belt more or less parallels the trend of the faults and gives the impression that ancestral northeast-trending faults may have guided its emplacement. Post-intrusive adjustment along some of these faults has placed the two-mica granite in fault contact with contiguous biotite granodiorite. Normally, where not in fault contact, the muscovite-biotite granite-biotite granodiorite contact is transitional.

Muscovite-biotite granite closely resembles biotite granodiorite and is distinguished from it only by contained primary muscovite, which occurs in books or laminated plates that are large enough to recognize in hand sample. The rock is massive, light gray, medium to coarse grained, and equigranular to porphyritic. Principal minerals of the rock are oligoclase, quartz, and potassium feldspar. The content of muscovite in the samples ranged from 3 to 9 percent, and that of biotite from 2 to 8 percent. Garnet is a common accessory mineral, but hornblende was not found and sphene

ight gray on fresh surfaces but commonly stained rusty to reddish on veathered surfaces. The rock is medium to coarse grained and equigranula to porphyritic. Biotite is altered to chlorite or to iron oxides, which account for the characteristic reddish stain. Feldspars in the rock are altered to clay minerals or sericite. Commonly, feldspars are so intensely altered that identifying the original mineral is uncertain. Locally, the rock is moderately to intensely silicified either by silica flooding of the matrix or by countless interlacing veinlets of quartz that are 2 mm (millimeters) or less in thickness. The increased silica content makes the rock resistant to erosion and accounts for the high ridge points and the steeper-gradient gorges where cut by

Altered Biotite Granodiorite (Cretaceous)—Altered biotite granodiorite is

area. The most conspicuous outcrop is the high, red-tinted, sparsely timbered ridge at the head of Grayback, Shaws, and California Gulches about 4 km due south of Idaho City. Other exposures are along and near the south end of the high ridge between Grimes and Mores Creeks at the head of Stierman Gulch. A prominent exposure is on both sides of Mores Creek near the mouth of McKinley Gulch. Larger exposures of the rock are farther south along the top of the high ridge that separates Mores Creek from the Boise River, especially near the heads of Voquelin Gulch and Dunnigan Creek.

Altered biotite granodiorite is exposed at several localities in the Boise Basin

All mapped exposures of the altered biotite granodiorite are near exposures of younger plutonic rocks of Eocene age. Many of them are also near or along prominent northeast-striking faults. Field evidence indicates that alteration of the biotite granodiorite was generated by Eocene hydrothermal activity. Some of the larger exposures of altered granodiorite very likely overlie buried Eocene intrusive rocks. Biotite Granodiorite (Cretaceous)—The most common rock type in the

Boise Basin area. The rock is light gray, medium to coarse grained, and equigranular to porphyritic. Phenocrysts of the porphyritic variety, like those near Quartzburg, are 2 cm (centimeters) or less in length and are principally potassium feldspar. Porphyritic varieties of the rock were not mapped as separate units. Plagioclase (weakly zoned oligoclase) is the principal minera in the rock. Quartz is a common constituent, chiefly somewhat darkened and commonly appearing as scattered aggregates of contiguous crystals rather than as large single crystals. Biotite makes up 2 to 12 percent of the rock and commonly is partially altered to chlorite. Sericite, an alteration product, is widespread throughout the rock, but primary muscovite is sparse collected from the Boise Basin area. Accessory minerals include sphene, zircon, monazite, allanite, ilmenite, and magnetite.

MAP SYMBOLS

Contact: dashed where approximately located, dotted where concealed Fault: dashed where approximately located, dotted where concealed; bar and ball on downthrown Strike and dip of beds

Strike and dip of flow foliation

Vein: showing strike and dip

Mine shaft: number keyed to name in Mines and Mine: number keyed to name in Mines and

Adit: number keyed to name in Mines and Prospects Prospect: number keyed to name in Mines and

Placer-mined area: major placered areas shown by symbol on base map; boundaries of other placered areas not shown N⊙ Dated rock sample (see Table 1)

AGES OF PLUTONIC ROCKS

The location of samples of plutonic rocks from Boise Basin and vicinity dated during the present study or in other studies, is shown on the map by symbol and letter. The K-Ar age determinations are given in Table 1.

Analyzed basalt sample (see Table 2)

Nine samples of dioritic rocks average 46.3 Ma; the first seven samples in Table I, plus sample IC-58 and sample IC-77 (from the Missouri mine located only a short distance north of the map's north boundary). This average excludes Eocene hornblende-biotite granodiorite samples P-147 and I-22 (Table 1), both of which are south of the map boundary and, for reasons unknown to the authors, present ages that are younger than appear normal

Only one sample of biotite (pink) granite (sample P-150-1, Table 1, locality T) is known to have been dated in the Boise Basin vicinity. The K-Ar age of

for the dioritic rocks. The 46.3 Ma average coordinates exactly with the

average (46.3 Ma) of three samples of dioritic rocks from the western part

of the Challis 1° x 2° quadrangle (Fisher and others, 1992). The two averages

indicate that 46 Ma is a reasonable age to assign Eocene dioritic rocks of

On the basis of these analytical returns on Eocene plutonic rocks, the dioritic rocks would appear to be slightly older than the granitic rocks. This age relationship checks with field observations in the Challis 1° x 2° and Hailey 1° x 2° quadrangles, where apophyses of biotite granite were found to cut Eocene dioritic rock and where remnants of older dioritic rock were found in the younger biotite granite (Kiilsgaard and others, USGS Bulletin 2064, Chapter U). This same age relationship is indicated at the biotite granite exposure in the upper reaches of Little Muddy Creek, where intrusive biotite granite is enclosed by quartz monzodiorite.

Granitic rocks of the Atlanta lobe of the Idaho batholith are Late Cretaceous in age, probably 75 to 100 Ma (Armstrong and others, 1977). This range in age was supported by K-Ar (potassium-argon) radiometric determination of samples from the Atlanta lobe in the contiguous Challis 1° x 2° quadrangle

to range from 64 to 97 Ma in age (Kiilsgaard and Lewis, 1985).

In that quadrangle thirty samples of granitic rocks from the lobe were found

Three samples of biotite granodiorite and one of muscovite-biotite grani

are from the Quartzburg area, from sample points E, G, H, and I on the map

which correlate with samples IC-45, IC-55, IC-38, and IC-40 in Table 1. The same mineral, sericite, was dated in each sample. K-Ar ages of the four samples range from 61.7 to 71.3 Ma, a spread considered excessive for such closely spaced samples. The range probably reflects different amounts of argon in the rocks, all of which were affected by nearby Eocene plutonism The K/Ar age of 47 Ma for sericite from sample IC-43 (Table 1, locality C on map) of hydrothermally altered Cretaceous biotite granodiorite obtained from the nearby Coin Bond mine dump is too young for Cretaceous rocks. The sample may reflect even greater loss of argon in the rock from Eocene plutonism, or it may reflect the age of sericite developed by hydrothermal alteration of the existing Cretaceous rock. The Eocene plutonic effect is emphasized by the age of 47.0 Ma obtained for sample HN-GH-7. The sample of muscovite from biotite granodiorite, analyzed by the 40Ar/39 age-spectrum method, shows argon reset by a geologic event at 47 Ma, date that coincides with the age of Eocene plutonism and which probabl reflects the age of that plutonism rather than the cooling age of the intruded granodiorite. Further substantiation of the Eocene effect is in the K-Ar age of 45.8 Ma obtained in a drill core sample from a dike that cuts Cretaceous biotite granodiorite (sample HN-GH-3, Table I, map locality F). The age of

the dike coincides with ages obtained for Eocene plutonic rocks of the Boise

Table 1. Ages of Cretaceous, Eocene, and Oligocene

Sample Latitude Longitude Rock Mineral Map Age (Mineral Location 84-34K 43°46′31" 115°55′24" Tqm Biotite O 46.1 +/-84-47K 43°44′30″ 115°50′41″ Tgd Biotite P 47.0 +/-84-60K 43°58′57" 115°54′29" Tqm Hornblende A 45.8 +/- 0 84-61K 43°58′28" 115°56′14" Td Biotite B 45.6 +/- 0. 35-148K 43°39′29" 115°55′56" Td Biotite S 46.0 +/ 301K 43°42′34" 115°48′11" Tqm Biotite R 43.8 +/on 43°55'46" 115°46'14" Kgd Sericite J 65.7 +/ 04 43°53′20" 115°47′13" Kgd Sericite L 59.7 +/-44°00′16″ 115°49′09″ Kgd Sericite - 47.6 +/-43°53′03″ 115°47′04″ Kgd Sericite M 61.7 +/-60 43°53′56″ 115°45′39″ Kgd Sericite K 60.9 +/-8 43°57′04" 115°59′41" Kgd Sericite H 69.0 +/-40 43°56′47" 115°59′42" Kg Sericite I 71.3 +/-43° 57′34″ 115° 58′28″ Kgd Sericite C 47.0 +/- 1 55 43°57′16" 115°59′29" Kgd Biotite G 67.2 +/-58 43°58′57″ 115°54′28″ Tqm Biotite A 45.5 +/ 77 44°00′25″ 115°51′03″ Tqm Sericite - 48.4 +/-GH-3 43°57′12" 115°58′49" Tr Muscovite F 45.8 +/-H-7 43°57′25″ 115°58′52″ Kgd Muscovite D 47.0 +/- 0 47 43°35′40" 115°57′20" Tgd Biotite - 41.5 +/-0-1 43°39′06" 115°46′29" Tg Biotite T 41.2 +/ 2 43°36′00″ 115°59′28″ Tgd Biotite

1/30 Ar age-spectrum method, and Zimmerman dated zircon from sample 84-15K u. on track method. All other samples were dated by the potassium-argon method. Sam mine); RB-70 (east, at the Hayfork Campground on Highway 21), P-147 (south, bank of the roalong Boise River 4.5 km west of Arrowrock Dam, and I-22 (southeast, road bank of Highw

3-68 43°43′33" 115°56′53" Kgd Biotite Q

Major regional faults are the principal geologic structures in the Boise Basin vicinity. Two patterns of faults dominate: one that is a northeast striking and the other north striking.

Disturbed muscovite, argon reset by a geologic event at 47.0 Ma

Northeast-trending, high-angle, subparallel, discontinuous regional faults, aligned grabens, breccia pipes, eruptive centers, and roughly aligned intrusive rocks of Eocene age that cross the Challis 1° x 2° quadrangle were identified by Kiilsgaard and Lewis (1985) as the trans-Challis fault system. The fault system extends southwest into and across the Boise Basin. Although traced to great length from the Boise Basin in a northeast direction across Idaho most of the faults could not be traced southwest of the Boise Ridge fault. The system appears to be part of a broad pattern of Tertiary crustal extension along which faulting has been intermittently active since Precambrian time. A rough alignment of the Tertiary dikes, Eocene plutonic rocks, and northeasttrending faults is apparent in the northwest quadrant of the map. The alignment

but many of the faults are unnamed. Mineral Mountain Fault—The Mineral Mountain fault is the principal northeast-trending fault near Quartzburg. The fault is marked by a sheared zone on the west side of Mineral Mountain, which is in alignment with a shear zone exposed in the road bank of the Woof (Wolf) Creek road south of the Alder Creek Summit (Placerville 7.5-minute quadrangle). The fault is also aligned with a major sheared zone in highly altered biotite granodiorite that is exposed in pits and trenches on the Hilda Mae property near the head of California Gulch. Farther southwest, near the portal of Iowa mine adits, the fault extends into the sheared zone approximately parallel to the Gold Hill vein, a zone Ballard (1924) described as being half a mile or more in

width. No trace of the fault was found southwest of the Boise Ridge fault.

suggests that emplacement of the intrusive rocks and associated gold-silver

deposits was guided by the northeast-trending faults. The following text

describes major northeast-trending faults that have been assigned names,

Ophir Creek Fault—The Ophir Creek fault is exposed at the forks of Ophir Creek southeast of the Mineral Hill mine. From there it extends along the east side of Mineral Mountain into the valley of the South Fork of the Payette River, where it is exposed in roadcuts of U.S. Forest Service unimproved road 382 that leads from Grimes Pass north into the Payette River valley. The fault is also exposed north of the map area in the bank of State Highway 21, 0.6 km east of Little Gallagher Creek. About 700 m northwest of Grimes Pass in an area along Sweet Creek, Eocene quartz monzodiorite is displaced against Cretaceous biotite granodiorite along the fault.

the West Fork of Clear Creek northeast to the junction of the North and East Forks of Ophir Creek and beyond, leaving the map area at the headwaters of Applejack Creek. On the ridge between Applejack Creek and Little Muddy Creek, Eocene quartz monzodiorite is displaced against Eocene biotite granite along the fault. The fault was not found west of the Boise Ridge fault. Muddy Creek Fault—Near the map's northern boundary on the ridge between Muddy and Little Muddy Creeks, lacustrine sedimentary rocks of the Payette Formation are faulted against Cretaceous muscovite-biotite granite along the Muddy Creek fault. Farther to the southwest, Cretaceous muscovitebiotite granite is displaced against biotite granodiorite along the fault. No trace of the fault was found southwest of the Boise Ridge fault.

Clear Creek Fault—The Clear Creek fault extends from the headwaters of

Grimes Creek Fault—The Grimes Creek fault is concealed by alluvium over much of its strike length, but at the northeast end and in the center of the area, movement along the fault has placed Cretaceous muscovite-biotite granite against Cretaceous biotite granodiorite. Muscovite-biotite granite has been intensively altered along the fault, especially at a ridge point that protrudes into the Grimes Creek valley in sec. 13, T. 6 N., R. 4 E. Southwest from the ridge point, as may be seen on the Warm Springs Point 7.5-minute topographic map, the fault accounts for a remarkably aligned series of ridge notches and eroded subsidiary-stream valleys that cross present topography almost at right angles. It is a clear example of an ancestral valley that was eroded along the fault in a S. 30 W. direction, the drainage of which subsequently was captured by Grimes Creek through its steeper-gradient, subsidiary streams of Wild Goat, Rattlesnake, Wild Horse, Macks, and Pine Creeks. A logging road constructed in 1985 along a southwest-trending subsidiary of Rattlesnake Creek, presents an excellent view of the Grimes Creek fault, which dips 75 degrees to the southeast at that locality. Dense brush and a thick cover of grus concealed the southwest end of the fault and it could not be determined whether the fault terminated against the

Elk Creek Fault—Evidence of the Elk Creek fault is exposed along the upper reaches of Elk Creek, on the ridge between Deer Creek and Wet Gulch, and in a tributary to Slaughterhouse Gulch. About 0.5 km west of the Warm Springs Resort, movement along the fault has placed lacustrine sedimentary rocks of the Payette Formation against Cretaceous biotite granodiorite. About 2 km farther to the southwest, movement along the fault has displaced Eocene quartz monzodiorite. Whether the fault continues to the southwes or merges with the Mores Creek fault could not be determined.

Mores Creek Fault—The Mores Creek fault is exposed along the upper

Boise Ridge fault or extended to the southwest.

reaches of Mores Creek, east of the map. The fault is also well exposed in Washington and Illinois Gulches near the eastern border of the map. At Idaho City the fault is concealed by alluvium of Mores Creek, but its inferred location is supported by different attitudes of Payette Formation sedimentary rocks on either side of Mores Creek, differences that can be explained only by adjustment along the fault. Farther to the southwest, where the fault crosses McKinley and Milk Ranch Gulches, adjustment along the fault has placed Eocene quartz monzodiorite against Cretaceous biotite granodiorite. Whether the Mores Creek fault terminates west of Grimes Creek or merges with another northeast-trending fault was not determined.

Kelly Gulch Fault—The Kelly Gulch fault is one of a series of northeasttrending faults that cross the lower reaches of Robie Creek, extending from the southwest corner of the area for 10 km or more to the northeast. The faults appear to cross the north-trending Boise Ridge fault, although the Boise Ridge fault was not observed in the intersection area. The Kelly Gulch and associated northeast-trending faults cross Boise Ridge near Aldape Summit. They have been traced southwest to Fivemile Creek but have not been detected in the Boise foothills about 4 km farther to the southwest. In the Boise foothills, S.H. Wood (written commun., unpublished map of the Boise North 7.5-minute quadrangle) has identified a major pattern of northwest-trending faults that extend along the northern side of the Snake River Plain. The Snake River Plain is downdropped with respect to the mountains to the north. Apparently, the Kelly Gulch fault and associated ortheast-trending faults terminate against the northwest-trending faults that bound the Snake River Plain.

The Kelly Gulch fault and associated northeast-trending faults are especially evident along the ridge between Robie and Daggett Creeks where sheared biotite granodiorite, rock alteration along the faults, deep weathering, and water saturation have resulted in several landslides. The threat of reactivated movement by the landslides poses a significant geologic hazard to roads built in the area and to residential buildings constructed on the landslides.

Boise Ridge Fault—The principal north-trending fault in the mapped area

is the Boise Ridge fault, which extends along the eastern base of Boise Ridge, the high ridge that marks the western side of the Boise Basin. Lindgren (1898) called attention to a "great disturbance" along the eastern base of Boise Ridge, and Anderson (1947) mapped a fault at this locality in the area west and north of Quartzburg. The northern extension of the fault subsequently was mapped north of the Hailey 1° x 2° quadrangle along the western side of Garden Valley and north of Crouch (Fisher and others, 1992). Our present mapping extends the fault south of Quartzburg and south of Trail Creek, where displacement along the fault has brought Columbia River basalt of Late Miocene age in fault contact with Cretaceous biotite granodiorite. Farther south near the North Fork of Robie Creek, the fault becomes indistinct and surface traces of it are lost in an area of dense timber, brush cover, and

Rocks on the western side of the fault have been uplifted with respect to rocks on the eastern side. A comparison of the base of the Columbia River basalt on Hawley Mountain with the base of similar basalt that caps ridges near Placerville indicates that rocks on the western side have been uplifted

as much as 580 m. Uplift of the western block is emphasized by the tilt o the basalt on Hawley Mountain, which is as much as 45 degrees to the west, in contrast to the minor, if not absence of, tilt in basalt at Placerville. Uplift of the western block is further emphasized by the patch of High gravel tha rests on basalt south of the lookout on Hawley Mountain and which is several hundred meters higher in altitude than High gravel at Placerville or

any areas to the east, but which probably was deposited at about the same Movement along the Boise Ridge fault can be no older than latest Miocene. This age is indicated by the displacement of the Columbia River basalt of Late Miocene age. North of the Hailey 1° x 2° quadrangle and about 5 km

north of Crouch, shale and sandstone of the Late Miocene Payette Formation have been tilted as much as 45 degrees west. A comparison of the High gravel on Hawley Mountain with High gravel east of Boise Ridge fault suggests that movement on the fault could be as young as Pleistocene. Willow Creek Fault—The Willow Creek fault enters the map area in the southeast corner where it has displaced biotite (pink) granite of Eocene age

is indistinct. The fault extends at least 30 km to the south and southeast of

ECONOMIC GEOLOGY

streams started on Wolf Creek near Placerville in 1898 and on Grimes Creek near Centerville in 1899 (Ballard, 1924). Wolf Creek is shown as Woof Creek on the Placerville 1:24,000-scale topographic map. Gold dredges worked the low-gradient gravel deposits, which could not be mined profitably by other placer methods.

that led right to the Illinois vein outcrop and notes that practically all of the placer deposits in the basin were below known gold-bearing veins. That with precious-metal deposits. It has been the most productive mineralized observation holds true a century later. No significant placer deposits have area and presents the best chance for future discoveries. Mineral exploration been found in the basin upstream from gold-bearing veins. Extensive piles of placer tails along Mores, Grimes, and Granite Creeks, and the search for them is warranted. marked by symbols on the appropriate 1:24,000-scale topographic base maps, attest to the extensive placer mining that has been done along those streams. Piles of boulders and gravel along the hillsides of these streams and at countless other places are further evidence of the extent of placer mining

letter P, with no attempt to mark the limits of the placered area. Gold dredging in the Boise Basin ended in 1951 when the Idaho-Canadian Dredging Company moved its bucket-line dredge from Mores Creek near Idaho City to Long Valley north of Cascade. Only three small-scale placer operations were active in the basin during the time of our study. Two of these were near Placerville, and the third was at Centerville.

Placer mining and prospecting along various streams led to the discovery

of gold-bearing quartz veins. Claims were staked on the Gold Hill quartz vein in 1864. Mine development on that vein and other nearby northeasttrending veins of the porphyry belt led to the establishment of the nearby town of Quartzburg. Mines that developed along the northeast-striking lode deposits include the Mountain Chief, Belshazzar, Mayflower, Silver Star, Last Chance, Gold Hill, and Mineral Hill. Of these, the Gold Hill mine was the most productive. It was the largest producer of lode gold in the Boise Basin and for several years the largest gold producer in Idaho. Mining operations at the Gold Hill mine ended in 1938. Prospectors also found gold-bearing quartz veins on the ridge between

Mores Creek and Elk Creek north of Idaho City. The veins differ from those near Quartzburg in that they strike northwest rather than northeast. Placer gold mined from deposits along Elk and Mores Creeks is believed to have originated from these veins. Gold mines developed along the northwesttrending veins include the Illinois, Gambrinus Surprise, Forest King, Washington, Elkhorn, and Boulder. All of the mines were shallow. Ore from the lode deposits was treated in small, inefficient stamp mills, and recovery of the gold was poor.

Many mineralized quartz veins in or near the Boise Basin, other than those in the northeast-trending belt through Quartzburg or in the northwesttrending veins north of Idaho City, have been prospected, but none has been developed into a significant, productive mine. In recent years sporadic mineral exploration and mining activity has occurred at many lode deposits in the Boise Basin area, but no significant tonnage of ore has been produced since mining operations ceased at the Gold Hill mine in 1938.

The total amount of gold mined from the Boise Basin will never be known

Early mining records are incomplete. Much of the early placer gold probably was never reported. Initial gold production from Boise Basin was lumped with gold produced elsewhere in Idaho. Lindgren (1898) noted that gold produced in the area from 1863 until 1896 had been estimated to exceed \$100 million, an amount he felt to be exaggerated. Using U.S. Mint reports and other reliable sources, Lindgren (1898) prepared a table of probable gold production from the Idaho Basin (Boise Basin) for the period 1863-1896 that totaled less than \$45 million, an estimate that appears to be far more accurate than the higher figure. Jones (1916) updated production statistics from Boise County to 1914, and Anderson (1947) further updated the production from Boise Basin through 1940. Kiilsgaard and others (1989) used published and unpublished statistics from the U.S. Bureau of Mines to update production records through 1982. Aside from a few unrecorded ounces of gold from small placer operations, no gold was produced from Boise Basin from 1982 to 1994.

According to Kiilsgaard and others (1989), the total accumulated output of gold from Boise Basin from 1863 to 1982 amounted to 2,818,596 ounces, which makes this area the largest producer of gold in the state. Based or gold prices over the production period, the accumulated value of the gold is set at \$63,148,010. Of the total gold output, 76 percent or 2,149,105 ounces was taken from placer mines, and the remaining 24 percent from lode mines.

Mineral deposits of the Boise Basin vicinity are structurally related to

northeast-trending faults of the trans-Challis fault system, and genetically related to Tertiary igneous rocks that have been intruded along or near the northeast-trending faults. Most of the mineral deposits are veins or lodes composed of several veins, but two deposits are breccia pipes. The veins may be subdivided into two sets: one that strikes northwest, and the other northeast. Gold has been the principal metal mined in both sets of veins.

exploration of the mineral deposits has ranged from simple prospect pits at some sites to thousands of meters of underground workings at others. Almost all of the underground workings were inaccessible to the authors. The deposits have been described by other geologists (Lindgren, 1898; Jones, 1916; Ballard, 1924; and Anderson, 1947), who based their descriptions on examinations of the prospects and mines when they were accessible and commonly being worked. Readers are referred to those reports for detailed descriptions of the deposits.

Known or reported mines and prospects are shown on the map by a symbol and accompanying number; the numbers are keyed to names listed in the mine and prospect table shown on the map. Most of the mine and prospects listed in the map table and many of the mine locations shown on the map are from Anderson (1947). Since Anderson's time, lode mining in the area has been stagnant with essentially no mineral production and very little

POTENTIAL MINERAL RESOURCES

dikes, northeast-striking faults, and northeast-striking veins. The belt extends

through Quartzburg and continues to the northeast beyond the border of

the map. The belt contains abundant geologic features commonly associated

-----An objective of this study was to identify areas that could contain concealed mineral deposits. We were also interested in potential resources that might be known but which for one reason or another had not been mined. With these objectives in mind we have considered the potential resources under two categories: lode and placer.

Within the map area, the porphyry belt locality has the best potential for concealed lode deposits. The porphyry belt, as described previously, is a broad zone of intrusive, porphyritic, plutonic rocks of Eocene age, associated

Number or Prospect Weatherby (Blue Rock)

against Cretaceous biotite granodiorite. The fault may be traced to the divide between Cottonwood Creek and Thorn Creek, but its location north of there

Jackass Creek Fault—The Jackass Creek fault in the northwest corner of the map area displaces Columbia River basalt against Cretaceous biotite granodiorite. The fault is believed to extend many kilometers north and south of the area. Movement along the fault can be no older than Late Miocene.

the map area (Worl and others, 1991).

Gold was discovered in the Boise Basin in August, 1862, near present-day Pioneerville (Lindgren, 1898). Subsequent discoveries soon followed near Centerville, Placerville, and Idaho City. Most placer gold was found in stream gravel along Grimes, Mores, Granite, and Elk Creeks and in their tributaries. Large placer deposits were also found in Terrace (bench) gravel that locally flanked the larger streams and in High gravel, some deposits of which were more than 100 m above nearby streams. Water for mining some High gravel deposits was obtained from melting snow banks, but such mining could be done only through a short spring season. As mining progressed, extended and elaborate ditch systems were built to bring water from the larger streams to points above the Terrace and High gravel deposits. Gold dredging of large gravel deposits along the lower-gradient principal

Placer deposits varied widely in location, size, and gold content. Some of

the richest deposits were small in volume and immediately downstream

from auriferous quartz veins. Lindgren (1898) comments on the rich placers

in the belt may not find the large-tonnage, bulk-minable, low-grade gold deposits sought in recent years. Deeper gold-silver deposits are more likely, Another area of potential promise is the iron-stained ridge of altered biotit granodiorite south of Idaho City that extends south from the molybdenum copper deposit in Grayback Gulch. The regional alteration of rocks on that in the Boise Basin as described by Lindgren (1898), Ballard (1924), Anderson ridge, the exposures of copper and other minerals in the rocks, and th presence of anomalous stream-sediment samples at sites where no upstream (1947). Placered localities are shown on the map by a circle enclosing the

> occurrences, the exploration of which may lead to minable resources Gold—An enormous volume of gold-bearing placer gravel exists in the Boise Basin, certainly measurable in tens of millions of cubic yards. Gold content

> > The future of intensive placer gold mining in the Boise Basin hardly warrants consideration however, for there is very little chance that such mining will be done. High gravel at various locations might be mined on a small scale, if sediment settling and the recycling of wash water can be done to prevent polluting the water-quality downstream, but public opposition to all waterdisturbance ventures is to be expected. Public opposition to turbid water and to the devastated landscape of dredged areas along Mores and Grimes Creeks led to the termination of dredge mining in the basin in 1951 and even more opposition is to be expected for future, large-scale placer operations. More people are living downstream from potentially dredgeable ground in 1996 than anytime in the past. The growing city of Boise and a large part of the Snake River Plain that is under cultivation are dependent on the Boise River and its tributaries for drinking and irrigation water supply. During the drought of the early 1990s, irrigation water sometimes was

mineralized exposures were seen all suggest widespread mineralized

of the gravel is unknown but, on average, probably is low as most of the

gravel has been placered, some of it more than once. Profitable mining at

even selected localities would require large-scale, dredge-mining operations.

7.5-minute topographic map

14 Gold Hill

Whisky Johnson

30 Little Klondike

7 Washington adit

31 Shanahan

40 Cloverleaf

41 Cleveland

42 Eureka

43 Mascot

45 Illinois

48 BLW

46 Gambrinus

47 Wild Horse breccia

49 McKinley adit

51 Mud Springs

52 King Solomon

Brown's lode

4 South African

7 Morning Mist molybde

55 Lincoln adit

56 Blue Rock

58 Dry Creek

59 Lightning

60 Silver King

61 Grubstake

62 Scorpion

63 Bumblebee

64 Ridge prospect

66 Paymaster

68 Big Giant

70 Nevada

69 Turntable tunnel

Mudders Gulch

Dunnigan Creek

75 Smith Creek prospect

65 McCarthy (Last Chance

67 Cook (Boise lode)

50 Boomer

44 Lucky Boy

Monazite—Although future large-scale placer mining in the Boise Basin is not expected, significant quantities of the rare-earth mineral, monazite, in the gravel constitute a potential resource that should not be overlooked. Monazite in the placer gravel was first described by Lindgren (1898). An effort was made in 1909 by the Centerville Mining and Milling Company to recover monazite at a plant near Centerville. Processes employed by the plant are described by Sterrett (1909). Unfortunately, the Centerville plant burned in a forest fire in August, 1910, whereupon monazite production ceased. The next effort to recover monazite was in 1946-1949 when part of the black sand concentrate from the Idaho Canadian and the Baumhoff-Marshall dredges, then operating on Mores and Granite Creeks, respectively was treated at a magnetic separator, from which 40 tons of monazite was recovered and sold.

inadequate in the late summer months. These factors, plus growing public

concern about instream water quality, will generate massive and overwhelming

future opposition to any major effort to dredge placer gravel in the Boise

In 1949 the U.S. Bureau of Mines explored for monazite in the Boise Basir (Kline and others, 1950). The exploration consisted of drilling holes through the gravel, sinking shafts in the gravel, and bulldozing trenches. Most of the work was done along Grimes Creek and its tributaries. Particular effort was devoted to Wolf Creek near Placerville, to the gravel deposits west of the junction of Wolf and Granite Creeks, to the area at the junction of Granite and Grimes Creeks, and to the Rye Flat area on the lower part of Grimes Creek near the mouths of Rattlesnake and Wild Goat Creeks. In 34 drill holes, the amount of monazite found ranged from 0.29 to 1.96 pounds a cubic yard of gravel and averaged 0.56 pound a cubic yard. Two samples from trenches were higher in monazite content, averaging 1.56 pounds a cubic vard. Three samples from the Idaho Canadian dredge, then operating on Mores Creek about 2.3 km upstream from Idaho City, averaged 0.19

pound a cubic vard. The U.S. Bureau of Mines's tests and other information

exist in the Boise Basin gravel to be considered a significant national resource.

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on Boise Basin placer gravel indicate that sufficient quantities of monazite

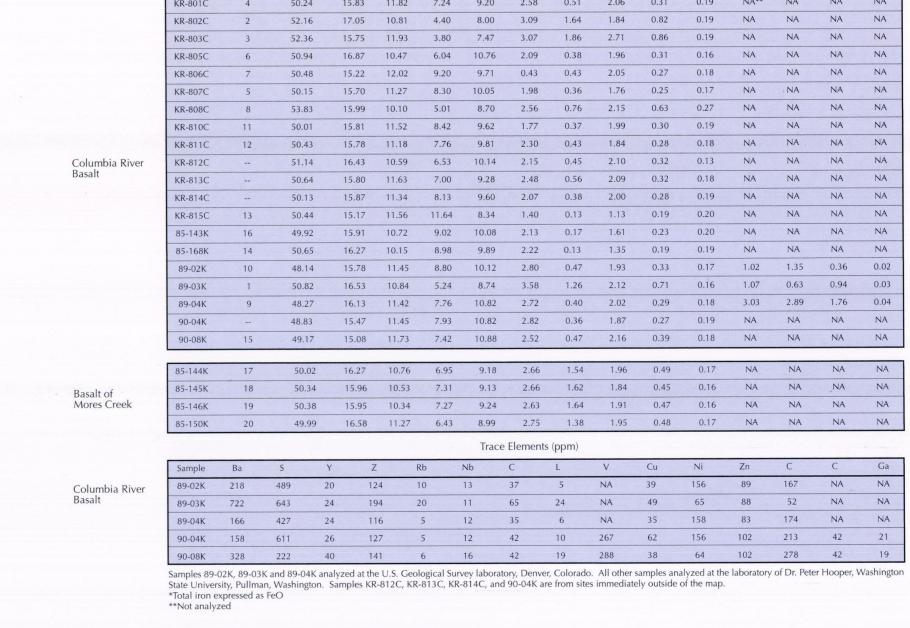
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Table 2. Analytical Data on Basalts Exposed in the Western Part of the Map. imple Location SiO_2 Al_2O_3 FeO^* MgO CaO Na_2O K_2O TiO_2 P_2O_5 MnO LOI H_2O+ H_2O-

340, scale 1:250,000.



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