The Geology and Mineral Deposits of Part of the Western Half of the Hailey 1°×2° Quadrangle, Idaho

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with a section on The Neal Mining District
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U.S. Geological Survey Bulletin 2064-W

Prepared in cooperation with the Idaho Geological Survey, Idaho State University, and the University of Idaho

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
Charles G. Groat, Director

This publication is only available online at:
http://geology.cr.usgs.gov/pub/bulletins/b2064-w/

Version 1.0 2001

Published in the Central Region, Denver, Colorado
Manuscript approved for publication April 20, 2001
Graphics by authors
Photocomposition by Gayle M. Dumonceaux

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Metric Conversion Factors

Multiply	By	To obtain
Miles	1.609	Kilometers
Feet	0.3048	Meters
Inches	2.54	Centimeters
Tons	1.016	Metric tons
Short tons	0.907	Metric tons
Troy ounces	31.103	Grams
Ounces	28.35	Grams

Geology and Mineral Deposits of Part of the Western Half of the Hailey 1°×2° Quadrangle, Idaho

By Earl H. Bennett

Abstract

Rocks in the western half of the Hailey 1°×2° quadrangle of south-central Idaho include various units of the Atlanta lobe of the Idaho batholith (biotite granodiorite to two-mica granite) of Cretaceous age and plutons and dikes of Tertiary (Eocene to Miocene) age that intrude the batholith. Eocene plutonic rocks consist of a bimodal suite of anorogenic granite and tonalite-granodiorite and hypabyssal rhyolite and rhyodacite dikes. Rocks of the Eocene Challis Volcanics are scarce in the map area but are widespread to the east. Rhyolite ash flows of the Miocene Idavada Volcanics and basalt of the Snake River Plain crop out in the southern part of the area. Lacustrine rocks of probable Eocene to Holocene age are present in the vicinity of Anderson Ranch Reservoir. Quaternary basalts and gravels are widespread on the South Fork of the Boise River, and alluvial deposits are common along active drainages. Metasedimentary rocks of unknown age crop out on House Mountain, Chimney Peak, and on the ridges east of Anderson Ranch Reservoir.

Older structures in the Idaho batholith include a major fault beneath House Mountain that may be a decollement for one of the large thrust sheets in eastern Idaho or part of an extensional core complex. The southern part of the Atlanta lobe of the Idaho batholith is cut by northeast-striking faults (parallel with the Trans-Challis fault system) that are related to Eocene extension and by northwest-oriented faults that formed during basin and range extension in the Miocene. The basin and range faults have prominent scarps typical of basin and range topography. The combination of northeast and northwest faults has broken the batholith into a series of rhomboid blocks. Some of these northeast and northwest faults are older structures that were reactivated in the Eocene or Miocene, as indicated by Ar^{40}/Ar^{39} dates on mineralized rock contained in some of the structures.

The Idaho batholith and associated rocks in the map area host several hundred mines and prospects in 18 mining districts. The deposits range in age from Cretaceous to Eocene, and many were developed for precious metals. Most of the deposits are in quartz veins in shear zones in granitic rocks of the batholith. Several districts were actively being explored for low-grade, bulk-minable, precious-metal deposits in the late 1980s and early 1990s.

Introduction

The geology of most of the western half of the Hailey 1°×2° quadrangle in south-central Idaho was mapped and the mineral deposits studied from 1984 to 1988 as part of the U.S. Geological Survey Conterminous United States Mineral Assessment Program (CUSMAP). The Idaho Geological Survey participated in this program, concentrating on the southern part of the Atlanta lobe of the Idaho batholith.

This paper describes the geology and mineral deposits in Elmore County, south-central Idaho between the western edge of the Hailey 1°×2° quadrangle (long 116° W.) and Smoky Dome (long 115° W.) and roughly between the Snake River Plain to the south and the Middle Fork of the Boise River to the north (fig. 1). The Boise River (North, Middle, and South Forks) is the major drainage. Towns in the area include Featherville, Pine, Prairie, and Fairfield. Rocky Bar, north of Featherville, and Mayfield, northwest of Mountain Home, are ghost towns. The main paved access to the area is from U.S. Highway 20, which goes from Mountain Home across the Camas Prairie.

Geology

Granitic rocks of the Idaho batholith underlie most of the western half of the Hailey 1°×2° quadrangle north of the Snake River Plain (fig. 2) (Bennett and others, 1989). The Idaho batholith is divided into two lobes, the Atlanta lobe to the south and the Bitterroot lobe to the north (Armstrong and others, 1977). Granitic rocks in this area are mostly Cretaceous in age and are part of the south end of the Atlanta lobe.

In places, the batholith contains roof pendants and xenoliths of metamorphic rocks of uncertain age. The Cretaceous batholith is intruded by Tertiary plutons and associated dike swarms. Several small exposures of the Eocene Challis Volcanic Group are present near Anderson Ranch Reservoir. Lacustrine sediments of probable Miocene age locally overlie these volcanic rocks. The southern end of the batholith is covered by the Miocene Idavada Volcanics and by Quaternary sediments and basalts of the Snake River Plain. Quaternary gravels and alluvium are the youngest sedimentary units in the area.

Major Rock Units

Metamorphic Rocks

Metamorphic rocks of uncertain age are present as roof pendants and xenoliths in the batholith. Major exposures include the following: House Mountain; Chimney Peak; Lime

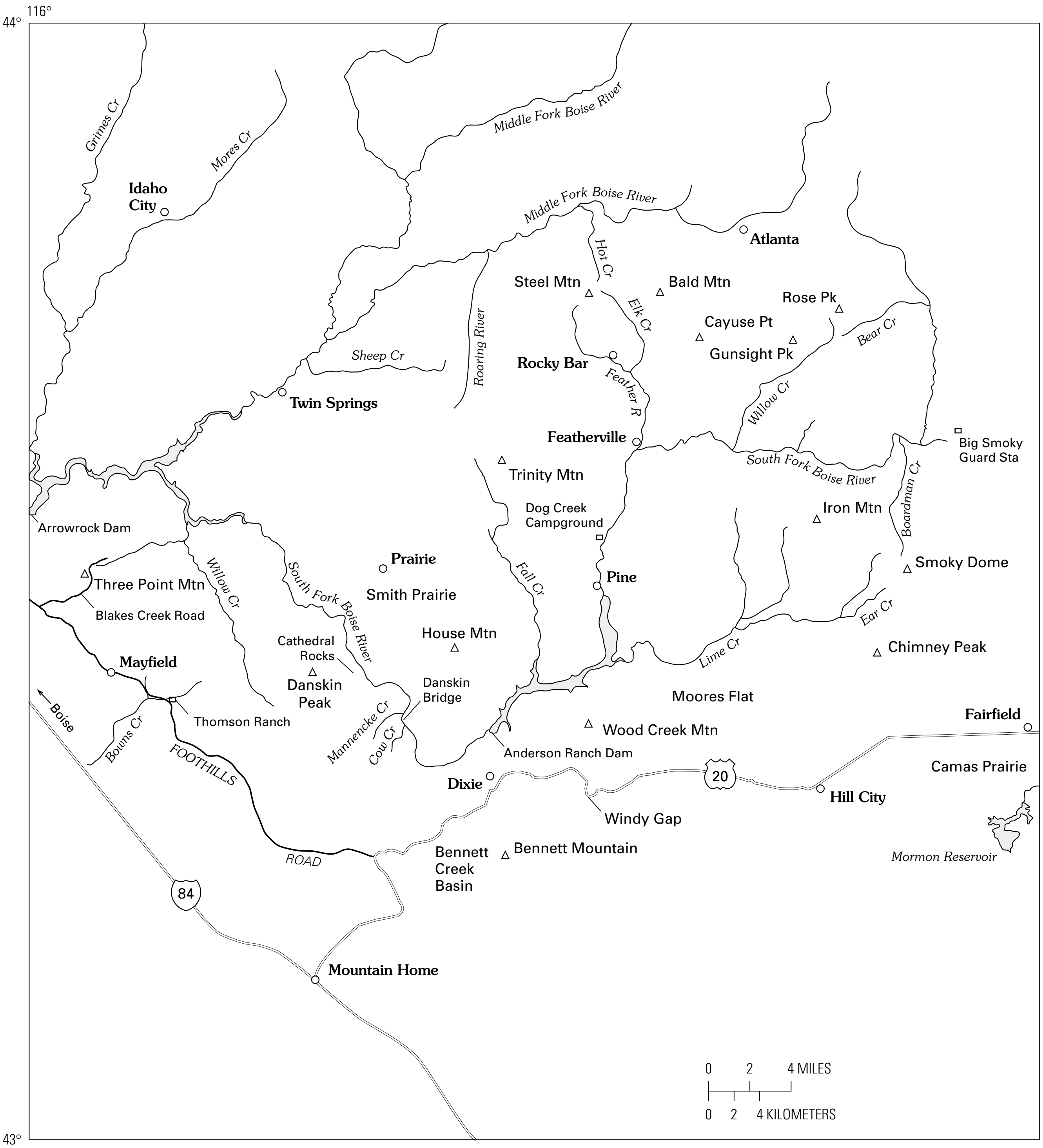

Figure 1. Location map showing the western half of the Hailey 1°×2° quadrangle, Idaho.

Creek; numerous small pendants and xenoliths along the ridges east of Anderson Ranch Reservoir; exposures along the dirt road between Pine to Dixie Gulch Hot Springs on the east side of the South Fork of the Boise River; and Wood Creek Mountain.

Metamorphic rocks at House Mountain include biotite quartzite, diopside-calc-silicate gneiss, and diopside-graphite marble (Jacob, 1985). At Chimney Peak, the rocks are calc-silicate gneiss and quartzite. The correlation of metamorphic rocks in the study area with other metasedimentary rocks in Idaho is unknown. The rocks are probably equivalent to Paleozoic rocks farther to the east or to Precambrian rocks at the north end of the Sawtooth Range near Stanley, Idaho (Fisher and others, 1983). The metamorphic rocks obviously represent the roof of the batholith. Most are associated with aplite and pegmatite that are at the top of the batholith and intrude the roof rocks.

Rocks of the Idaho Batholith

The Idaho batholith is composed of several units of Cretaceous age (Kiilsgaard and Lewis, 1985; Lewis and others, 1987). In the Atlanta lobe, tonalite is intruded by biotite granodiorite that grades into two-mica granite. A late stage of the two-mica granite, leucogranite, is present as numerous dikes and small plutons. Leucogranite is rare in the western part of the Hailey 1°×2° quadrangle. In addition to the above common rock types, a large area between House Mountain and Smoky Dome contains an unusual abundance of pegmatite and aplite dikes, as compared with most of the Atlanta lobe.

Isotopic dates for batholith rocks are summarized in Lewis and others (1987). The tonalite is believed to have formed about 95-85 Ma. The granodiorite exhibits a complex cooling history (Lund and others, 1986) but probably formed between 85 and 75 Ma. The two-mica granite is 80-70 Ma, based on concordant dating of muscovite-biotite pairs by both conventional K/Ar and $Ar^{39/40}$ techniques. Leucogranite plugs and dikes are about 70–75 Ma based on K/Ar, and $Ar^{39/40}$ dates.

Tonalite bodies that form the western border zone of the batholith are near the 0.704/0.706 strontium isopleth that marks the boundary between continental crust to the east and accreted terranes to the west (Armstrong and others, 1977; Fleck and Criss, 1985; Criss and Fleck, 1987). Tonalite is also present along the eastern side of the batholith (Fisher and others, 1983).

Hornblende tonalite is present along the South Fork of the Boise River between Little Jumbo Creek and Boardman Creek. It weathers to sharp pinnacles and the canyon of the South Fork narrows considerably. Numerous rapids and the steep topography in this part of the canyon are distinctive and picturesque. Unfortunately, contact relationships between the tonalite and the surrounding granodiorite are not exposed. Two K/Ar dates (hornblende) of 104 and 96 Ma are similar to other tonalite ages; however, these ages may be due to excess argon in the hornblende. The tonalite is similar in appearance to tonalite in the Loon Creek area on the Challis 1°×2° quadrangle to the north of the study area (Fisher and others, 1983).

Along the western border zone of the Idaho batholith in the Challis quadrangle, the tonalite is intruded by massive biotite granodiorite, the main phase of the batholith. A broad band of this granodiorite extends northeast-southwest across the Hailey quadrangle from the Snake River Plain to the Sawtooth Valley (fig. 3). Another large mass is between the Sheep Creek batholith (Eocene) on the Middle Fork of the Boise River and the Tertiary complex near Idaho City (fig. 2).

The biotite granodiorite is gradational into two-mica granite that is present only in the western part of the study area. The two-mica granite occasionally contains small red garnets. Highly weathered exposures of two-mica granite occur along and around Indian Creek north of Mayfield. Another well-exposed outcrop was mapped at the mouth of Pole Creek, just west of Fiddler Flat. There are no known exposures of two-mica granite east of Danskin Peak Lookout; however, there are exposures of the granite north of the Middle Fork of the Boise River (Kiilsgaard and others, in press).

The area between House Mountain and Smoky Dome, including most of Anderson Ranch Reservoir, contains primarily biotite granodiorite that is intruded by large numbers (greater than 50 percent of the rock) of pegmatite and aplite dikes. The striped appearance of the ridges extending east from House Mountain Lookout to the reservoir (north of Evans Creek) that are visible from the top of the Anderson Ranch Dam grade is due to plants growing differentially along aplite and pegmatite dikes and on granodiorite (fig. 4). In some places around the reservoir, for example on the Anderson Ranch Dam grade, there are so many dikes that the host granodiorite looks like totally engulfed, ellipsoidal xenoliths.

This amount of aplite and pegmatite is unusual in the southern part of the Atlanta lobe and is the highest concentration noted to date in the Challis and Hailey quadrangles. The roof of the batholith near Elk City in the Elk City 1°×2° quadrangle to the north also contains a high concentration of pegmatite and aplite (Lewis and others, 1990). The pegmatite and aplite are assumed to be Cretaceous in age because no similar younger or older rocks have been described.

Tertiary Intrusive Rocks

A number of Tertiary (Eocene) intrusions are shown in figure 2. Plutonic rocks include a bimodal suite of quartz monzodiorite and granite (Bennett and Knowles, 1985; Lewis and Kiilsgaard, 1991). As elsewhere in the region, distinctive Tertiary epizonal pink granite is commonly spatially associated with rocks of the quartz monzodiorite suite.

Major granitic bodies of Tertiary age include Smoky Dome, the Sheep Creek batholith (formerly the Twin Springs pluton but renamed by Lewis and Kiilsgaard, 1991), small plutons south of the Camas Prairie near the Blackstone mine (DeLong, 1986), the granodiorite at Cat Creek (fig. 5), and granitic rocks near Hill City and Mormon Reservoir. These A-type or anorogenic granites (Collins and others, 1982), are generally more radiogenic than either the Cretaceous rocks or the quartz monzodiorite suite, appear as anomalies on airborne radioactivity surveys, and range in age from 45–40 Ma (Bennett and Knowles, 1985).

Large masses of rock of the quartz monzodiorite suite (including granodiorite, tonalite, and gabbro) are west of the Sheep Creek batholith, south of the Sheep Creek batholith in the Trinity Peaks, surrounding Smoky Dome on the north, south, and east (Iron Mountain, fig. 6), and at the mouth and along the lower stretch of Lime Creek. The quartz monzodiorite suite generally contains hornblende and complexly zoned plagioclase and magnetite and commonly xenoliths or restites that distinguish these rocks from Cretaceous granitic rocks. These rocks range in age from 55–45 Ma (Johnson and others, 1988; Lewis and Kiilsgaard, 1991).

A number of gabbroic plugs and dikes are present in the Ear Creek area. Several of these were intruded along the Moores Flat fault. A few gabbroic dikes similar to the Ear Creek rocks are present just south and west of Trinity Mountain Lookout, and poor exposures were noted south of Bennett Creek basin (about 1.5 mi southwest of Dixie Summit). Gabbro has not been observed elsewhere in the Atlanta lobe. The gabbroic rocks are assigned a speculative Tertiary age, based on intrusive

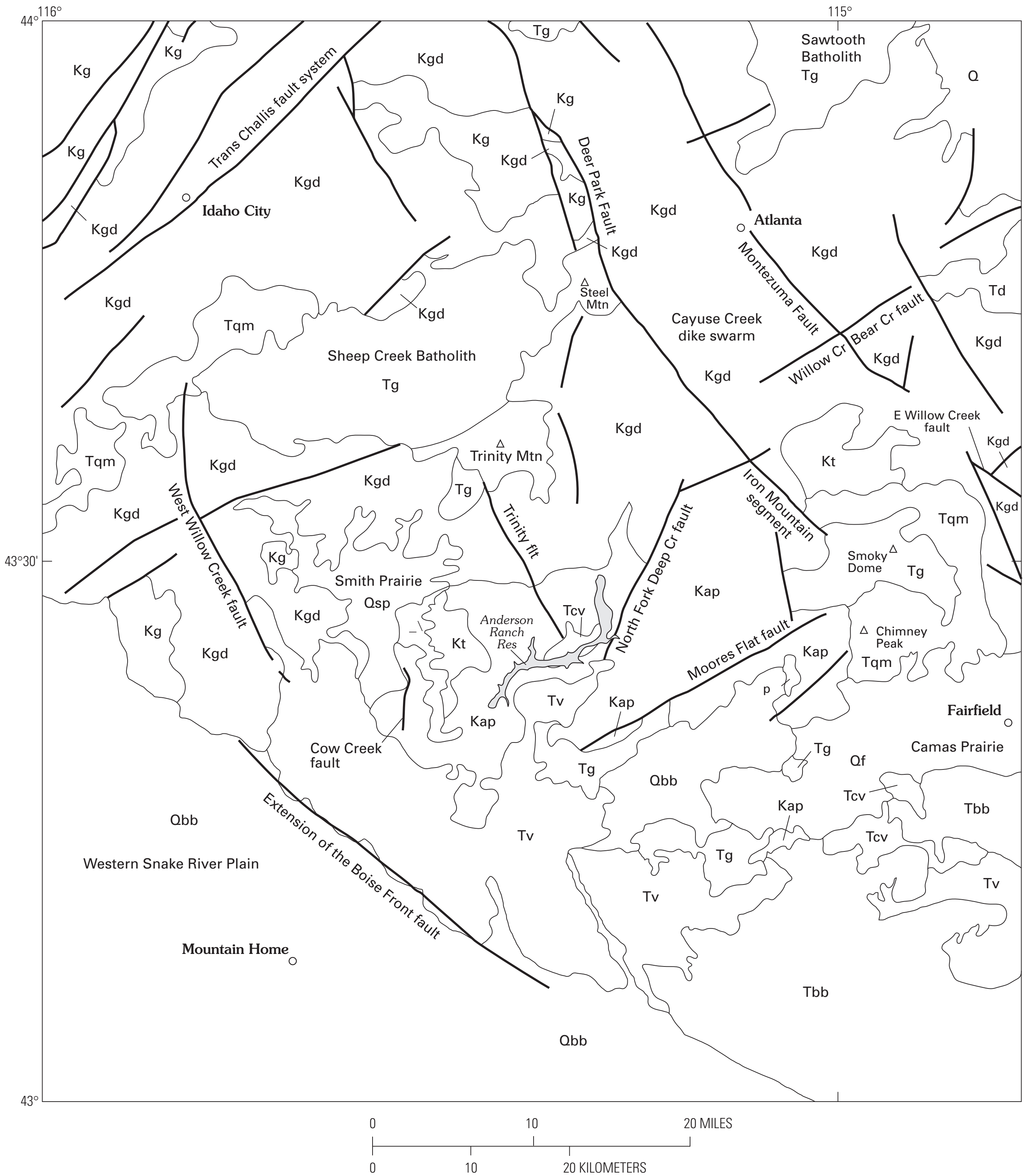

Figure 2 (above and facing page). Generalized geologic map of the western half of the Hailey 1°×2° quadrangle, Idaho.

relationships. Some of the exposures of the monzodiorite at Lime Creek look very similar in outcrop to the gabbroic rocks.

Dike Swarms

As elsewhere in the Atlanta lobe, dike swarms of Eocene age are common in the western half of the Hailey 1°×2° quadrangle. Most of these dikes are related to the bimodal Tertiary plutonic suite noted above and are described in Bennett and Knowles (1985). The dikes are mapped as rhyolite (pink granite related) or rhyodacite dacite (quartz monzodiorite related).

Rhyolite dikes in the western half of the Hailey 1°×2° quadrangle are relatively rare as compared to the swarms of

EXPLANATION FOR FIGURE 2

	Quaternary rocks and deposits
Qbb	**Basalt, undivided (Pleistocene)**
Qf	**Alluvial fans and gravels**
Qsp	**Smith Prairie Basalt (Pleistocene)**
Q	**Undivided Quaternary deposits and other rocks**
	Tertiary rocks
Tbb	**Basalt, undivided (Miocene)**
Tv	**Idavada Volcanics (Miocene)**
Tcv	**Challis Volcanic Group (Eocene)**
Tqm	**Quartz monzodiorite**
Tg	**Granite (pink)**
Td	**Diorite**
	Cretaceous rocks
Kgd	**Biotite granodiorite**
Kg	**Muscovite-biotite granite**
Kt	**Tonalite**
Kap	**Aplite/pegmatite complex**
	Paleozoic(?) and Precambrian(?) rocks
P̶zp€	**Metasedimentary rocks and roof pendants (age uncertain)**

rhyolite dikes mapped in the Challis 1°×2° quadrangle. Swarms of dikes are present near Three Point Mountain, a swarm extends from Negro Creek to northeast of Chimney Peak, and a small dike or plug is present west of the townsite of Dixie. The numerous dikes just west of Smoky Dome are more of a pink granophyre than rhyolite and are unusually abundant.

A major rhyodacite and dacite dike swarm hosted by Cretaceous granodiorite, the Cayuse Creek dike swarm (fig. 2) is present northeast of the granodiorite at Trinity Mountain. Numerous dikes in this swarm are exposed along the road from Featherville to Rocky Bar, along the Lincoln Creek road, and along Little Cayuse Creek (Slavik, 1987). To the north, the swarm ends abruptly at the divide between Lincoln Creek and Red Warrior Creek. The swarm strikes northeast, paralleling the Willow Creek-Bear Creek fault. Both Gunsight and Ross Peaks are outcrops of large dikes. The number of dikes increases to the east as basin and range faults are crossed. A few dikes are present west of the Iron Mountain segment of the Deer Park fault, more dikes are present between this segment and the Montezuma fault, and a great many more dikes are present east of the Montezuma fault, along the north-south segment of the South Fork of the Boise River north of the Big Smoky Guard Station (fig. 2) (Good, 1986).

Excellent examples of dike-pluton relationships were noted where basin and range faults have preserved older batholith rocks and Tertiary dikes on the downthrown side of the faults and exposed the corresponding parent plutons of the Tertiary dikes on the upthrown side. The granophyre-rhyolite dike swarm just west of the pink granite that forms Smoky Dome (separated by the Iron Mountain fault segment of the Deer Park

Figure 3. Typical biotite granodiorite terrane in the Mayfield Peak 7.5-minute quadrangle, Idaho. View looking south across Willow Creek from near the head of Fornham Creek.

Figure 4. Ridge north of Evans Creek, Anderson Ranch Reservoir area, Idaho. Vegetation patterns are controlled by pegmatite dikes in granodiorite just east of House Mountain Lookout.

Figure 5. Cat Creek summit, Idaho, looking north toward Wood Creek Mountain. Granodiorite at Cat Creek is in foreground. Wood Creek Mountain consists of aplite and pegmatite dikes in biotite granodiorite; small remnants of metamorphic pendants are preserved at higher elevations. A northeast-trending fault separates the two areas.

fault, fig. 7) is a good example. The alignment of the Little Cayuse Creek dike swarm and the Trinity Mountain granodiorite also indicates a dike-pluton relationship.

In addition to the bimodal suite described above, fine-grained andesite(?) dikes are present in the study area. These dikes increase in number toward the Snake River Plain and commonly are oriented northwest, parallel with the trend of basin and range faults. The dikes are believed to be related to basalts of the Snake River Group or the Idavada Volcanics, but they could also belong to the lower part of the Eocene Challis Volcanic Group.

Challis Volcanic Group

Rocks of the Eocene Challis Volcanic Group are present in the vicinity of Anderson Ranch Reservoir (just west of the Lime Creek road) and just south of Windy Gap on U.S. Highway 20. These rocks are part of the lower, older andesite suite that is the most widespread part of the Challis volcanic field. Most of the andesite flows are thought to be from local vents rather than from large calderas, unlike the younger ash flows in the Challis Volcanic Group. An excellent description of the Challis Volcanic Group in the region is given in Moye and others (1988).

Intercalated with the andesite units are fine-grained sedimentary rocks that may be lake- bed deposits similar to, but more indurated than overlying Miocene(?) age lacustrine deposits. Apparently, this part of the South Fork of the Boise River (now Anderson Ranch Reservoir) contained several large lakes intermittently during the past 45 million years. Perhaps Eocene volcanic activity dammed ancestral drainages, resulting in formation of the lakes in a manner similar to the manmade dam that today controls the reservoir.

Idavada Volcanics

The southern part of the Atlanta lobe is covered in places by rhyolite of the Miocene Idavada Volcanics. In the Hailey 1°×2° quadrangle, Idavada rocks are preserved in a triangular-shaped wedge north of the intersection of the eastern and western Snake River Plains. The Camas Prairie (Cluer and Cluer, 1986) is a crude northern boundary of the Idavada exposures. No attempt was made to subdivide the Idavada in this study; however, Wood (1989) and Wood and Gardner (1984) described the Idavada units on Bennett Mountain and at Danskin Peak. They noted two sequences of densely welded ash-flow tuff: the older rhyolites of Bennett Mountain and the younger rhyolites of the Danskin Mountains. These sequences are separated by a major fault that forms the west scarp of Bennett Mountain. Combined thickness of the two sequences is estimated at more than 3,280 ft.

These tuffs are similar to tuffs in the southwestern part of the Snake River Plain (Owyhee County) described by Ekren and others (1984) and Bonnichsen and others (1989). Little or no pyroclastic fabric is preserved in these rocks, and the rocks must

Figure 6. Tertiary monzodiorite containing inclusions (enclaves) near the Iron Mountain Lookout. Pen shown for scale.

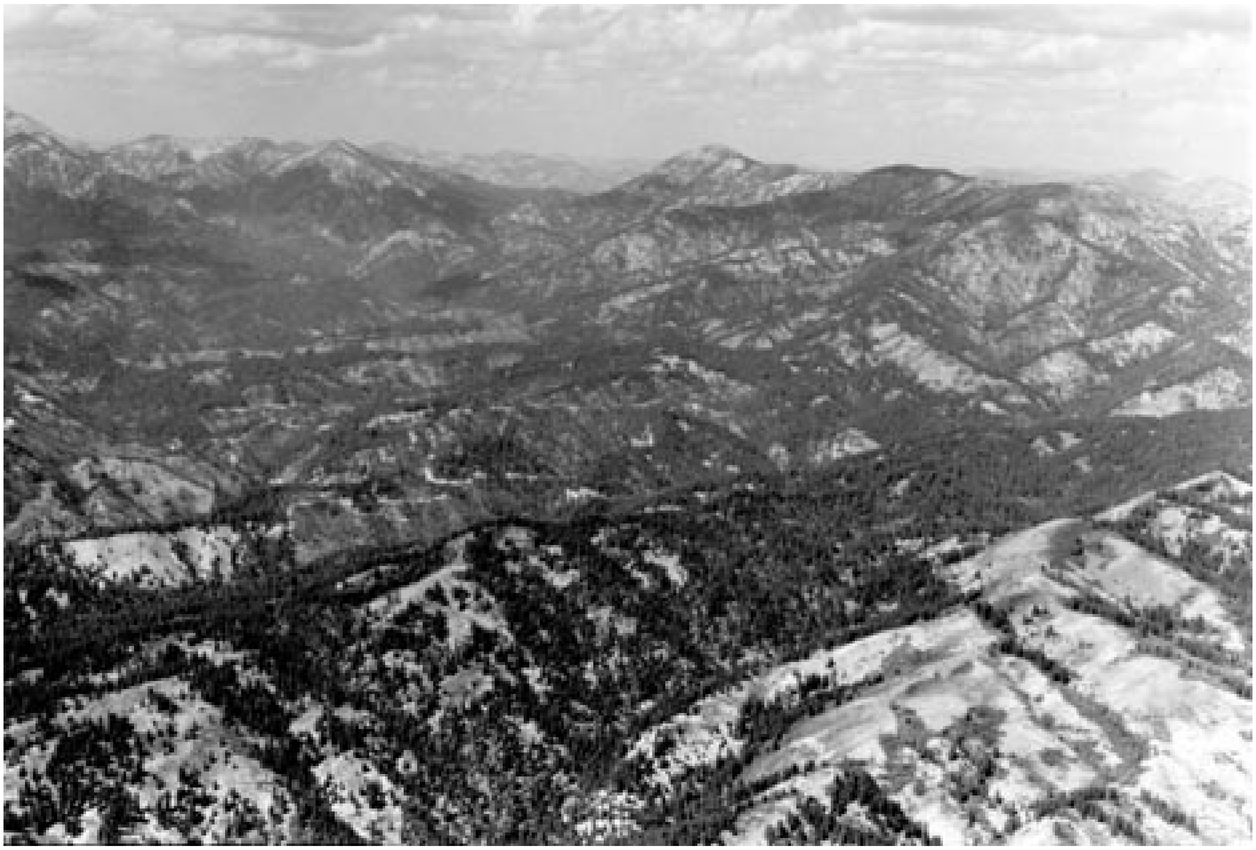

Figure 7. Looking northwest from just west of Smoky Dome, Idaho. Steel Peak is to the far left in the background. Higher peaks in middle and right background are on the east side of the Iron Mountain segment of the Deer Park fault. The rock east of the fault is granodiorite and some dikes. The center of the photograph is the downdropped western side of the fault; the rock is also mostly granodiorite. Light-colored rocks in the right corner are aplite and pegmatite dikes (part of the swarm just west of Smoky Dome).

have been very hot when extruded. Some of the Idavada rocks in Owyhee County may have been giant rhyolite lava flows (Bonnichson and Kauffman, 1987). All authors agree that these are unusual rhyolites, and their genesis is still not fully understood. The age of the Danskin Peak-Bennett Mountain flows is not known, but, based on the assumed age progression of the Yellowstone hot spot (Leeman, 1989), they probably formed about 10–8 Ma.

A series of basin and range faults (an older set trending north-northwest and a younger set trending northwest) cuts the Idavada Volcanics and Bennett Mountain. These faults have tilted blocks of the Idavada to the northeast. Numerous cold springs mark the location of these faults and are quite striking in their map pattern. The west and east forks of Long Tom Creek, Pony Creek, and Willowdale Creek-Pole Creek follow three of these structures.

West of the last exposure of rhyolite at Danskin Peak, several very thick and persistent dikes are present that, in hand specimen, bear a striking similarity to Idavada ash flows. A few of these are exposed along the Blacks Creek road between the Snake River Plain and the divide between Blacks Creek and Wood Creek near Three Point Mountain. The great length of these dikes is clear from exposures of one of the Blacks Creek dikes that is visible about 2 mi east of the junction of the Blacks Creek-Foot Hills roads on the Foot Hills road. The best exposure of one of these dikes is on private land, about 1 mi north of the Thomson Ranch on Bowns Creek. These dikes strike north-northwest, are very thick (as much as 100 ft), and have pronounced horizontal joints (fig. 8). One of the exposures at Thomson Ranch is a black vitrophyre that has very large (as much as 20 mm) sanidine phenocrysts. A whole-rock chemical analysis of a sample collected by Thor Kiilsgaard shows 63 percent SiO_2 and 17 percent Al_2O_3. This analysis is significantly different from a typical analysis of Idavada rhyolite, which shows more than 70 percent SiO_2 and less than 14 percent Al_2O_3 and indicates that the dikes are not related to Idavada lavas. These dikes do not resemble any of the Eocene or other dikes that have been observed in the Challis and Hailey studies. These would be the first dikes described in the Idavada, if they belong to this unit.

Lacustrine Deposits

In the Anderson Ranch Reservoir area a sequence of Miocene(?) lacustrine deposits overlie the Challis Volcanics. These deposits are widespread in Idaho (T.H. Kiilsgaard, oral commun., 1990) and are equivalent to the Latah Formation in northern Idaho and to the Payette Formation north and west of Boise. The beds range from fine-grained silt and clay to gravel;some contain pieces of plant fossils.

Figure 8. Dike of unknown age, Thomson Ranch on Bowns Creek. Mayfield 15-minute quadrangle, Idaho.

Basalts and Gravel Deposits

In the South Fork of the Boise River Canyon and Anderson Ranch Reservoir area there are many exposures of flat-lying basalts, a number of which form rimrock along the river and above the reservoir. Howard and Shervais (1973) and Howard and others (1982) described the basaltic volcanic rocks of the Smith Prairie area in detail. Ten flows were recognized at Smith Prairie, Anderson Ranch Reservoir, and along the South Fork of the Boise River. The plateau at Smiths Prairie is formed of flows of the Steamboat Rock Basalt that erupted from a vent located 2 mi south of the town of Prairie and flowed 37 mi down the South Fork to the Snake River Plain. The Steamboat Rock Basalt is dated at about 1.8 Ma by K-Ar methods and correlates with Pliocene and Pleistocene rocks of the Idaho Group (Malde and others, 1963). The basalt flows dammed the South Fork of the Boise River, and gravels were deposited on and behind the dam. Subsequently, a vent on the hillside above Smith Creek erupted the basalt of Smith Creek and then several smaller flows. Next, the Smith Prairie Basalt (about 0.2 Ma by K-Ar methods) and correlative in part with the Pleistocene and Holocene Snake River Group of Malde and others (1963) was erupted from vents on Dry Buck Creek. By this time, the South Fork had eroded deeply through earlier flows that had filled the canyon. Flows of the Smith Prairie Basalt went down Black Canyon and refilled 500 ft of the South Fork Canyon and once again dammed the river. Some of these flows reached the present site of Arrowrock Dam. Gravel was deposited on the Smith Creek basalt dam, and remnants of these gravels are preserved along the river. Subsequent erosion has lowered the river course through both lava dams leaving remnants of the Prairie Basalt basalt that are now locally called the “Lower Bench” (fig. 9). The narrow canyon and associated rapids, so beloved by Boise rafters and drift boaters, are the result of the second canyon filling and erosion. Pillow basalts mark where basalts flowed into the river. An excellent example of pillow basalts is along the Anderson Ranch Reservoir road where it climbs from Fall Creek to the plateau rim above the reservoir on the way to Pine.

One of the most interesting areas in this study is located in upper Mennecke Creek west of the Danskin Bridge. Here numerous landslides and small slumps are developed in a thick sequence of gravels (fig. 10). There are at least two gravel units: a younger unit composed of loose gravel and an older indurated gravel. The older gravel is tilted about 45° to the east (fig. 11). The flat-lying younger unconsolidated gravel overlies the older indurated unit and, in places, flat-lying basalts overlie both deposits (fig. 12). The two gravel units may be related to the basaltic volcanism as described by Howard and Shervais (1973). The older gravel may have been deposited when the river was dammed by the Steamboat Rock Basalt and the younger gravel was deposited when the river was dammed by the Smith Prairie Basalt. The unconformity may record movement associated with the Cow Creek fault, which is exposed in Mennecke Creek (fig. 13). If this interpretation is correct, then the Cow Creek fault was reactivated between the eruption of the basalts, sometime between the Pliocene-Pleistocene and the Holocene. As noted earlier, basalt dikes in the Cow Creek fault are sheared and shattered, also implying relatively recent movement. Both

Figure 9. View into the South Fork of the Boise River near Dawes Creek, Idaho. Older basalt flows of the South Prairie Basalt form the high rim on the right side of the photograph, younger flows form the "lower bench." Granodiorite of the Idaho batholith is on the left.

Figure 10. Landslides in gravels of Mennecke Creek west of the Danskin Bridge, Idaho. View looking south; tuffs of the Idavada Volcanics form back ridge.

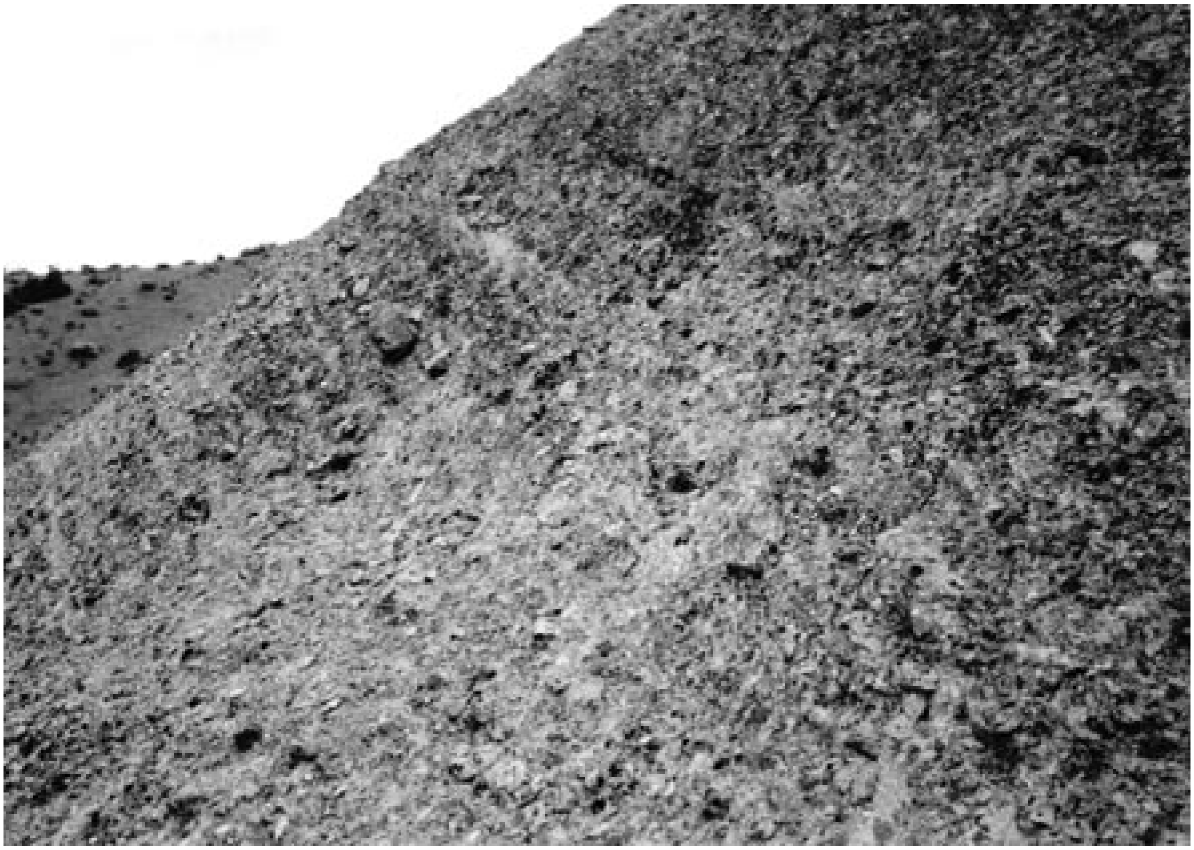

Figure 11. Indurated tilted gravels on east side of Mennecke Creek, Idaho.

Figure 12. Gravels below basalt in Mennecke Creek, Idaho.

Figure 13. Cow Creek fault (far right), older gravels (center), and younger gravels (left) in Mennecke Creek, Idaho. Smith Prairie Basalt forms flat plain on both sides of the South Fork of the Boise River. Smith Prairie is in the center of the photograph and House Mountain is to the right in the background.

gravels obviously predate recent downcutting that has left gravel benches preserved above the present river and reservoir level.

Some of the gravel in Mennecke Creek may be older than the basalts. At several locations near the contact of the gravels with the Idavada Volcanics, it appears that some gravel lies under the volcanic rocks. These sediments are probably equivalent to the Miocene lacustrine deposits described earlier.

Just west of Mennecke Creek, a red scar is visible where a basalt dike cuts gravels. The dike is a feeder for basalt flows that cap the gravels in this area. Late Cenozoic basaltic dikes are common along the southern edge of the Atlanta lobe and are related to young Snake River Plain basaltic volcanism. Many such dikes are present in the southern part of Anderson Ranch Reservoir area, and they probably fed some of the flows that are preserved in the South Fork of the Boise River canyon (called the basalt of Anderson Ranch by Howard and others, 1982). Some dikes may also have followed basin and range faults, as evidenced by Red Mountain (fig. 2), a young basalt cinder cone that sits astride the Trinity Mountain fault (fig. 14). The basalt of Fall Creek (Howard and others, 1982) flowed from Red Mountain down Fall Creek to the South Fork of the Boise River (now Anderson Ranch Reservoir). Other examples of basalt apparently related to basin and range faulting are small patches of columnar basalt near the Iron Mountain fault just west of the Iron Mountain Lookout and basalt along the West Willow Creek fault.

Alluvial Deposits

All active streams in the study area contain alluvial deposits typical of this part of Idaho. Large quantities of silt and sand are being impounded behind Anderson Ranch Dam and may someday form a lacustrine deposit.

Structure

The structural history of the western half of the Hailey 1°×2° quadrangle is relatively complex. Compression and extension in the Late Cretaceous and early Tertiary is indicated by the regional decollement(s) exposed at House Mountain and Chimney Peak. Two major periods of extension, one in the Eocene and another related to younger basin and range faulting, reactivated some older faults and formed new structures. The faulting has dissected the area into a series of complex rhomboid-shaped blocks that have all moved relative to each other.

Figure 14. Basalt lava flow from the Red Mountain vent along Fall Creek, Idaho, north of Fall Creek Lodge.

Cretaceous-Tertiary(?) Compression and Extension(?)

House Mountain Decollement

Below the other metamorphic rocks on House Mountain is orthogneiss that I believe formed either as part of a Cretaceous-Eocene decollement related to extension or during regional thrusting. The orthogneiss crops out along the lower part of the Cow Creek grade and along the road from South Fork to Prairie road on the hill above Danskin bridge. The protolith for some of the orthogneiss on Prairie Hill is biotite granodiorite of the batholith. Just west of the first switchback at the bottom of the hill is sheared granodiorite and to the west of this exposure are the Cathedral Rocks, which are made up of undeformed granodiorite that underlies the decollement.

According to the extension hypothesis, the orthogneiss is part of the decollement of an eroded core complex similar to core complexes in the Pioneer Mountains east of Hailey and near Priest Lake in northern Idaho, as well as elsewhere in the western United States and in British Columbia, Canada (Jacob, 1985). That core complexes in Washington and British Columbia have a ductile component related to Late Cretaceous compression and a more brittle component related to Eocene extension (Rhodes and Hyndman, 1984). The orthogneiss at House Mountain may be the ductile component of the core complex and the highly shattered and broken rocks around Anderson Ranch Reservoir the more brittle component.

According to the regional thrusting hypothesis, the orthogneiss represents a deep-seated decollement to one of a series of major thrust sheets in eastern Idaho (Skipp, 1987). Laramide thrusting in Idaho started before intrusion of the batholith and probably continued through batholith formation, as indicated by intrusion of several thrust faults by the batholith (Skipp, 1987).

Unloading the batholith by thrusting overlying sedimentary sequences to the east may have reduced lithostatic pressure on the batholith magma chamber and triggered the release of volatiles represented by the abnormally high concentration of aplite and pegmatite between House Mountain and Smoky Dome. Undeformed aplite and pegmatite dikes cut the orthogneiss at House Mountain (fig. 15), but some pegmatite may be the protolith for the orthogneiss. If the age of all of the aplite and pegmatite is Cretaceous, then the decollement formed during the Cretaceous and was intruded by its own aplite and pegmatite dikes.

Chimney Peak

Metamorphic rocks in the pendant at Chimney Peak are underlain by gneissic hornblende granodiorite. The foliation in the gneissic rocks is so pronounced that outcrops appear like stacked poker chips or playing cards (fig. 16). Hornblende forms a strong lineation in the foliation plane that indicates movement of the Chimney Peak metasedimentary rocks to the southeast. I believe that the gneissic granodiorite is equivalent

Figure 15. Orthogneiss and sheared biotite granodiorite and aplite and pegmatite dikes that are intruded by undeformed aplite and pegmatite dikes. Top of the Prairie grade on the road from Danskin Bridge to Prairie, Idaho.

Figure 16. Sheared poker chip biotite-hornblende granodiorite north of Chimney Peak on Salix Creek, Idaho.

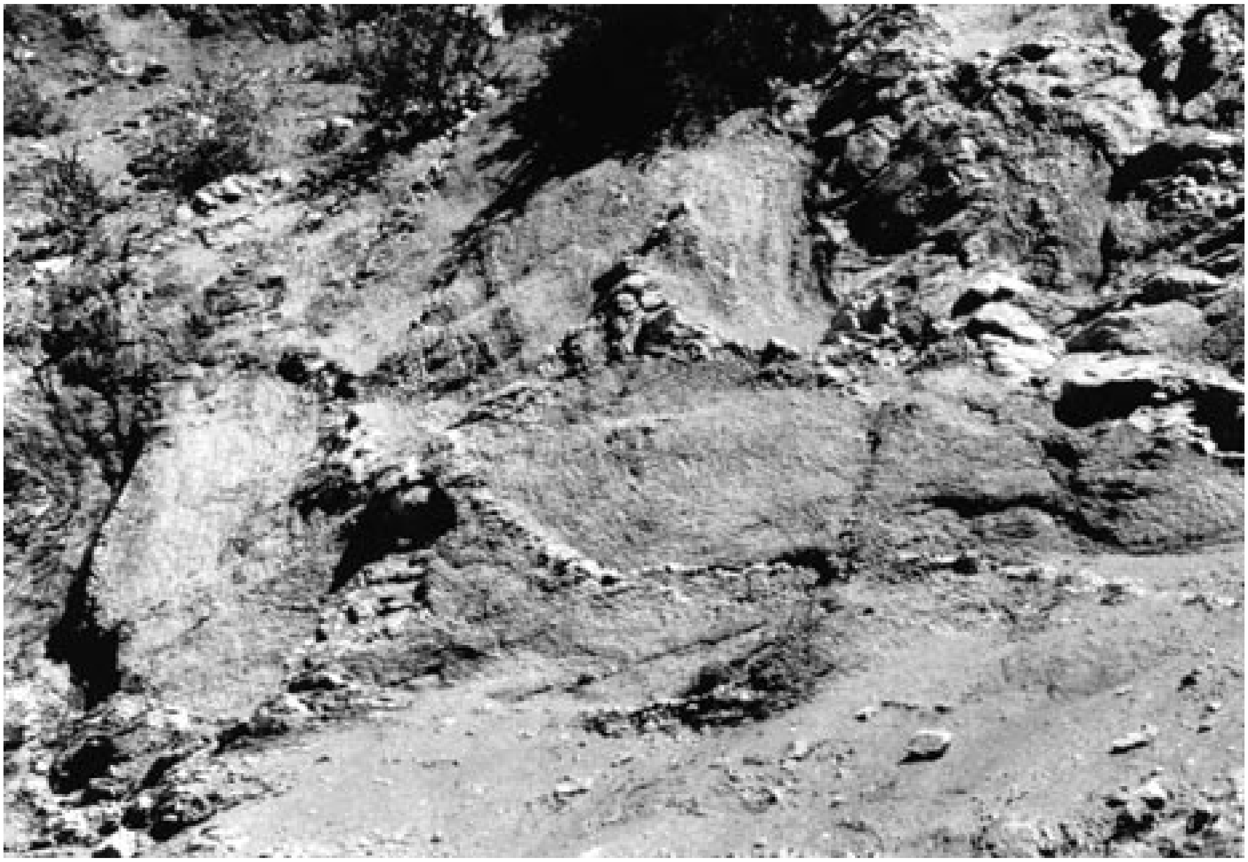

Figure 17. Orthogneiss and sheared biotite granodiorite on the old Pine to Dixie Gulch Hot Springs road, Idaho.

to the orthogneiss at House Mountain and is part of the regional decollement in this area. Pegmatite and aplite surrounding Chimney Peak are foliated (Worl and others, 1991) and in places, nonfoliated pegmatites intrude these foliated rocks.

Old Pine-Dixie Gulch Hot Springs Road Orthogneiss

Orthogneiss that has a protolith of granodiorite and aplite and pegmatite is present about 1 mi south of the intersection of the Pine to Dixie Gulch Hot Springs road on the east side of the South Fork of the Boise River. The first gneissic outcrops going south from the hot springs are where the road comes very close to the South Fork (fig. 17). As on Prairie Hill, the orthogneiss is cut by undeformed Cretaceous age aplite and pegmatite dikes and younger Tertiary dacite and rhyolite dikes. Foliated granodiorite is exposed in a small hill just before the Dog Creek campground on the Pine to Dixie Gulch road on the west side of the river. At the southern intersection of the roads that traverse the east and west sides of the river from Pine to Dixie Gulch, just east of Pine, are outcrops and float from metamorphic rocks that form small pendants and xenoliths all along the ridge east of the South Fork and the reservoir, from Pine to Lime Creek. The metamorphic rocks at Lime Creek were not subdivided during this study, but there is orthogneiss in the sequence. All of these exposures may be related to the House Mountain decollement.

Cow Creek Fault

A number of exposures at the top of the Cow Creek grade show features that are typical of major faults in the Idaho batholith (fig. 18). Granodiorite and pegmatite have been ground to a white powder, and remnants of granodiorite are present in the gouge. Basalt dikes of probable Pliocene-Pleistocene age cut the fault but are in turn sheared and shattered. The Cow Creek fault is believed to be relatively flat. Exposures similar to those on the Cow Creek grade are present in Mennecke Creek about 2 mi west of Cow Creek (fig. 19). The Cow Creek fault was probably active during basin and range extension because it is similar to exposures of the Deer Park fault at Big Elk Creek (fig. 22). The Cow Creek fault is, however, much flatter than the typical basin and range fault and may be a more complex structure related to the House Mountain decollement that was later deformed during basin and range extension. The Cow Creek-House Mountain decollement separates aplite and pegmatite and included metasedimentary rocks east of Prairie from monotonous granodiorite and two-mica granite of the batholith to the west.

Mylonite near Hall Gulch

DeLong (1986) described three types of mylonite in batholith rocks near Halls Gulch, south of the Camas Prairie. He believed that formation of the mylonite was related to the intrusion of the batholith.

Figure 18. Cow Creek fault near the top of the Cow Creek grade. Light-colored exposures are biotite granodiorite gouge. Dark bands (left side of photograph) are sheared basalt dikes.

Figure 19. Outcrop between Mennecke Creek and Cayuse Creek, Idaho. The fault gouge in biotite granodiorite is interpreted as being part of the Cow Creek fault (see fig. 13).

Thrusting and the Batholith

In Idaho and western Montana, a pie-shaped wedge of continental crust lies between two major linear features, the Lewis and Clark line to the north and the eastern Snake River Plain to the south; the strontium isopleth in western Idaho marks the western edge of old continental crust. This wedge of continental crust includes the Helena salient in the overthrust belt in Montana and the major thrust sheets in eastern Idaho.

A possible explanation for the salient is as follows: Collision of the accreted terranes in western Idaho moved the thrust plates that are now in eastern Idaho and western Montana eastward. The Lewis and Clark line and the Snake River Plain, old continental plate boundaries, were reactivated and accommodated this compression by left-lateral movement on the Lewis and Clark and right-lateral movement in the eastern plain. This thrusting was maximum in the pie-shaped wedge. As thrusting continued, thrust sheets stacked up and thickened the continental crust between the Lewis and Clark line and the eastern Snake River Plain. When subduction resumed following accretion, the greatly overthickened continental crust contributed large volumes of granitic magmas that eventually formed the Idaho batholith. A similar scenario has been suggested by Skipp (1987).

Eocene Extension

The effects of a major extensional event during the Eocene that affected Idaho from the Snake River Plain northwest into central British Columbia is well documented (Ewing, 1980; Bennett, 1986). Bennett (1986) noted that Eocene extension in Idaho is confined to a crustal block bordered on the south by the eastern Snake River Plain and on the north by the Lewis and Clark line. He noted that both features could be much older than Eocene and may represent platelet boundaries in the North American plate. Extensional stress oriented northwest-southeast generated or reactivated northeast-trending faults. Best known of these northeast-trending structures is the Trans-Challis fault system, that extends across Idaho from Idaho City to Gibbonsville and into the alkaline province in Montana (Kiilsgaard and others, 1986). In Montana, this structure is known as the Great Falls lineament (O'Neill and Lopez, 1985). Along the Trans-Challis fault system are numerous Tertiary rhyolite dike swarms and granitic plutons. A significant number of gold mines and prospects also are along this structure, including the important mines at Boise Basin and the newly discovered Beartrack deposit, the largest gold discovery in the State's history. Major mines at Atlanta, Rocky Bar, and the Neal district are along other northeast-trending shear zones. The age of the deposits at Atlanta (69.1 Ma and 68.1 Ma on vein muscovite, Snee and Kunk, 1989) and at Rocky Bar (58–57 Ma on vein muscovite; Snee and Kunk, 1989) strongly suggest that there was earlier movement (Cretaceous-Paleocene) on some of the northeast structures that were reactivated in the Eocene. Most of these districts are being explored today for heap-leach, bulk-minable, low-grade gold deposits. The eastern Snake River Plain may be another locus of Eocene extension, and the Pioneer core complex (Wust and Link, 1988) and House Mountain decollement (Jacobs, 1985a) may also be products of this extension. In the western part of the Hailey 1°×2° quadrangle, northeast-trending faults have been crosscut and dissected by younger basin and range faults; however, radar imagery (fig. 20) clearly shows the strong northeast structural grain.

Eocene and Older, Normal Northeast-Trending Faults

Major northeast-trending faults in the western part of the Hailey quadrangle include the Willow Creek-Bear Creek fault, the Moores Flat fault, the Middle Fork of the Boise River fault, the Trans-Challis fault system near Idaho City, the North Fork of Deep Creek-Yellow Pine Creek fault, and a fault that separates House Mountain from a hummocky area to the north along the Deer Creek-Meadow Creek road. Note that there are three Willow Creek faults: the northeast-trending Willow Creek-Bear Creek fault; a northwest-trending basin and range fault along the Willow Creek in the center of the Hailey quadrangle (East Willow Creek fault, an extension of the Montezuma fault); and another northwest-trending basin and range fault along the Willow Creek that crosses the Blacks Creek road southwest of Prairie (referred to herein as the West Willow Creek fault). Another possible northeast-trending fault is along the upper reaches of Lime Creek.

The Willow Creek-Bear Creek fault has a hot spring at its southwestern end and is the locus of several mineral deposits on Bear Creek including the Red Horse and El Oro mines. Granodiorite exposures just east of Shake Creek Ranger Station along the South Fork road are strongly foliated and may be where the Willow Creek-Owl Creek fault crosses the road. The Moores Flat fault probably controlled the emplacement of several Tertiary intrusions. It may also explain why the forks of Lime Creek flow from north to south and then turn west, parallel with the strike of the fault, and why the drainages south of the fault all flow southward. The Moores Flat fault is also on the projection of the Dillon lineament and may be the structure that forms the scarp on the west end of Bennett Mountain. The Middle Fork fault is aligned with the northeast-trending southern boundary of the Sawtooth Range, which may be fault controlled (Kiilsgaard and others, 1970). Other smaller unnamed northeast fault segments are shown on the geologic map of the Hailey 1°×2° quadrangle (Worl and others, 1991).

Eocene dikes and plugs were intruded along northeast-trending structures such as the Trans-Challis fault system. The location of the gabbro plug and other Tertiary intrusions along the Moores Flat fault indicates a similar relationship. This relationship does not mean that these northeast structures formed in the Eocene, only that major movement occurred during the Eocene. Several of these northeast structures are older than Tertiary, as proven by the aforementioned Cretaceous-Paleocene mineralized rock along some of these faults. The Trans-Challis fault system and eastern Snake River Plain may represent even older major intracontinental fractures.

Regional Northeast Structures and Trends

The pronounced northeast structural grain in the Hailey 1°×2° quadrangle can be described as a series of four

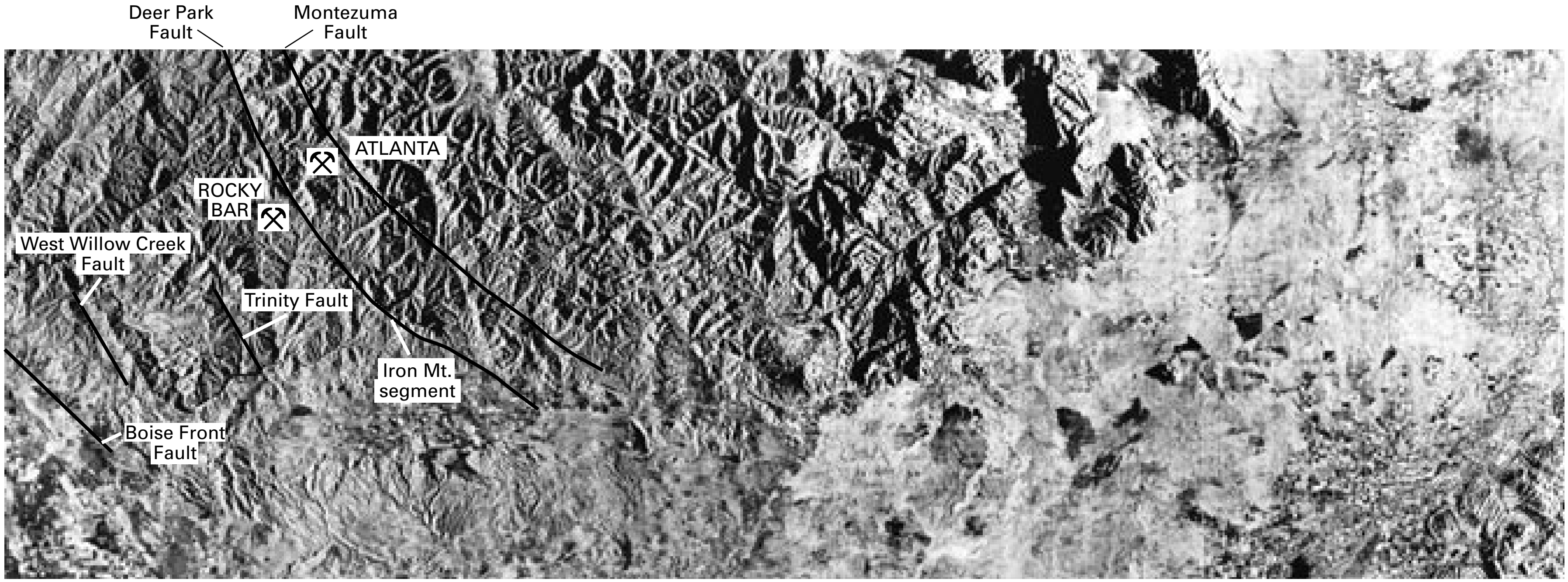

Figure 20. Radar image of the Hailey 1°×2° quadrangle, Idaho.

northeast-trending belts characterized by different rock types. The four belts from south to north are the eastern Snake River Plain, an extension of the Dillon Cutoff, the Twin Springs-Sawtooth lineament, and the Trans-Challis fault system.

The eastern Snake River Plain is the southern limit of Eocene extension. It is interpreted as the trace of the passage of the Yellowstone hot spot (Miocene to present), the driving force for at least part of present-day seismic activity in the basin and range province in this part of Idaho and Montana. The eastern Snake River Plain is separated from the next Eocene belt to the north by younger Idavada Volcanics, basalts, and sedimentary rocks.

The next Tertiary belt to the north is broad and contains a number of Tertiary granites including rocks near the Blackstone mine, outcrops near Hill City, Smoky Dome, and other exposures to the northeast. The pink granite at Mormon Reservoir, the southernmost exposure of Tertiary granite in the Hailey 1°×2° quadrangle, and is part of this belt. Farther to the northeast, the belt includes Tertiary granite exposures on Big Smoky and Prairie Creeks, the Boulder batholith north of Ketchum, and small Tertiary stocks at Glassford and Ryan Peaks (Fisher and others, 1983). The granite in Copper Basin, and the Mackay stock (Idaho Falls 1°×2° quadrangle), and perhaps the Pioneer core complex may be part of this system. The belt coincides with the southwest extension of a lineament first referred to by Ruppel (1982) near Horse Prairie in Montana. This lineament was recently studied by O'Neill and others (1990), who named it the Dillon cutoff. In Montana, the Dillon cutoff marks the contact between thin-skinned thrust sheets in the frontal fold and thrust belt and block-uplifted older basement rocks to the east in the Lima recess. Ruppel (1982) noted that the Dillon cutoff in the Dubois 1°×2° quadrangle in Idaho is a broadly defined zone that roughly separates Paleozoic rocks south of the lineament from Precambrian rocks to the north in the Beaverhead and Lemhi Ranges. The Dillon cutoff also forms the drainage divides between major streams and rivers in east Idaho including the Lemhi River-Birch Creek, Pahsimeroi-Little Lost River, Big Lost River-Warm Springs Creek (Salmon River), and Big Wood River-Salmon River divides. O'Neill and others (1990) suggested that the Dillon cutoff coincides with the Great Falls tectonic zone. They stated "the Great Falls tectonic zone apparently first formed as a Proterozoic linear orogen that now marks the northwest margin of the Wyoming Archean province."

North of the Dillon cutoff in the study area, a northeast-trending belt, defined by the Sheep Creek-Trinity Tertiary complex and the Sawtooth batholith, is referred to as the Twin Springs-Sawtooth lineament in this paper. The Twin Springs-Sawtooth lineament is separated from the Dillon cutoff by a wide band of granodiorite that extends across the Hailey quadrangle from Mayfield to the Sawtooth Valley. The Twin Springs-Sawtooth lineament is shorter than the Dillon cutoff or the Trans-Challis fault system and appears to end at the Sawtooth Valley. The gap between the Sawtooth batholith and the Sheep Creek batholith in the Twin Springs-Sawtooth lineament is a basin and range graben formed between the Montezuma and Deer Park faults (fig. 2). The graben contains Cretaceous batholith rocks and younger dike swarms. It also contains the ore deposits at Atlanta Hill, one of the most productive mining areas in this part of the Hailey quadrangle.

The fourth northeast belt is the Trans-Challis fault system in the Idaho City area; it is separated from the Twin Springs-Sawtooth lineament by a band of granodiorite and two-mica granite. The Trans-Challis fault system, as noted previously, extends all the way across Idaho and into Montana where it merges with the Great Falls tectonic zone. It should be noted that the granodiorite belts between the Tertiary belts contain numerous Tertiary dikes and therefore probably overlie Tertiary plutons at depth.

The spacing between the four northeast-trending belts is too regular to be coincidental. Recent work in the Elk City and Hamilton 1°×2° quadrangles in north-central Idaho shows that a similar pattern of belts continues north of the Trans-Challis fault system. A major northeast-trending band of Tertiary granite is roughly coincident with the Bargamin fault (Lewis and others, 1990) in the Elk City 1°×2° quadrangle and a newly described northeast-trending graben containing Tertiary intrusive rocks is in the Hamilton 1°×2° quadrangle (R.S. Lewis, unpub. mapping, 1991).

Brittle Deformation

The number of pegmatite and aplite dikes and the brittle deformation (fig. 21) in the Anderson Ranch Dam area are striking. A very large, almost flat fault is exposed at the top of the road that goes down to the dam. Directly above this fault is the open pit from which fill for the dam was obtained. The material in the pit looks in places to be highly sheared granodiorite and pegmatite. The pit and other examples of cataclasis noted in many exposures of granitic rocks around the reservoir may be products of Eocene extension. A younger basin and range extensional event may be superimposed on the Eocene event.

Basin and Range Extension

Regional basin and range extension from the Miocene through the present is well documented in the study area (Bennett, 1980). This extensional event occurred at about right angles to the Eocene extension and produced or reactivated major northwest-trending structures. These structures extend from eastern Idaho (including the Beaverhead, Lemhi and Lost River Ranges) (Ruppel, 1982) across the southern Atlanta lobe to the most westerly structure, the Boise front fault (northeast edge of the western Snake River Plain). Faults of this type in the western part of the Hailey 1°×2° quadrangle area include the Montezuma fault (includes East Willow Creek fault), the Deer Park fault (Anderson, 1934) (including the Iron Mountain segment), the Trinity fault, the West Willow Creek fault, and the extension of the Boise front fault that separates the batholith from the Snake River Plain. As noted, a small basalt vent is on the Iron Mountain segment of the Deer Park fault, just west of the Iron Mountain Lookout, and Red Mountain, a recent basalt vent, is on the Trinity Mountain fault. Basin and range structures do not show well on the radar imagery, but the graben between the Deer Park fault and the Trinity fault is visible on figure 20.

Figure 21. Anderson Ranch Dam, Idaho. Pegmatite and aplite dikes in granodiorite are the main rock unit, and a number of basalt dikes crosscut the granitic rocks.

A spectacular cross section of the Deer Park fault is exposed where the road crosses a small bridge at Elk Creek about 4 mi north of Rocky Bar up Blake Gulch (fig. 22). From this location, the lineament associated with the Iron Mountain segment of the Deer Park fault is obvious, extending off to the southeast to Iron Mountain and Smoky Dome. Biotite granodiorite is totally sheared for about 100 ft on either side of the Elk Creek bridge and appears as an unconsolidated bright-white powder containing fragments of batholith rocks. The trace of the fault ascends Elk Creek across the east side of Steel Mountain and then descends Hot Creek (contains hot springs) on the north side of the mountain (fig. 23). The fault separates Eocene pink granite on Steel Mountain from Cretaceous biotite granodiorite northeast of the fault at Bald Mountain. The ridge that parallels this fault from Bald Mountain to Cayuse Point to Iron Mountain is mostly biotite granodiorite containing Tertiary dikes.

A number of hot springs along or near some of the Eocene faults indicates relatively recent movement along these segments, probably in response to basin and range tectonics. As noted, some of these faults moved during the Cretaceous and Paleocene. The crosscutting of northeast-trending Eocene (or older) structures by northwest-trending Miocene or younger structures has broken the study area into a series of rhomboid-shaped blocks that have moved relative to each other in response to basin and range extension. This rhomboid pattern greatly complicates the tectonic chronology for this area and makes it difficult to decipher what type of movement occurred and when on any of these faults.

This rhomboid pattern is similar to that described for the shape of the Boulder batholith in Montana (Schmidt and others, 1990). Emplacement of the Boulder batholith was controlled by northeast-trending and east-trending fault sets. Satellite plutons associated with the batholith were emplaced along northwest-trending faults. The Boulder batholith was emplaced at about 78-70 Ma and therefore is older than the Tertiary intrusions in Idaho. This Cretaceous age adds further support to the idea that in Montana and Idaho some northeast and northwest faults are older than Tertiary and have a long history of movement.

North-Trending Faults

A number of north-trending faults were mapped or inferred in the western part of the Hailey 1°×2° quadrangle. One of these, the Pine-Featherville fault, north of Dog Mountain, separates aplite, pegmatite, and metamorphic rocks to the east of Pine from granodiorite to the west. The road follows the fault from Pine to Featherville. The pinnacles near Tollgate Creek that are visible just west of the Pine-Featherville road are highly sheared granodiorite believed to be related to the faulting. Several hot springs, including a spring at the bridge over the South Fork at Dixie Gulch, Paradise Hot Springs, and hot springs on Warm Springs Creek northeast of Featherville, are on the trace of the fault. The age of the north-trending faults is unknown but the faults are probably very young and are perhaps the same age as the east-trending faults shown on the geologic map of the

Figure 22. Elk Creek fault (segment of the Deer Park fault) on the James Creek road from Rocky Bar to Atlanta, Idaho. Light-colored outcrop is gouge from faulted biotite granodiorite. Fault trace is in the middle of Elk Creek. Note the similarity to the Cow Creek fault shown on figure 8.

Figure 23. Hot Creek fault, just north of the Elk Creek segment of the Deer Park fault, Idaho. Steel Peak, composed of Tertiary granite, is to the right of hot Creek and biotite granodiorite to the left.

Hailey 1°×2° quadrangle (Worl and others, 1991). Some of these structures such as the Pine-Featherville fault, are oriented about 45° to the northwest-trending basin and range faults and may be tangential shears between two such basin and range structures.

Geologic Summary

The western half of the Hailey 1°×2° quadrangle is dominated by rocks of the Idaho batholith that are overlain by metamorphic rocks of uncertain age. Compression during the Cretaceous may be recorded by decollements at House Mountain and Chimney Peak. A complex sequence of faults that formed or were reactivated during Late Cretaceous to middle Tertiary extension have broken the area into a series of rhomboid-shaped blocks that have been complexly tilted. Formation of Eocene and Miocene volcanic and plutonic rocks accompanied extensional activity. This faulting and associated plutonic and volcanic activity are related to the ore deposits in the area.

Mineral Deposits

The purpose of the Hailey CUSMAP program was to evaluate the mineral potential of the Hailey 1°×2° quadrangle. The western half of the Hailey quadrangle contains several hundred mines and prospects in 18 mining districts. The following sections describe the major deposits in nine of these districts (fig. 24), including the Skeleton Creek, Lime Creek, Rocky Bar, Neal, Pine, Volcano, Dixie, Featherville, and Roaring River mining districts and several deposits that are outside these district boundaries. The important deposits near Idaho City and Atlanta (Yuba district) are discussed by Kiilsgaard, Scanlan, and Stewart (in press) and Kiilsgaard and Bacon (in press).

Periods of Mineralization

Mineral deposits in the western part of the Hailey 1°×2° quadrangle can be divided into three main groups: Late Cretaceous-Paleocene deposits, Eocene deposits, and possible Miocene and younger deposits. The distinction between Late Cretaceous-Paleocene deposits and Eocene deposits, if one exists, is not totally clear at this time. It is possible that mineralization was almost continuous from 70 to 40 Ma. The division is based on several Ar^{40}/Ar^{39} dates on sericite from mines and more dating and study is needed to solve this problem.

Late Cretaceous-Paleocene Deposits

The age of mineralization at Rocky Bar and Atlanta has been debated for many years. New $Ar^{40/39}$ dates for these deposits (Snee and Kunk, 1989) indicate a Late Cretaceous-Paleocene age for the mineralization at both locations. Deposits in these areas are within northeast-trending shear zones that were assumed to be Eocene. Therefore, some of the northeast structures had movement prior to the Eocene. Deposits in the Yuba district (Atlanta Hill) are hosted in Cretaceous granodiorite preserved in a graben between the Montezuma and Deer Park faults. The mines at Rocky Bar are just west of this graben and are also hosted in Cretaceous granodiorite.

Some deposits known to be Eocene in age in the Trans-Challis fault system are associated with rhyolite intrusive rocks of Eocene age. Rhyolite dikes are rare at Rocky Bar and at Atlanta Hill. At Rocky Bar, a thin rhyolite dike crosscuts a mineralized shear zone and is definitely younger than the mineralized rock (Dave Cockrum, GEXA, oral commun., 1989). Anderson (1943) noted a similar relationship near old Spanish Town in the Rocky Bar district. By inference with rhyolite of known age elsewhere, the mineralization is pre-Eocene.

EXPLANATION FOR FIGURE 24

Mining districts

A	Neal
B	Yuba-Atlanta Hill
C	Skeleton Creek
D	Roaring River
E	Rocky Bar—Includes Red Warrior and Bear Creek mining districts
F	Featherville
G	Pine (Pine Grove)
H	Lime Creek
I	Dixie
J	Volcano

Mines and other properties

1	Homestake-Hidden Treasure
2	Daisy
3	Sunbeam-Sunshine
4	Twin Springs placer
5	Sheep Creek placer
6	Hermada
7	Atlanta Hill
8	El Oro
9	Red Horse or Frazier
10	Old Sam or Turner
11	Decker Horstenstine
12	Rinebold
13	Avalanche-Richmond
14	Vibrator
15	Vishnu (Clifton Bell)
16	Morning Star (Canada mill)
17	Ada-Elmore
18	Independence
19	Mountain Goat
20	Ophir
21	Spanish Town
22	Wide West
23	Bonaparte mine
24	Marsh Creek mine
25	Shake Creek prospect
26	South Park Dredging Company
27	Franklin
28	Mountain View
29	President, Hawthorne, Jingo, Hornet
30	Highland Mary
31	Copper King
32	Mountain View tungsten
33	King shaft
34	Index
35	Cat Creek mine
36	Bowerman group
37	Blackstone
38	Volcano
39	Revenue
40	Index group

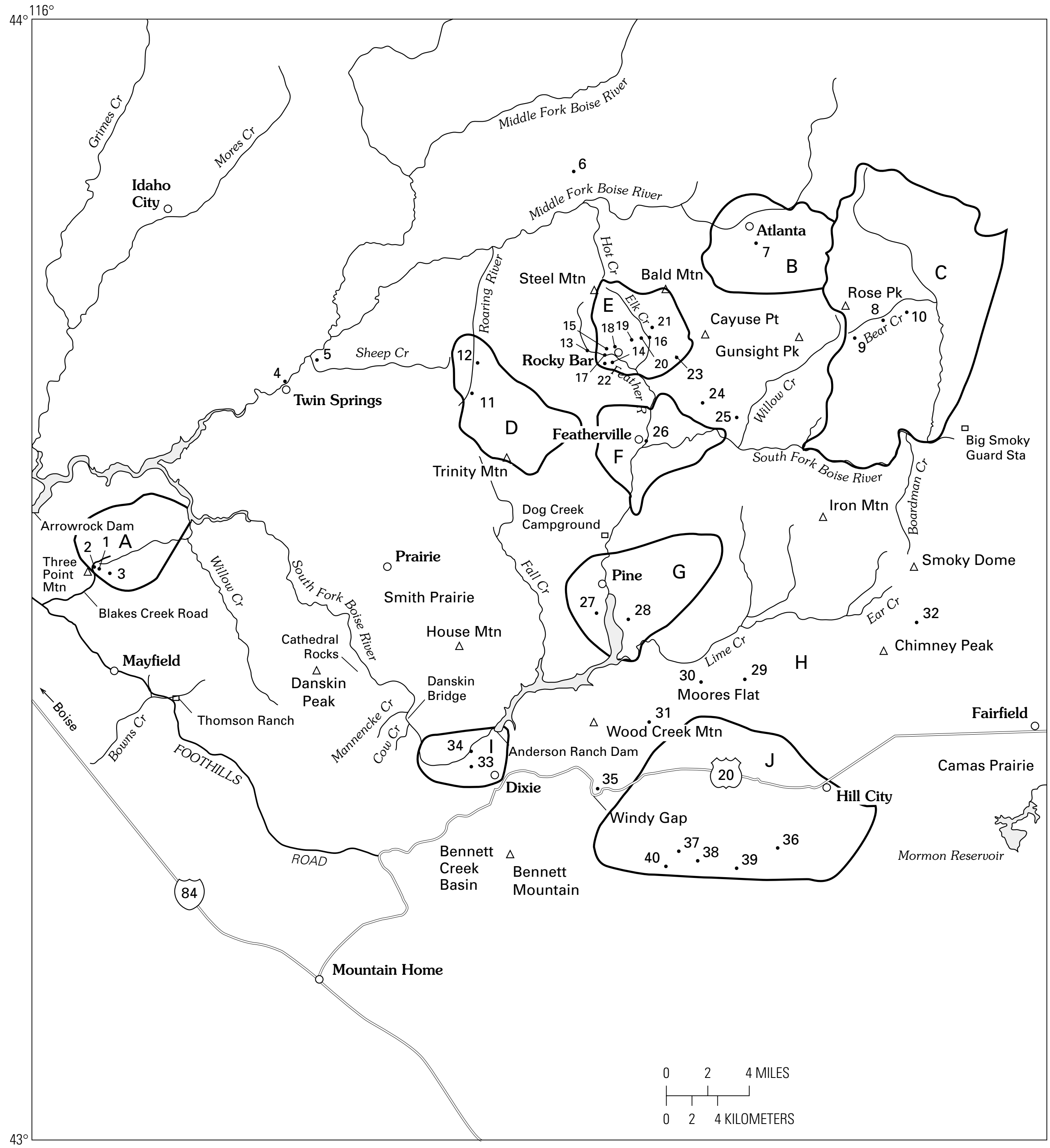

Figure 24 (above and previous page). Map showing location of selected mineral deposits and mining districts in the western part of the Hailey 1°×2° quadrangle, Idaho modified from Gustafson (1987) and Ross (1941). The Neal and Lime Creek districts (informal) were not included in Ross's map and, the Dixie district, which was shown incorrectly on Ross's map is shown in its correct location.

Work in the Elk City 1°×2° quadrangle to the north (Lewis and others, 1990) suggests that gold deposits near Elk City are probably Cretaceous-Paleocene in age and are similar to deposits in the Gospel Hump area dated as Cretaceous by (Lund and others, 1986). As noted, mineralization at Rocky Bar, Atlanta, and in other districts may also be Cretaceous in age.

Eocene Deposits

The Trans-Challis fault system (Kiilsgaard and others, 1986, 1989) contains many gold mines, including the mines at Idaho City (about 3 million ounces, the largest gold producing area in Idaho) and the recently discovered Beartrack property north of Salmon (probably the largest single lode gold discovery in the State's history). Northeast-trending structures are important controls for deposits elsewhere in the western part of the Hailey quadrangle. Several mines in the Willow Creek-Bear Creek drainage, including the Red Horse and the El Oro, are directly on a northeast-trending structure. Likewise, the mines in the Lime Creek district and several adjacent prospects are on the northeast-trending Moores Flat fault.

The association of rhyolite and northeast-trending structures that is so dominant in parts of the Trans-Challis fault system may also be true for the Hailey 1°×2° quadrangle. The Gold Hill mine in the Centerville district (Boise Basin) is hosted in a rhyolite contained in a northeast-trending shear zone. Deposits in the Neal mining district are in northeast-trending shear zones, and Three Point Mountain, just west of the deposits, contains a rhyolite dike swarm. A rhyolite dike is also exposed just west of the King shaft in the Dixie mining district.

Possible Miocene and Younger Deposits

Elsewhere in Idaho and Oregon, for example, the DeLamar mine in Owyhee County, the Tolman mine in Cassia County, the Idaho Almaden mine in Washington County, and several new prospects in Malheur County, Oregon, epithermal basin and range mineralization is well documented. These "hot springs" deposits are hosted in sandstone, other sedimentary rocks, and rhyolite intrusive rocks but not in batholith rocks. The low grade and apparent paucity of basin and range deposits in the batholith suggest that granitic rocks are a poor host for this type of ore deposit. Basin and range related mineralization probably was not very important in the study area.

Several mines or prospects including the Marsh Creek mine, the Shake Creek prospect, and the Bonaparte mine (and prospects north of the mine), are astride or close to the Iron Mountain segment of the Deer Park fault, which is believed to be a basin and range structure. None of these deposits have had substantial development, based on the size of mine dumps and production figures available in the literature. Adularia from the Marsh Creek mine (R.E. Sanford, oral commun., 1991) was dated by Ar^{40}/Ar^{39} methods at 39.3 Ma (Eocene). The Hermada antimony mine (described by Popoff, 1953) (not visited by the author), on the East Fork of Swanholm Creek, is also very close to the Deer Park fault. An Ar^{40}/Ar^{39} date of 61.2 Ma (Snee and Kunk, 1989) indicates that mineralization at the Hermada mine is older than basin and range extension. If the Marsh Creek and Hermada mines are in some way related to the Deer Park fault, then there was pre-basin and range movement along this structure.

Neal Mining District *by* Thor H. Kiilsgaard *and* Earl H. Bennett

The Neal mining district is about 15 mi east of Boise, east and southeast of Three Point Mountain. The northern part of the district is along the divide between Wood Creek and Blacks Creek (figs. 24, 25). Access is from Interstate 80 via the Blacks Creek exit or by dirt road south from the town of Prairie. The only published geologic description of the district is by Lindgren (1898).

Production

Lindgren (1898) estimated a value of $200,000 for gold produced from the district through 1897. Using a value of $20.67 per ounce of gold, the price paid for 1000-fine gold dring the period of production, the $200,000 represents a production of 9,675 ounces. Unpublished data from the U.S. Bureau of Mines, for 1901 to 1991 show production of 20,135 ounces of gold and 15,428 ounces of silver (table 1). Placer production from the district has been minimal. Assuming some error in the records and no production data for the years 1898, 1899, and 1900, it is reasonable to believe the district has produced at least 30,000 ounces of gold.

The most productive mines in the district have been the Homestake-Hidden Treasure, the Golden Eagle and the Daisy; smaller producers include the Sunset and the Sunshine-Sunbeam. Of these mines, the Homestake-Hidden Treasure and the Daisy are on the same vein zone.

History

Lindgren's (1898) description of veins in the district is based on notes by F.D. Howe, who was superintendent of the Hidden Treasure mine. Veins of the district have a common N. 70°–83° E. trend and the same general dip to the south. Based on form, the veins can be differentiated into three classes: (1) veins filling larger fault fissures, on which are located the principal mines; (2) veins along minor shearing planes of the granite, more or less irregular, but generally containing high-grade ore; and (3) veins of hard white quartz that do contain precious metals. The major veins are displaced by north-trending faults. Much of the gold is free, but some is in pyrite. The veins also contain minor accessory sulfide minerals, including sphalerite and galena.

Lindgren (1898) described the country rock of the district as gray granite cut by numerous dikes. He called attention to large syenite porphyry dikes that cross Blacks Creek about 2.5 mi southwest of the Daisy shaft and to narrow lamprophyre dikes that follow along the vein at the Homestake and the High Five mines. He thought that the lamprophyre dikes probably antedate the veins.

Wells (1983) provided a brief overview of early discoveries in the Neal mining district. In December 1888, Arthur Neal, enroute to Boise with his pack string, discovered mineralized float. He found the mineralized source the following year and, with his partner George House, began mine development. These and other early workers were hampered by a lack of capital and water in the dry region. Similar to other districts in Idaho, most of the mines in the Neal mining district were financed and operated by eastern capitalists.

The following historical summary of mining activity in the Neal mining district was taken from annual reports on the mining industry of Idaho by the Idaho State Mine Inspector,

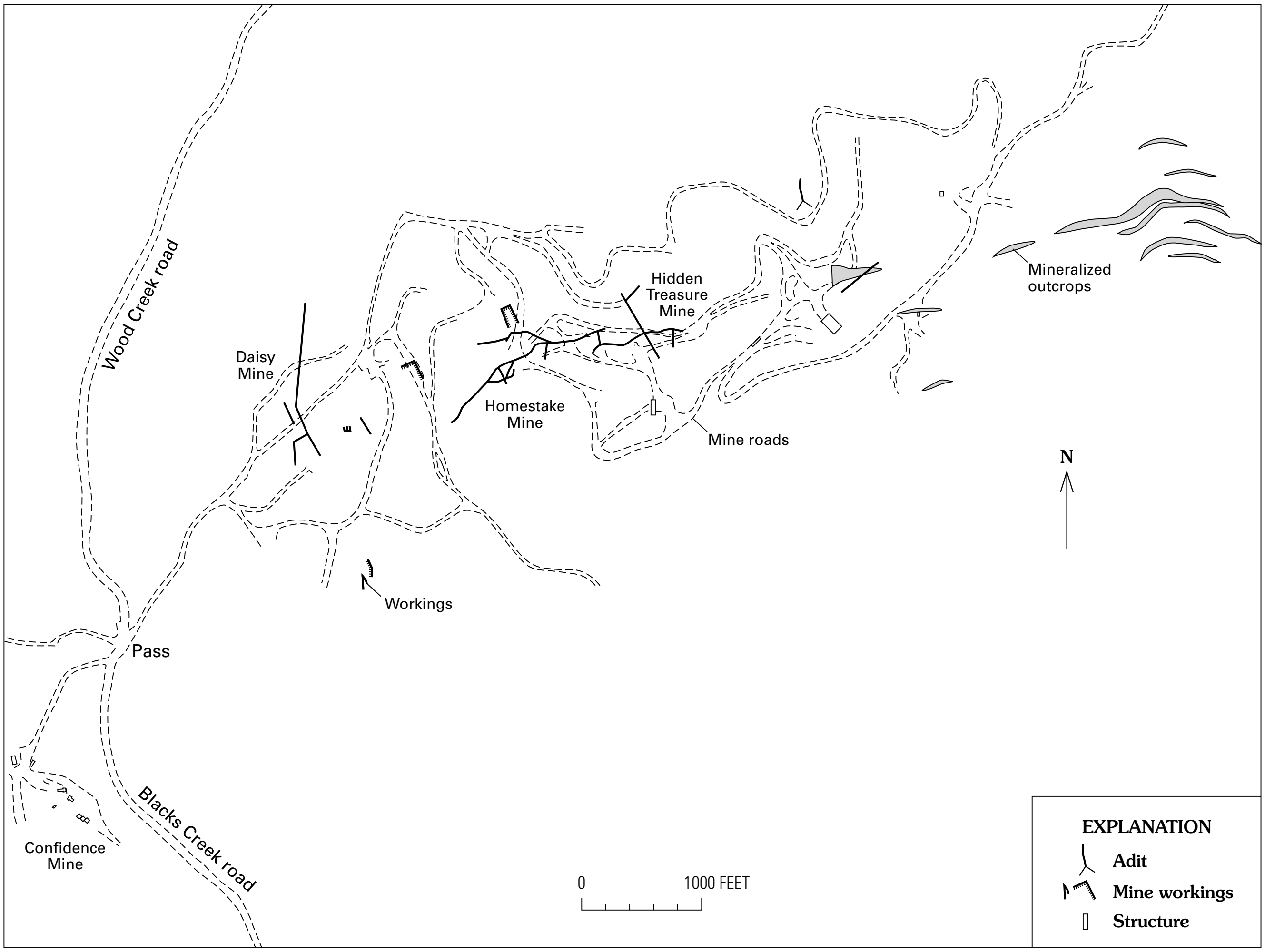

Figure 25. Location map of the Neal mining district, Idaho. Location of mining district is shown on figure 24.

Table 1. Gold-silver production from mines of the Neal mining district, Idaho, 1902–1991.

[Compiled from U.S. Bureau of Mines unpublished production records]

Property or operator	Tons of ore	Gold (ounces)	Silver (ounces)	Production years
Homestake-Hidden Treasure	35,644	13,961	10,219	1902–1941
Daisy	1,888	1,121	1,260	1902–1906
Golden Eagle	11,911	4,138	2,864	1902–1915
Sunset	75	68	32	1923–1939
Sunshine-Sunbeam	100	45	50	1902
Flat Creek	26	8	2	1938
Elmore[1]	702	768	951	1902–1904
Various operators	75	54	50	1908–1939
Total--------------------------------	50,421	20,163	15,428	—

[1]May be mislocated. Production form shows that mine is in the Neal mining district, but section, range and township location figures, also on the production form, indicate that the ore was mined from the Rocky Bar area.

(1902–1979), from U.S. Geological Survey reports on mineral resources of the United States (1903-1924), from U.S. Bureau of Mines reports on mineral resources of the United States (1924–32), and from U.S. Bureau of Mines mineral yearbooks (1924–1989).

Homestake, Hidden Treasure, and Daisy Mines

In 1902, New York capitalists planned on building a new mill at the Hidden Treasure mine. Ore from this mine previously had been processed in an old Balbach mill. The Daisy mine was sold by George Bredhoeft to a Chicago and Wisconsin interest for $225,000. In 1903, the Hidden Treasure, Homestake, and Ella Hill mines were all operating. The Homestake had a 200-ft deep vertical shaft and several thousand feet of crosscuts.

In 1902–03, the Ella Hill mine was being developed by a long tunnel, and ore was found at the bottom of a 55 ft shaft in the No. 13 mine. The Overlook mine was being developed by eastern interests under the direction of J.W. Murphy.

In 1904, considerable work was done at the Homestake mine, and progress was made at the Ella Hill, South Star, and Badger properties. Good ore was discovered at the Daisy. In 1907, the Daisy and Homestake mines were operated by the George F. Roth Company of Rochester, New York. This company also has been referred to as the Homestake and Mountaineer Mining Company. The company employed 20 men and had constructed a 10-stamp mill. Mine workings included a 2,000-foot adit and two shafts, 200 and 400 ft deep. The company did 1,500 ft of development work. A 30-ton-per-day cyanide plant was added in 1908 and another 2,000 ft of underground work completed. A new 10-stamp mill and a 60-ton-per-day cyanide plant were installed in 1910. By then, the main shaft was 600 ft deep.

By 1911, the Daisy, Homestake and Hidden Treasure mines (referred to by the U.S. Bureau of Mines as the Roth property) were connected by underground workings. A 3,000-foot adit connected underground workings with the mill, which was on the Hidden Treasure property. Veins were persistent to a depth of 500 ft and contained refractory ore (gold in pyrite) and some galena and sphalerite. Sixty-five men worked in the mine and mill. The stamp mill was upgraded by installation of new plates, and Pachuca tanks were added. The year 1911, a record year for mine and district production, 17,292 tons of ore were mined.

Mining continued at the Roth property until 1915, but the heyday of operation was past and the property never again approached the production rate of 1911. Very little ore has been produced from the property since l915. The mill burned in May 1913, but was rebuilt. About 440 tons of ore were mined in 1923–24 and a total of 15 tons of ore in 1925 and in 1938–41.

In 1936, the Cordova Mining Company did 500 ft of development work at the Homestake-Hidden Treasure mine, using a crew of six men. The company opened the main adit for 515 ft and did 192 ft of additional underground work the following year. In 1938, Cordova leased the property to H.D. Languille, but no further development activity was reported.

Golden Eagle Mine

The Golden Eagle mine, one of the older mines in the Neal mining district, is about 5 mi southwest of the Homestake mine. Little evidence of the surface plant of the mine was recognizable in 1990; however, the caved, inclined shaft that led to the principal underground workings is located S. 88 W. and 1,500 ft distant from the intersection of the Blacks Creek and the Mayfield roads.

The Golden Eagle produced 3,000 tons of ore in 1902. By 1903, the mine was developed by a 300-foot shaft from which three levels were driven. A new company was incorporated in 1904 to take over the mine, and an 80-ton Chilean mill was built. A new shaft, the one referred to in the preceding paragraph, was started several hundred feet west of the old one. The new inclined shaft eventually was sunk to a depth of more than 375 ft and several levels were driven from it. Ore shoots ranged from 45 to 105 ft in strike length and extended both east and west from the shaft. The vein ranged from 5 to 20 ft in width and had average gold values of $10 to $15 per ton (with gold at $20.67 per ounce). In 1906, its most productive year, the mine produced 6,170 tons of ore. There is no record of production from the mine after l915.

Other Properties

Several prospects and small mines in the Neal mining district sporadically produced small amounts of ore. These include the Sunset, from which 75 tons of ore were produced during the period 1922–1938; Flat Creek, from which 26 tons were mined in 1938; Sunshine; Elmore; and Badger. Minor tonnages of ore from these and other properties are recorded under the name of the operator, who may have been a lease holder who produced ore from one of the better known mines such as the Homestake. The location of such minor productive sites cannot be ascertained from existing records.

Geologic Setting

The Neal mining district is underlain by biotite granodiorite of the Idaho batholith that has been intruded by a variety of Tertiary dikes, most common by rhyolite. Most of the dikes strike northeast and dip steeply, generally conforming in attitude to other swarms of dikes exposed elsewhere in the Hailey 1°×2° quadrangle (Worl and others, 1991). Gouge along the walls of some of the dikes exposed in bulldozed cuts suggests that the dikes were intruded along pre-existing faults.

The most conspicuous dikes in the Neal mining district are large, long, north-striking, brownish dikes that cross Blacks Creek road about 2.5 mi southwest of the Daisy shaft. In hand specimen the dike rock appears to be rhyolite, but analytical determinations of three samples indicate an average SiO_2 content of about 65 percent, too low for rhyolite. The rock also has an unusually high K_2O content, an average of 4.86 percent, and it contains hornblende. The dike rock was classed as syenite porphyry by Lindgren (1898), but modern terminology suggests that it is quartz trachyte. Northeast-striking dikes of similar chemical composition crop out in the vicinity of the old mine workings.

A discontinuous series of lamprophyric dikes extend along the Daisy-Homestake-Hidden Treasure vein zone from the Confidence mine in the southwest to beyond the Homestake claim in the northeast. The dike rock is dark green to black and dense and contains conspicuous phenocrysts of biotite. Where seen in bulldozed cuts, the dike rock is sheared and hydrothermally altered along northeast-trending faults, as is the contiguous, biotite granodiorite. At most exposures, the dikes range from a few inches to 3–4 ft in thickness; however, about 250 feet north of the Daisy shaft, several strands of lamprophyric dike make up an aggregate thickness of 25 ft. At that location, small pods of mineralized quartz in the lamprophyre indicate that the dike is pre-ore, similar to a lamprophyre dike observed by Lindgren (1898) in the middle of a 4-foot vein at the Homestake mine. There are no age data for these lamprophyric dikes; they may be Cretaceous in age and related to the Idaho batholith rather than Tertiary in age, similar to other dikes of the district.

Bounding the more mineralized part of the northern part of the Neal mining district are two high-angle northeast-striking faults, one of which, the Blacks Creek fault, has been traced for several miles of strike length. The faults probably formed before the dikes, and, in part, may have guided emplacement of the dikes.

Principal Veins

Principal veins of the Neal mining district strike N. 65°–85° E. and dip 40°–45° SE. Clear vitreous quartz is the chief vein mineral, and at the outcrop it is stained a rusty color by oxidized pyrite. Pyrite casts in quartz are common, and auriferous pyrite on lower levels of the Homestake-Hidden Treasure mines was mentioned by Lindgren (1898). The mineralized quartz is discontinuous along the vein zone. In places no quartz is visible, but in other places the mineralized shoots are as thick as several feet. Much of the vein material is altered, sheared biotite granodiorite. Fault gouge, generally a few inches thick, is common along the veins, although 4 ft of gouge and clay is present along the hanging wall of the Golden Eagle vein.

Two northeast-trending veins crop out in the vicinity of the Daisy shaft and continue northeast through the Homestake patented claim. The veins are subparallel with the northeast-trending faults and the dikes in the area. The location of the veins probably was controlled by the northeast-trending shears. The southernmost of the two veins may to have been the principal vein worked in the Daisy-Homestake-Hidden Treasure mines. The vein is well exposed on the ridge 300 ft northeast of the Daisy shaft and projects very close to the collar of the shaft, which was obliterated by bulldozing in 1989. The vein continues northeast of the claim-block boundary, and prospect pits indicate that it or a nearby subparallel vein continues for more than 2,000 ft to the northeast beyond the patented claim-block boundary. Old workings have obliterated the vein outcrop at the High Five mine, although field evidence indicates that the vein explored at that mine strikes northeast, and probably is a continuation of the Daisy-Homestake-Hidden Treasure vein or another vein of that pattern. The northernmost of the two veins may be en echelon in nature because, although it crops out on the ridge northeast of the Daisy shaft, it was not found in holes drilled near the east end of the claim block and probably had pinched out by that point.

Two other northeast-trending veins, about 2,000 ft south of the Daisy shaft, have been tested by underground workings and prospect pits. Pieces of mineralized quartz on the dump of an old caved adit suggest that the adit was driven on a vein that may be traced on the outcrop, but no recorded ore production can be associated with the workings. Surface exposures of the vein pass close to the northern edge of the Ella Hill claim and may be the vein that was explored from that claim.

The Golden Eagle vein crops out about 5 mi southwest of the Daisy shaft. The vein strikes N. 70° E., dips about 45° SE, and has been traced along the outcrop for more than 1,000 ft. Country rock of the vein is biotite granodiorite of the Idaho batholith, that is intenively hydrothermally altered as far as 15 ft from the vein. Feldspar in the granodiorite has been altered to sericite or various clay minerals. Drill holes through the vein indicate that as much as 4 ft of clay extends along the vein hanging wall. According the Idaho State Mine Inspector's report for 1904, the gold-bearing width of the vein zone ranged from 5 to 25 ft and had average gold values of $10 to $15 per ton (price of gold $20.67 per ounce).

A northeast-striking vein is exposed in a bulldozed open cut about 2.4 mi southwest of the Daisy shaft, north of the Blacks Creek road, SW1/4 sec. 23, T. 2 N., R. 4 E. The vein strikes N. 70° E., dips southeast, and consists of sheared biotite granodiorite and iron-stained quartz. Casts of sulfide minerals are present in the quartz, but the minerals themselves have been oxidized and removed. The vein plots along the southwest projection of the Daisy-Homestake-Hidden Treasure vein pattern. Judging from the dump, the bulldozed open cut may have obliterated an adit that formerly explored the vein.

In the Neal mining district there are many old prospect pits and small dumps, on some of which are fragments of mineralized quartz, where no vein outcrops could be seen and no vein attitudes determined.

Other Veins

Although the principal veins in the northern part of the Neal mining district strike northeast, subparallel with the major faults and dikes of the district, other, smaller veins intersect the northeast-trending structures at acute angles. These veins strike northwest and may be gash veins; that is, veins that formed along tensional fractures created by differential strike-slip movement along the regional northeast-trending faults. Typical of these gash veins is the vein at the Sunshine property that was being explored in 1989. That vein strikes N. 75° W., dips 55° SW., is about 4 ft thick, and consists of sheared and altered biotite granodiorite.

Two other northwest-striking gash veins, both only a few inches thick, are exposed in prospect pits east of the patented claim block. Because of their small size, neither is shown on figure 24.

A more conspicuous example of a gash vein of this pattern crops out northwest of Three Point Mountain, on the north side of Charcoal Creek, NW1/4 sec. 9, T. 2 N., R. 4 E. That vein, which was explored by an adit that was caved at the portal in 1987, strikes N. 60° W. and dips 55° NE. Where exposed, the vein is about 1 ft thick and consists of sheared biotite granodiorite and iron-stained quartz.

Comparison of Veins in the Neal Mining District With Those of the Quartzburg and Yuba Mining Districts

The principal veins of the Neal miningdistrict are similar in many respects to the main veins in the Quartzburg and Yuba mining districts (fig. 24). The veins strike northeast, subparallel with regional northeast-trending faults that probably exerted structural control on the location of the veins. The veins also are subparallel with Tertiary dikes that have been intruded along shears related to the regional faults. Quartz is the principal mineral of the veins, which have been worked primarily for gold, although more silver has been mined than gold. Minerals from which copper, lead, and zinc have been extracted also are present in the veins but in negligible amounts. Both Daisy-Homestake-Hidden Treasure vein of the Neal mining district and the Atlanta lode of the Yuba mining district follow pre-mineralization lamprophyric dikes that may be of Cretaceous rather than Tertiary age.

At Quartzburg, the veins cut across rhyolite dikes that intrude quartz monzodiorite of Eocene age; thus, the veins can be no older than Eocene. By comparison, in the Neal mining district at the Jackson prospect on Charcoal Creek, west of Three Point Mountain, Lindgren (1898) noted that gold ore occurred as joint coatings and impregnations in a quartz porphyry dike. Based on our examination of the Jackson prospect, we describe the dike as rhyolite, one of the many Tertiary rhyolite dikes in the area. Our classification places the gold ore as post-dike, or Tertiary, in age. A somewhat similar comparison was made from findings on a dump south of the Daisy shaft. There, a dump fragment of dacite porphyry dike contained a section of an iron-stained quartz veinlet. There was insufficient quartz for a sample, but the quartz was obviously mineralized and was similar in appearance to quartz on mine dumps of the Neal mining district. Similar dacite dikes elsewhere in the Hailey 1 2 quadrangle are no older than Eocene; thus the Neal ore probably is no older than Eocene. On the other hand, if the lamprophyric dikes along the Daisy-Homestake-Hidden Treasure vein and along the Atlanta lode in the Yuba mining district are of Cretaceous age, the ore in the veins at both locations could be of Cretaceous age.

Mineral Exploration of the Neal Mining District in the 1980's

Daisy-Homestake-Mountaineer Area

Centennial Mine Company, a subsidiary of Meyer Resources, began an exploration program in the northern part of the district in February 1989. The program consisted of drilling reverse circulation holes and was confined mostly to the Daisy, Homestake, and Mountaineer patented claims in the northern part of a block of patented claims (fig. 25). It concentrated on exploration of the Daisy-Homestake-Hidden Treasure vein zone and was confined mostly to the area extending northeast from the vicinity of the Daisy shaft to the claim block boundary. Some holes were drilled on the north-trending ridge that is 3,000 ft northeast of the Daisy shaft. A total of 205 holes were drilled.

According to James Carver, Project Geologist, Centennial Mine Company, the objective of the exploration program was to determine whether a large block of ground could be outlined that would be amenable to open-pit mining. Because much of the southeast-dipping vein zone traverses a southeast-dipping hillside, it was reasoned that a minimum of barren overburden would have to be removed to reach mineralized ground.

Drilling results indicated that mineralized bodies along the vein zone are discontinuous. Some holes were essentially barren, whereas others had mineralized intercepts of as much as 40 ft. Whether such intercepts represented one vein or more than one vein was indefinite. Lamprophyric dike intercepts were found all along the vein zone. Neither the drill-hole data nor surface geologic mapping confirmed the existence of north-trending offsetting faults, as reported by Lindgren (1898). Instead, the mineralized orebodies probably are en echelon along the vein zone and swell and pinch out.

According to Donald Blow, lease holder of the patented claim block while the exploratory work was underway, the drilling confirmed a mineralized block of 356,000 tons that averaged 0.076 ounces of gold per ton. The drilled resources were deemed inadequate for the open-pit, heap-leach mining and processing operation planned by Centennial Mine Co., which terminated its exploration program in 1990 and dropped its Neal property holdings.

Golden Eagle Mine

Ten holes, the aggregate length of which totals 12,000 ft, were drilled on the Golden Eagle vein in 1986–87 by the Yanke Company, Boise, Idaho (Dan Yanke, oral commun.,1991). The holes were drilled on both sides of the caved shaft of the Golden Eagle mine, extending for about 200 ft northeast and southwest from the shaft. Drilled intercepts showed a 3- to 4-foot-thick zone of clay, gouge, and altered granodiorite along the hanging wall of the Golden Eagle vein zone, a zone that ranged from 3 to 20 ft in thickness. One hole contained 13 ft of material that averaged 5 ounces of gold per ton, and another hole contained 4 ft of 0.50 ounces of gold per ton. A hole that extended well into the vein footwall encountered a small, parallel vein about 60 ft into the footwall of the Golden Eagle vein.

Confidence Mine

The Confidence mine, 1,500 ft southwest of the Daisy shaft, west of the Blacks Creek road, and immediately southwest of the block of patented claims, was developed on what is probably the southwest extension of the Daisy-Homestake-Hidden Treasure vein zone. The J and D Placer and Lode

Mining Co. conducted development work at the mine in 1987. A short inclined winze was sunk to the southwest in the vein, from which a short drift was driven to the collar of another inclined winze in the vein, from the base of which a short drift was driven to the southwest. These workings were driven beneath an old inaccessible adit that followed the vein and from which high-grade ore reportedly had been mined. The face of the lower drift was about 125 ft from the portal of the upper winze and an estimated 50 ft below the ground surface. The mine workings were driven along the hanging wall of a lamprophyre dike, although the final 10 ft of the lower drift was entirely within the dike. A few hundred pounds of mineralized quartz and granodiorite was obtained from pockets along the vein which was processed in a small mill at the mine portal. The mining program was unsuccessful and work at the mine terminated in l987 or early l988.

Sunshine Mine

In 1989, a northwest-striking vein on the Sunshine claim was being explored by E. Loveland of Boise, who was using a small front-end loader to excavate an open cut on the vein. The open cut was only a few feet long. There was no evidence of additional work at the site in 1990.

Blacks Creek Prospect

The Blacks Creek prospect is near the junction of the Blacks Creek and the Mayfield (Foot Hills) roads, about 100 ft west of the Blacks Creek road and about an equal distance north of the Mayfield road. In 1987, Dan Yanke of Boise sank a shaft to a depth of about 15 ft at the prospect to test some small veinlets of mineralized quartz in the biotite granodiorite. The work was not encouraging, and as of 1991 no further work had been done at the site.

Pine (Pine Grove) Mining District

The Pine (Pine Grove) mining district is just south of the town of Pine at the north end of Anderson Ranch Reservoir. A good dirt road connects U.S. Highway 20 to a paved road that goes from Lime Creek to Pine. The only published descriptions of this district, including the Franklin mine, the most significant producer, are in Ballard (1928) and in various yearly reports of the Idaho State Mine Inspector.

Franklin Mine

The Idaho State Mine Inspector (1919) noted that the Franklin mine had produced some $400,000 in gold by 1919. The U.S. Bureau of Mines indicated that the mine produced 18,384 ounces of gold and 12,611 ounces of silver from 29,692 tons of ore and 1,001 tons of tailings from 1902 until the mine closed in the 1930’s. Ballard (1928) gave the production at $750,000, based on U.S. Mint records.

According to the Idaho State Mine Inspector (1909), the Franklin vein is in a fissure in granite; the vein strikes N. 20 W. and dips steeply east. Numerous aplite and pegmatite dikes are 275 ft to the west of the mine (the mine is near the northern edge of the aplite and pegmatite zone described previously). The lowest level of the mine was 450 ft below the apex and 900 ft of drifting on this level found good ore. The inspector continued, “The main ore shoot has a pitch between the surface and the No. 2 level of 45 degrees to the south. This pitch necessitated drifting north a considerable distance to find the ore from a point vertically under where it was struck in No. 1 level.” In 1928, Ballard noted that the mine had been added to the nearby W.R. Deckard property that contained the Objective vein. The Objective vein is 645 ft east of the Franklin and parallel with it. Ballard noted that both veins were fissures that contained quartz and pyrite and occasional “kidneys” of galena and sphalerite. High-grade gold in the upper workings (to a depth of 450 ft at the No. 3 level) concentrated in an oxide zone similar to other deposits in the area. Below the No. 3 level, sulfide ores were dominant.

The following account of the early development of the Franklin mine and other mines near Pine is from Wells (1983). Gold was discovered in a blind tunnel at the Franklin mine on May 16, 1887, by prospectors working for Oliver Sloan, who lived in Pine Grove. By 1888, a gold rush was underway and a 10-stamp mill had been constructed at the mine by a St. Louis company. Sloan sold his interest and developed the town of Pine to serve the miners. British investment spurred the development of these mines in 1892. In 1897, the Franklin mine was sold.

The following history from 1902 to date is taken from Idaho State Mine Inspectors reports (1902-1979), the U.S. Geological Survey (1905-1923), and U.S. Bureau of Mines (1924–1989) yearbooks, and various reports by the Idaho Bureau of Mines and Geology and the Idaho Geological Survey.

In 1902, the Franklin mine had two drifts, and a 10-stamp mill was running. In 1903, the Idaho State Mine Inspector described a remarkable gold discovery at the Franklin mine, owned by Robert P. Chattin. The inspector noted that the mine had been developed 10 years previously by a company that failed and had been equipped with a 10-stamp mill. Chattin obtained the property in 1902 and had driven a 207-foot-long crosscut into an area where rich float had been found. The ore was in a shear zone in granite that included a green dike. Chattin extracted 3,000 tons of ore averaging $25 per ton in free gold. A new crosscut tunnel, started in August, 145 ft below the original tunnel, found the ore. The company planned on driving another 700-foot-long tunnel at the base of the hill. In 1904, the mine produced $70,000 in gold from the 10-stamp mill, despite the fact that the mill was inoperative about half of the time. About 2,000 ft of new drifts were completed during the year. At the No. 2 crosscut, a 1,000-foot-long drift was developed with 700 ft in ore. The new 700-foot-long tunnel (planned 2 years before) was completed from the valley level, 204 ft below the No. 2 and 600 ft below the apex. Little ore was discovered on this level despite of 900 ft of drifting done during the next few years. In 1905, a new 100-ton-per-day cyanide plant was constructed for processing tailings from the stamp mill (15,000 tons had accumulated during the previous 2.5 years). The Franklin produced a record 4,718 ounces of gold and 2,276 ounces of silver from 8,700 tons of ore and 1,000 tons of old tailings. Sixteen men worked the property, which reported large reserves.

In 1906, C.H. Gold Mines Company operated the Franklin mine with 35 men for part of the year. Although the water-powered mill was closed in the fall by an early freeze, the operation grossed $50,000 in 5 months. The next year, the mine operated with a force of 30 men and was developed to a depth of 400 ft. The ore in the lower workings was more refractory. A setback occurred in May 1908, when fire destroyed the stamp mill and cyanide plant. The mine was idle in 1909 but reopened the following year with a new 25 ton-per-day, 5-stamp mill and plant that had cyanide capability. Most of the production was from the middle tunnel level because, as noted, there was no ore in the lower level. A tramway carried the ore to the valley bottom, and the ore was then hauled one-third of a mile to the mill. The mill was enlarged to 10 stamps in 1910, and bullion was shipped from May to December. The Franklin mine operated for a short time in 1911. Lessees processed some ore by cyanide extraction in 1914.

In 1925, the Franklin Consolidated Gold Mines Company acquired the mine. The following year, the company rehabilitated old workings and started new development but suspended operations late in the year due to litigation. Some cleanup ore from the mine worth $1,400 was shipped in 1931 to Midvale, Utah. Lessees drove a new tunnel at the mine in 1932. In 1935, the Gold King Mining and Milling Company rehabilitated the property with a crew of 10 men and planned a 30–50 ton-per-day mill, but this operation was idled by the following year. There has been little activity at the property since the 1930's, although some surface work was reported at the lower adit in 1988.

Mountain View (Bonnie Anna) Mine

In 1904, the Mountain View mine, across the South Fork (reservoir) from the Franklin mine, was under development, and several shipments of high-grade ore were made. The following year, a new 10 stamp, 50 ton-per-day mill was built by the Provident Investment Company. The mill used electric power generated at Lime Creek. The mill shut down after a short time because of a lack of ore, however a new 1,500-foot-long adit was started from just above mill level. In 1906, the mill burned down, but work continued on the adit. In 1919, the LeBarr mine (the Mountain View mine) was taken over by George R. Colvin of Spokane. The mine was developed by a long tunnel that supposedly missed the ore because of faulting. Colvin believed that the fissure was faulted off and could be reached by a 500-foot-long tunnel from the main adit. He planned to process ore at the Franklin mill. In 1927, Omo Mines Corporation developed the Mountain View mine, and the S.E. Mining Company also worked at Pine. There is no more information about the Mountain View mine. According to the U.S. Bureau of Mines, production since 1902 has been minimal (51 ounces of gold and 19 ounces of silver from 31 tons of ore).

Ballard (1928) said the production from the Mountain View mine was $5,500, mostly from gold. Major production was from the Big Vein that strikes N. 65° E. and dips 60° SE. The best ore was at the intersection of the Big Vein with a north-striking structure called the Little Vein.

Skeleton Creek Mining District

The mines on Bear Creek in the Skeleton Creek mining district are accessible from the South Fork of the Boise River Road from Big Smoky Guard Station. In 1992 access was on a rough road west along Bear Creek to the El Oro, Red Horse, and other mines just south of the Red Horse, and a very rough road north from Bear Creek to the Tip Top mine.

According to the U.S. Bureau of Mines, the Red Horse mine produced 1,118 ounces of gold and 544 ounces of silver from 302 tons of ore from 1902 to date. El Oro mine, the largest mine in the area, produced 4,776 ounces of gold, 2,492 ounces of silver, and some copper and lead from 10,841 tons of ore. The Tip Top and Bear Creek mines have had only minimal production, less than 100 ounces of gold each. Other mines in the district that have had production were not visited during this survey and are not shown in figure 24. These include the Old Sam mine, 1.5 mi northeast of Newsome Peak, the Jolly Roger claims between the El Oro and Red Horse mines (just south of Bear Creek), and the Gold Mountain mine (Remington and other claims), 2 mi southwest of the Red Horse. These properties are described by Federspiel and others (1992).

The Red Horse mine is astride the Willow Creek-Bear Creek fault. The El Oro mine is on the south side of the fault, and the Tip Top mine is about 1.2 mi north of the fault. Most of the mines in this area are in shear zones parallel with Bear Creek in granodiorite and are associated with northeast trending Tertiary dikes.

In 1901, Robert Chattin, Martin King, and others made the initial discovery of ore on Skeleton Creek in the vicinity of the Red Horse mine. In 1903, Chattin ran a test batch of ore mined from a shear zone in granite and dikes through his mill at Pine. By the following year, the Red Horse group (known as the Chattin mine) had several hundred feet of workings on a fissure vein in granite. There was little further work until 1981, when a two-man crew added 70–80 ft of drift to the 800-foot-long adit at the mine. The Galey Construction Company opened the mine the following year but dropped the property after a disappointing exploration program.

In 1904 a new 700-foot-long tunnel was started at the Old Sam or Turner mine that had been previously developed by a 230-foot-long tunnel. The Frazier mine (owned by the Drake Mines Development Company of Chicago) was being developed, and the Nellie F. and Mary Glen were worked by Lincoln, Nebraska interests.

In 1907, the Frazier mine was incorporated as the El Oro Gold Mining and Milling Company by Erv Johnson, who planned on building a 10-stamp mill. According to Federspiel and others (1992), "The mine operated seasonally and intermittently from 1911 to 1942." Underground development consists of about 8,000 feet of crosscuts, drifts, and raises on three levels (Idaho State Mine Inspector's Report, 1937, p. 139). Workings are now inaccessible due to caving. A 30-ton per day, gravity reduction mill was erected about 1930 and was powered by a pelto wheel driven by water diverted from Bear Creek by a ditch situated along the north side of Bear Creek Canyon. The mill was converted in the 1930's to steam power and a flotation recovery process. Ore was transported to the mill by an aerial tramway from mine level 2. Fire destroyed the mill in the late 1940's. Some work was reported at the El Oro mine in 1981 and 1988 (Idaho State Mine Inspector).

In 1939, E.G. Platt and Aaron G. Carlson of Montana, representing Gold Hill Mining Corporation, did some development work at a quartz mine on Skeleton Creek. The mine had a 25 ton-per-day mill.

Featherville Mining District

Placer mining is an important part of the mining history in the study area. The largest operation in the area was the South Park Dredging Company which operated on the Feather River and on the South Fork of the Boise River near Featherville. Dredge spoils are obvious along the rivers and near the town, and part of the old dredge is sunk in a pond just east of the town.

In 1919, the Hammon Company (named for W.P. Hammon) of California obtained 1,100 acres of placer ground on the Feather River and announced plans for a major gold dredging project. In 1921, the South Park Dredging Company completed a power line to Featherville and started construction of a large dredge at a cost of a half million dollars. The company began dredging on August 21, 1922. In 1923, the dredge processed gold worth $200,000. In 1924, the dredge treated 1.6 million cubic yards of gravel and, with a capacity of 4,000 yards per day, was one of the largest gold dredges in Idaho. The 520 horsepower electric Yuba dredge had 67 9-ft^3 buckets that weighed 2,000 lbs each. The hull was built of Oregon fir; it was 105 ft long with a 44 ft 7 in. beam and drew 7 ft of water. The digging ladder was 75 ft long and weighed 50 tons. The tailing stacker was 124 ft long. Twenty men were employed to run the dredge plant, which was the largest gold producer in Idaho in 1924, 1926, and 1927 and the second largest in 1923 and 1925. Operations were suspended in June 1928.

Although not as large as the South Park venture, there were other placer operations on the Feather River. The S.G. Brendel operated in 1938 and the Feather Placers from 1959 to 1961; total production of the two operations was 36,917 tons of gravel yielding 375 ounces of gold and 136 ounces of silver.

Rocky Bar Area (Rocky Bar, Spanish Town, Bear Creek, and Red Warrior Mining Districts)

Anderson (1943) described the geology and ore deposits in the Rocky Bar area in detail. Readers are referred to this publication and to Ballard (1928) for an early history of the area. The following discussion updates Anderson's work.

Production

Anderson (1943) noted that peak production from mines in the Rocky Bar area was from 1875 to 1885 and had all but ceased in the next decade. Ballard (1928) estimated production from discovery to 1881 as $5,380,000 from lodes and $2,000,000 from placers. The U.S. Bureau of Mines noted minimal production from 1902 to date (table 2).

Table 2. Gold and silver production from mines in the Rocky Bar area, Idaho, 1902–present.

[Compiled from U.S. Bureau of Mines unpublished production figures]

Property	Tons of Ore	Gold (ounces)	Silver (ounces)	Years of Major Production
Independence	142	89	43	Unknown
Vibrator	150	75	40	Unknown
Vishnu	232	360	204	Unknown
Wide West	210	50	18	Unknown
Avalanche/Richmond	1,950	124	623	1939–1943
Clifton Bell	159	274	82	1904–1905
Hearts Content	100	4	8	1937
Morning Star	2,200	310	137	1932–1935

Geologic Setting

Mines in the Rocky Bar area account for most of the lode production discussed in this paper, most of which was occurred before 1900. The geology of all of the deposits is similar; fissures in granodiorite contain gold-bearing quartz veins. The area from Red Warrior Gulch to Spanish Town is now being actively explored for bulk minable gold deposits.

The age of mineralization in Rocky Bar area has been argued over the years; geologists are divided as to whether the deposits formed in the Cretaceous, Paleocene, Eocene. The same arguments apply to the gold deposits in the Atlanta area. There are very few dikes of Eocene age in the Rocky Bar area. Recent $Ar^{40/39}$ plateau dates (58–57 Ma) on sericite from mineralized samples from the Vishnu dump indicate a Paleocene age.

History

Readers are referred to Anderson (1943) and Ballard (1928) for a review of the early development and history of the mines in the Rocky Bar area. There has been very little significant work in the Rocky Bar area from 1943 to recent times. In 1986, a placer operator found several large blue-quartz cobbles containing thick bands of native gold in a test pit just west of the area. These samples are similar to the descriptions of ore mined at Rocky Bar before 1900 (Anderson, 1943). If the samples are typical, then the rich ore necessary to account for the early gold production in the district is believable, in spite of the lack of mineralized samples on the mine dumps today.

Marsh Creek Mine

The Marsh Creek mine, south of the Rocky Bar area shown on figure 24, is described in Ballard (1928). The principal working was a 400-foot-long adit that cut a large quartz vein about 30 ft wide inside the adit. In 1941, Marsh Creek Mining Company patented two claims on Marsh Creek. About 30 ft of crosscut was done in 1944. In 1947, the total workings consisted of two tunnels (150 ft and 180 ft long). A sample of adularia collected at the mine by R.F. Sanford in 1987 gave an Ar^{40}/Ar^{39} date of 39.3 Ma that indicates an Eocene age for this deposit.

Prospects North of the Bonaparte Mine

The Bonaparte mine is described in Anderson (1943). In 1986, trees about 8 in. in diameter were growing on the old dumps of the mine and there was no sign of recent activity. North of the mine, at the end of the mine road, two open adits appeared to be relatively recent, but no further information on the property was available.

Ophir Mine

In 1952, Western Mines Inc., rehabilitated 400 ft of tunnel and 200 ft of shaft at the Ophir group in Blakes Gulch north of Rocky Bar. Four men were employed. At the time, the property was developed by 5 tunnels (the longest was 500 ft long) and a 300-foot-deep shaft. There was a mill at the site. All assets of Western Mines, Inc. were transferred to Western Consolidated Mines in April 1952. In 1954, Western Consolidated Mines, Inc., employed 7 men at the Ophir who completed 110 ft of drifting and 60 ft of crosscuts and made surface improvements. There was little work after this.

Other Occurrences in the Rocky Bar Area

In the early 1980's, Galli Exploration optioned a large claim block in the Red Warrior, Rocky Bar, and Hardscrabble Gulch area. In 1986, the company drilled about 20 holes in Hardscrabble Gulch. Later that year, Royal Apex Silver, Inc., acquired Galli. In 1987, when Coeur d'Alene Mines Corporation merged with Royal Apex Silver, what was Galli Exploration was spun off as a separate company called GEXA Gold. An additional 26 reverse circulation holes totalling 7,450 ft were drilled in 1987 and 25 more holes were drilled in 1988. Most of this work was in Hardscrabble Gulch. Estimated reserves at this time were 275,000 tons of 0.037 ounces per ton gold in Hardscrabble Gulch and 313,000 tons of 0.046 ounces per ton gold in Wide West Gulch for a total of about 0.5 million ounces of gold. In 1989, GEXA signed an agreement with Newmont Exploration Limited to evaluate and develop the GEXA's 179 claims in the Rocky Bar area. Newmont drilled 19 reverse circulation holes in 1989, 30 holes in 1990, and 11 holes in 1991, including a deep hole at the Ophir mine. The drilling program increased both open-pit and underground reserves but not enough for Newmont's needs and the property was returned to GEXA in 1991.

Lime Creek Mining District

The Lime Creek mining district is an informal district, not listed in Ross (1941). It is near the junction of Hunter Creek and Hawk Gulch, about 2 mi south of Lime Creek. Access is by the Hunter Creek-Cow Creek dirt road from the Cow Creek Reservoir or by a rough road from Moores Spring to the Hunter Creek road.

All of the deposits in the district mines are located very close to the northeast-trending Moores Flat fault and are in quartz veins hosted in biotite granodiorite that was intruded by aplite and pegmatite dikes.

Work began at the President and Hawthorne claim groups in 1903, a late discovery in this part of Idaho. Seven men worked at the President, and the Hawthorne was developed by a 200-ft-long tunnel. During the same time period, the Jingo and Hornet mines were operated by a Salt Lake City company with 10 men and the mines had 600 ft of workings on a fissure vein. By 1904, the President mine (operated by the Lime Creek Mining Company) was equipped with a 25-ton roller mill that processed some gold ore. Plans called for a 1,000-foot-long tunnel. A tunnel was started at the Hawthorne on a 350-foot-long vein. In 1907, some ore was shipped that had been stockpiled several years before at the Jingo and Hornet. There was little further activity in the district until 1933 when 153 tons of stockpiled ore was shipped from the Jingo mine; the ore yielded 190 ounces of gold and 997 ounces of silver. About 22 tons of ore were mined the same year at the President by E.O. Binyon. There was no further record of work in the district until 1988 when MVC Resources drilled three holes totaling 1,500 ft near the Jingo, Hornet, and President mines.

The U.S. Bureau of Mines lists production from the Jingo and Hornet mines from 1902 to date as 257 ounces of gold and 1,537 ounces of silver from 211 tons of ore.

Volcano Mining District

The heart of the Volcano district is about 5 mi south of Highway 20. Access is by dirt road from the highway. The major property in the district is the Blackstone mine. DeLong (1986) and Allen (1940, 1952) described the geology of the Blackstone and other mines in the district.

From 1902 to the present, the Blackstone mine produced 838 ounces of silver and unspecified amounts of lead and copper from 81 tons of ore; the Bowerman group produced 1,416 ounces of silver from 41 tons of ore; and the Index group produced 240 ounces of silver from 60 tons of ore (U.S. Bureau of Mines). None of the mines produced more than a few ounces of gold.

There are two types of ore deposits in the Volcano district (DeLong, 1986). The Revenue and similar mines are in gold-bearing quartz veins in complex fracture zones, whereas the Blackstone mine is an epithermal to mesothermal silver telluride, base-metal, manganese oxide deposit. The Bowerman mine has characteristics of both types of deposits (DeLong, 1986). Mineralized rock in the Blackstone open pit is a central stockwork hosted in granodiorite; disseminated mineralization is present outside the stockwork. Delong (1986) suggested that the gold veins and the stockwork may either be independent of each other or represent different levels of the same system. A number of rhyolite dikes strike east-west across the area and a typical pink granite (biotite granite) of probable Eocene age crops out near the mine.

In 1914, a trial shipment of silver ore was made from the Bower prospect (Bowerman group?) near Hill City, and, in 1915, some silver-gold ore was shipped. There is little record of further development until 1929 when Consolidated Mines Syndicate started driving a tunnel on the Revenue group. According to Bell (1930), the Revenue tunnel penetrated 400 ft of decomposed granite and crossed a series of aplite dikes in decomposed granite. A number of rhyolite dikes and an andesite dike were exposed in the tunnel. The tunnel was 1,400 ft long by 1931, when Consolidated completed an additional 165 ft of workings. There was little work in 1932, but a small section of tunnel was completed the following year. A 2,000-foot-long tunnel was started in 1936, and work continued sporadically at the mine through 1939. All activity ceased by 1942. In 1948, Apache Mines Company optioned the Blackstone, Volcano, Index group, Mammoth group, Middlesex group, Independence mine, Hoffman mine, and the Revenue mine. There is no record of any substantial development by this company.

The Blackstone claims were located by J.J. Rich and J.H. Hawley in the 1890's. According to Bell (1930), the deposit was a "sheared quartz fissure richly stained with manganese oxide and copper carbonate" and was developed by a 100-foot-long tunnel. In 1984, Circa, Inc., began small shipments of concentrates from a mill built at Mountain Home to process about 10,000 tons of ore from the Blackstone open pit that had been mined since 1982. Circa optioned the mine from the Blackstone Mining Company. Five men were employed at the mill, and about $1 million was reportedly spent on the mine and mill. Hambro Resources optioned the property from Circa in 1985 and drilled nine holes at the mine. Richwell Resources conducted more drilling in 1987 at the Blackstone and reportedly found mineralized rock outside of the pit area. The company announced plans for constructing a mill at Fairfield, and a 20-ton-per-day pilot plant was reportedly tested in 1988. There has been no activity since then.

Dixie Mining District *by* Thomas M. Jacob

The location of the Dixie mining district is incorrectly shown on the mining district map of Idaho by Ross (1941) as on House Mountain; instead, it is just south of Anderson Ranch Dam. The approximately 6 mi^2 area that contains the district is easily accessible by paved road from U.S. Highway 20 by taking the Anderson Ranch Dam turnoff. The dumps of the King shaft are visible from this road across from the borrow pit from which fill for the dam was quarried. A cross section of the mine workings accessed by the King shaft is shown in figure 26.

Geologic Setting

Granodiorite of the Idaho batholith is the host rock for the abundant quartz veins in the Dixie district. The district is characterized by an abnormally high concentration of aplite and pegmatite dikes and by severe deformation, similar to the Anderson Ranch Dam area. Granitic rocks exhibit pervasive argillic and sericitic alteration. A number of dacite and rhyodacite dikes are in the area, and a rhyolite dike or small stock is exposed in the hill just west of the King shaft. Mineralization is milkey white quartz veins. Free gold was reported in the upper workings, but primary sulfide minerals including pyrite, galena, sphalerite, chalcopyrite, and molybdenite were encountered below 300 ft. Fluorite was observed on the mine dumps.

History and Production

The initial discovery of mineralized rock in the Dixie district is not documented but probably coincided with staking of the first claims. An anonymous 1933 report (perhaps authored by a mine shareholder) indicates that three claims were located in 1891 by Daniel H. Reber and two partners. These were the original King claim, site of the King shaft, and King vein, the major prospect and ore zone, respectively, of the district. Reber soon bought out his partners and remained the prominent mine developer until his death in 1929.

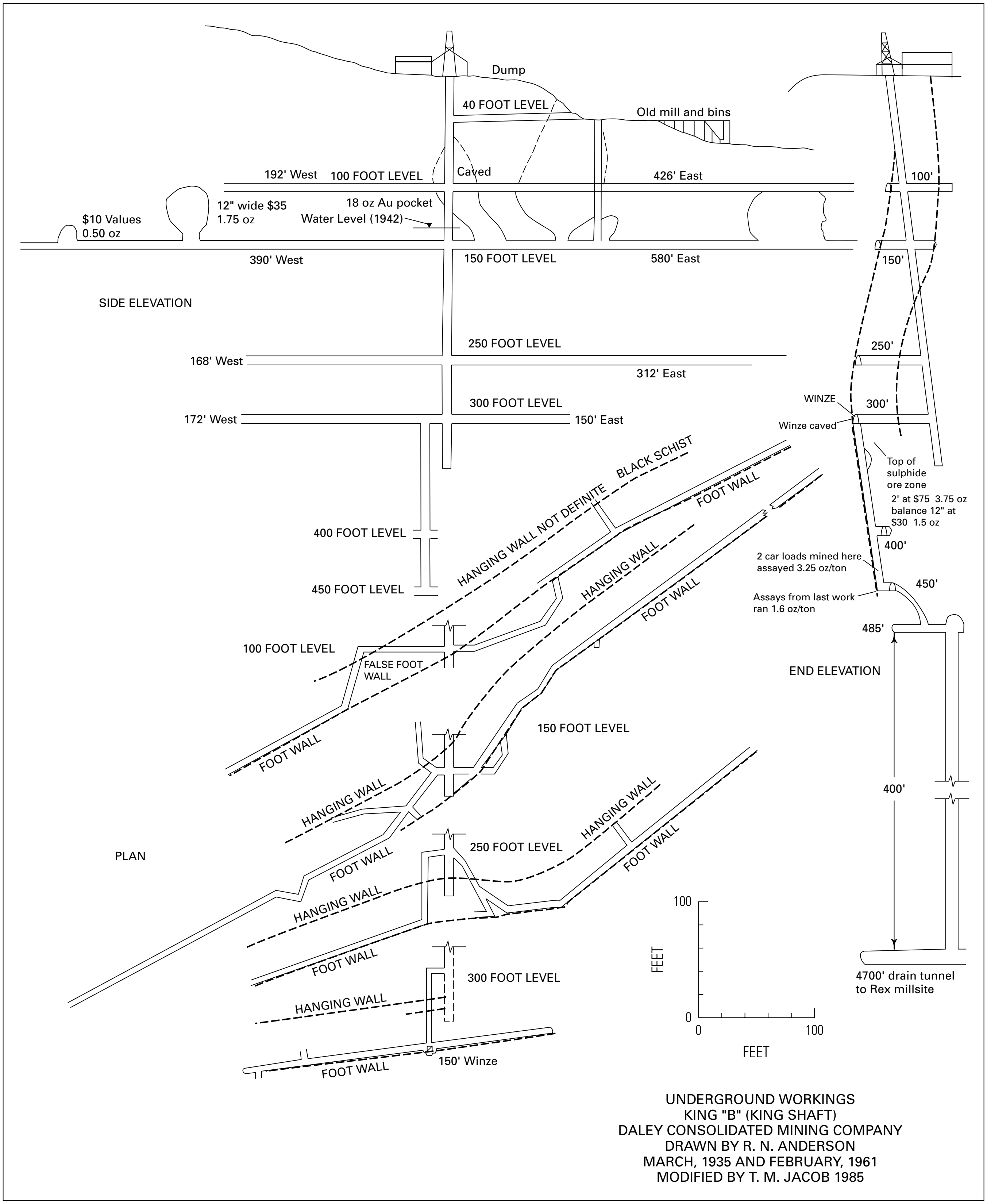

Figure 26. Mine workings of the King shaft in the Dixie district, Idaho. Modified from drawings by R.N. Anderson (March 1935 and February 1961), modified by T.M. Jacob (1985).

Newspaper accounts of activity in the district date as early as July 24, 1892, when "remarkably rich finds" were reported by several miners prospecting in the hills near the Dixie stage station. The Eddy mine, about 2 mi west of the station, was excavated to a depth of 60 ft; the face displayed a vein of ore 34 in. wide and assayed as much as $1,128 per ton in gold (at $20 per ounce). The Twin Hills mine consisted of two shafts exposing a vein of quartz 8 ft thick that averaged approximately $30 per ton in gold. Gold nuggets as large as a pea were reported as common in the vein of the Lone Jack mine. The Gold King mine, located on the King claims, was developed by a winze sunk along a vein of "very rich quartz." Identification of these various prospects, except for the Gold King mine (King shaft), is now uncertain.

A 5-stamp mill was constructed at the Eddy mine and began operation July 7, 1893. In 1894, a boarding house and store were erected to serve approximately 40 men employed in the mines. Daniel Reber sold a half interest in the mill and five mining claims for $50,000, reinvesting the money in lumber and mining equipment, and doubling the stamp capacity of the mill. Reber reportedly deposited 200 ounces of gold in the Salt Lake City mint during October 1895, the results of a 15-day mill run.

Difficulty in ore beneficiation became apparent in 1895 when roasting pans and furnaces were ordered for the mill. Mining was probably progressing below an upper oxide ore zone containing abundant free gold into a zone where the gold was intimately associated with sulfide minerals.

In 1896, the Gold King mine was incorporated as Golden King Mining and Milling Company with capital of $1,000,000 and holdings of 13 claims. New hoisting equipment was erected at the King shaft, and a pump was installed for dewatering. Early in 1897, the shaft reached a depth of 250 ft and there were numerous drifts and crosscuts. The stamp mill proved totally unsatisfactory for processing the ore, and in 1898 a 25 ton-per-day capacity cyanide reduction plant was installed. Milling of 1,700 tons of ore from the 150-foot level indicated a recovery rate of approximately 60 percent with returns of $6.50 per ton. Difficulties encountered late that year due to inadequate crushing in the ball mill eventually resulted in abandonment of the cyanide mill. In 1899, the property was reorganized as Crown Point Mining Company.

During 1900 as many as 22 men were employed in the King shaft, which was then 300 ft deep and exposed an ore zone 16 ft wide. An 8-foot thickness of footwall ore averaged $16 per ton and an 8-foot thickness of hanging wall ore averaged $4-$7 per ton. Late that year the ore zone was delineated as 212 ft long, ranging along strike from 6 to12 feet in thickness and assaying from $28 to $200 per ton. By 1901, approximately 2,350 ft of drifts and crosscuts had been developed. A brief tonnage report by Boise, Idaho, metallurgist J. A. Pack dated "prior to 1902" (probably early 1901) outlined proven ore from the 250-300 foot levels and estimated ore reserves from the 300-350 foot levels (table 3). Pack also estimated the tonnage of ore previously mined from the surface to the 250-foot level. Ore mined until that time was reported to be in an oxide zone; primary sulfides were encountered only after work had extended below 315 ft.

A lease for continued work on the King shaft was granted in 1901. Contrary to that agreement a winze was sunk from a crosscut on the 300-foot level just south of the shaft. After 70 ft of unproductive development, the lease was transferred to another party who extended the winze to the 400-foot level where ore was encountered. Samples collected from a vein 18 in. wide averaged $150–$200 per ton in gold. Because of the problems with the on-site mill, the ore was high-graded and shipped to Salt Lake City, Utah, for smelting, netting $55 per ton. In 1902, the upper part of the winze caved, exposing ore that the former lessees had missed by only 5 ft. Three carloads of ore were shipped and assayed as shown in table 4.

Crown Point Mining Company, apparently having absorbed adjacent properties and extending the boundaries of their claim group, now included 58 lode claims, placer claims, and a millsite. The company developed plans contingent on financial backing, to sink the King shaft to a depth of 600 ft, then drive a long crosscut-drain tunnel from within the Boise River canyon to intersect the shaft. Such a tunnel would eliminate the need for hoisting ore and pumping water.

The State Mine Inspection's report contains the first public record of work in the Dixie mining district. Reference is made to the Crown Point claims and to the plan of driving a crosscut tunnel from the Boise River to intersect the King shaft at depth. This crosscut-drain tunnel, called the Cumberland tunnel, was

Table 3. Tonnage and grade calculations for the King shaft, Dixie mining district, Idaho.

[Includes estimates of previously mined ore and reserves to a depth of 350 ft. From J.A. Pack report inferred to date from 1901]

Ore category	Vertical footage	Dimensions (length height thickness, in feet)	Ft^3/ ton	Tonnage	Price per ton	Value
Mined	0–150	?	?	10,000	$ 9	$ 90,000
Mined	150–250	410 100 7.5	14	21,964	$13	$285,532
Proved	250–350	410 50 7.5	13	11,287	$17	$201,059
Reserves	300–350	410 50 7.5	12	12,812	$22	$281,864
Total Value						$858,455

Table 4. Assay results of ore mined in the King shaft winze, Dixie mining district, Idaho, near the 300-ft level in 1902.

Date	Tonnage	Gold (ounces per ton)	Silver (ounces per ton)	Lead (percent)	Zinc (percent)	Copper (percent)
1902	19	1.6	6.5	6.3	3.2	—
1902	36	3.1	4.2	3.5	—	—
1902	22	3.2	7.1	8.5	4.5	1.1

Table 5. Assay results of material gleaned from the dumps of the King shaft, Dixie mining district, Idaho, 1917 and 1920.

[Leaders (—) indicate no data]

Date	Tonnage	Gold (ounces per ton)	Silver (ounces per ton)	Lead (percent)	Zinc (percent)	Copper (percent)
1917	14	1.27	4.73	4.50	4.30	0.82
1917	16	1.39	4.70	4.60	—	0.88
1920	2 cars	2.55	4.55	6.01	9.68	1.31

begun in 1904. The Crown Point claims and Cumberland tunnel were apparently unrelated to the claim group containing the King shaft, which was idle at this time due to legal problems. Rather than trending south, directly toward the King shaft, the Cumberland tunnel was driven east, thus avoiding property under litigation. Postulated ore zones in the easterly direction were apparently inferred from surface exposures; the anticipated Cumberland vein was regarded as an eastern extension of the King vein and the Crown Point vein, a parallel system approximately 3,000 ft to the north.

By 1906, legal problems with the claim block containing the King shaft were resolved. Daniel Reber obtained a loan to redeem the property and in 1913 negotiated for control of the Crown Point claims and Cumberland tunnel. The Daley Consolidated Mining Company was formed, and work focused on the Cumberland tunnel.

The King shaft was reopened in 1917, a new shaft house erected, and new pumping equipment installed. Attempts to reopen the old winze, which had previously been developed to a depth of 450 ft, failed due to bad ground and it was abandoned. Six men were hired to continue the main shaft, which was in good ground, downward from the 300-foot level.

Poor segregation of ore from waste during early development of the mine permitted direct smelter shipment of material collected on the dumps in 1917 and again in 1920. Results of these shipments are shown in table 5.

An agreement was signed in 1919 whereby $50,000 was paid for stock interest in Daley Consolidated. Forty feet of new shaft was excavated, and 51 claims were surveyed for patent. The remaining money was allegedly squandered, work ceased, and no patents were granted. Underground workings then totaled approximately 4,500 ft, including the King shaft and adjacent winze, five intermediate levels, and the Cumberland tunnel (contemporary length unknown). Further development was sporadic and minimal, generally consisting only of assessment work.

In 1925, the King shaft hoisting facilities burned and the shaft caved. In 1929, a quitclaim deed was issued to Idaho Delaware Mines Corporation, and Daniel Reber died while on a money-raising venture. William and Henry Green took control of the property under lease as the United Gold Mining Trust. Active operations resumed in 1932 with rehabilitation of buildings, installation of a new boiler, and miscellaneous improvements to the mine entrances and equipment.

In 1935, United Gold Mining Trust contracted Rex Anderson to restore the King shaft. Problems with caving and dewatering halted work at the 300-foot level, and efforts were shifted to the Cumberland tunnel. By 1940, the tunnel was driven an additional 180 ft. Dimensions of the Cumberland tunnel during development are unrecorded, but the tunnel is reported to have been driven a total of 1,860 ft, and the Cumberland vein is postulated to lie approximately 900 feet beyond that point. A blind ore body intersected at approximately 1,400 ft and 46 ft wide, and contained small stringers of sulfide ore assaying 1.2 ounces per ton gold and 6 ounces per ton silver.

In 1942, a range fire swept over the property destroying the old mill and outbuildings and all mining records contained therein, including the scant documentation of mining in the Dixie district. Also in 1942, the properties were deeded to Rex Anderson in lieu of payment for his work on the King shaft and Cumberland tunnel.

Construction of Anderson Ranch Dam was begun in 1941 at a site 1.5 mi upstream from the Cumberland tunnel. Approximately 9 million cubic yards of highly altered granitic rock, obtained from pits located east of Dixie Creek on Daley Consolidated claims, was used in the project. At completion in 1950, the Anderson Ranch Dam was the world's highest earthfill dam (456 ft).

Daley Consolidated Mines granted a lease to Index-Daley Mines Company for construction of the Anderson drain tunnel in 1952. From a point just west of the Cumberland tunnel, a crosscut 4,800 ft long was constructed. Unlike the Cumberland tunnel, the Anderson drain tunnel trends directly beneath the King shaft workings. Upon completion of the crosscut, a raise was constructed that eventually intersected the King shaft winze at the 450-foot level. No ore was shipped, and, for reasons unspecified, operations were discontinued. The mine has been idle since 1955, and only the first 960 ft of the Anderson drain tunnel are accessible. The U.S. Bureau of Mines reports that some gold ore was shipped by Index-Daley Mines Company to Midvale, Utah, in 1956.

In the early 1960's, Rex Anderson was granted patent for two millsites along the Boise River and for the King B lode claim. Daley Consolidated Mines Company currently consists of 58 claims, including the patented claims.

Other Mines In or Near the Dixie Mining District

The only description of other mines in the Dixie district is a mention by the Idaho State Mine Inspector in 1905 that the Gold Pan claims, owned by the North American Exploration Company and on Big Water Creek above Baskams ranch, were being developed. A 110-foot-long tunnel was being driven on a quartz vein.

Roaring River Mining District

Two molybdenum deposits on Roaring River, the Decker-Hortenstine and the Rinebold, were described by Schrader (1924). The molybdenum is hosted in quartz veins and in Tertiary granite of the Sheep Creek batholith. There has been no work on the deposits since Schrader's report. Bennett (1980) noted that Tertiary granite in Idaho contains a high background amounts of molybdenum, and this is true for the Sheep Creek batholith. During a reconnaissance geochemical study of the area, Bennett noted that 84 percent of stream samples considered anomalous in molybdenum (equal to or greater than 3 ppm) were collected from stream segments draining the batholith. In 1981, Inspiration Resources staked a large claim block that covered most of the Sheep Creek batholith. The company was rumored to be interested in molybdenum, uranium, and possibly tin in the granite. Little work was done to evaluate the area and the claims were dropped.

Other Mines in the Study Area

Over the years, the U.S. Bureau of Mines and Idaho State Mine Inspector have noted small mines or prospects that were active in the study area (fig. 24).

- In 1904, several discoveries were made on Moores Flat or nearby and were developed. One of these, the Highland Mary, was worked in 1905 by seven men. Southwest of the Highland Mary, the Copper King group was being developed on Wood Creek at the same time. The Copper King property was in granite that contained porphyry dikes.
- In 1906, the Cat Creek mine was developed on a fissure in the upper drainage of Cat Creek a few miles east of Dixie.
- In 1921, a test shipment of rich silver ore was mined from the Worlds Fair mine near Mountain Home.
- From 1938 to 1940, Charlie Ford, Joe Babington, and John May developed the Mountain View tungsten mine, 3 mi from Corral.
- In 1938, the Sheep Creek Mining Corporation operated a placer mine northeast of Twin Springs. President and manager was John J. Kinsella.
- In 1941, Boise King Placers began operating a 7.5 ft^3 bucket-line dredge at Twin Springs. The operation employed 27 men in 1942 but had shut down by the next year. Prior to this venture, a hydraulic placer on the Sun Flower claims (J.D. McGinnis) recovered 141 ounces of gold from 42,650 yards of terrace gravels from 1934 to 1941.
- In 1947, Herman Miller staked claims on an antimony prospect on the East Fork of Swanholm Creek. Later in the year, the Hermada Mining Company was formed. The vein was first worked in short adits and later from an open pit. The mine, described by Popoff (1953), is unusual because it contains an abundance of stibnite and no precious metals. Total production according to Popoff was 643 tons of antimony extracted from 5,048 tons of ore from 1947 to 1950. The ore was treated at a mill at Atlanta owned by Talache Mines, Inc. The stibnite is in quartz veins in north-northwest-trending fractures in the batholith. These structures are parallel with the Deer Park fault, which is about a mile west of the mine. An Ar^{40}/Ar^{39} date of 61 Ma indicates that this deposit is Paleocene.

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