UNITED STATES DEPARTMENT OF THE INTERIOR
J. A. Krug, Secretary
GEOLOGICAL SURVEY
W. E. Wrather, Director

Bulletin 944-C

GEOLOGY AND ORE DEPOSITS OF BOISE BASIN, IDAHO

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Prepared in cooperation with the
IDAHO BUREAU OF MINES AND GEOLOGY

Contributions to economic geology, 1943-46
(Pages 119-319)

UNITED STATES
OVERNMENT PRINTING OFFICE
WASHINGTON : 1947

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GEOLOGY AND ORE DEPOSITS OF BOISE BASIN, IDAHO

By ALFRED L. ANDERSON

ABSTRACT

This report covers a study of the geology and ore deposits of Boise Basin, in Boise County, Idaho, an area of some 300 square miles of relatively low mountainous country set back in the maze of higher mountains that extend across the central and northern part of the State. Boise Basin is drained by Moore and Grimes Creeks, tributaries of the Boise River. The center of the basin is about 25 miles in an air line northeast of Boise, the State capital.

Boise Basin has been famed for its rich placer deposits, discovered in 1862, but is less well known for its lode deposits, which have contributed more than $10,000,000, principally in gold. These deposits have been fairly actively exploited in recent years.

The area is underlain chiefly by the granitic rock of the Idaho batholith, of Mesozoic age, which is cut locally by dikes and stocks of pyroxene-hornblende-biotite diorite and hornblende-biotite granodiorite of early Tertiary (?) age and by a host of porphyritic dikes and stocks of lower Miocene age. The Miocene intrusives are composed for the most part of dacite porphyry, quartz monzonite porphyry, rhyolite porphyry, and rhyolite and are concentrated along certain zones of structural weakness conveniently designated as "porphyry belts." In places the granitic rock is concealed beneath lake beds and volcanics of lower Miocene age; and in other places with the dikes by flows of Columbia River basalt of middle or upper Miocene age, by Pleistocene basalt, and by Quaternary bench gravels and stream alluvium.

Apparently stresses transmitted differentially through the batholith against the weak trough of sedimentary rocks on the east during the Laramide orogeny produced zones of structural weakness in the batholith, which facilitated the intrusion of the dioritic and granodioritic magmas during the early part of the Tertiary (?) and localized deformation and igneous intrusion during lower Miocene time. The intrusion of magma along the structural zone during Miocene time apparently produced a "collapse structure" and provided fractures for the injection of porphyritic magmas from the deeper source along the cores of the uplifts. The so-called "porphyry belts" are the most conspicuous and most important structural features in the region and comprise the zones along which most of the ore deposits are concentrated. Subsequent crustal movements have also left their mark. In late Pliocene and Quaternary time the region was uplifted, the surface warped and faulted, and the present features of the landscape developed.

The ore deposits are mainly valued for their precious metals, particularly gold, but some of them have also contributed small amounts of base metals.

Metalization accompanied the igneous activity of both early Tertiary (?) and lower Miocene time, and the ore deposits therefore fall into two principal groups based on age. The early Tertiary (?) deposits comprise small lenticular veins in fissures and larger lodes along complex fissure and fracture zones produced by strong reverse faulting. The veins and lodes trend mainly west-northwest, dip southwest at moderate angles, and contain quartz as their most abundant filling. The quartz is accompanied by only scant amounts of sulfides, namely, pyrite, arsenopyrite, sphalerite, galena, tetrahedrite, chalcopyrite, and stibnite. Except for one antimony and two copper, lead, and zinc lodes, the deposits are classed as gold-quartz veins and lodes. The deposits are structurally complex and many reveal three main stages of deposition: barren quartz during the first stage; quartz and scant amounts of base metals during the second; and comb and drusy quartz, a little pyrite, stibnite, and variable amounts of gold during the third. Much of the ore is actually a filling in breccias of earlier quartz and consists largely of the comb and drusy quartz with the gold erratically distributed in small though rich ore shoots. The country rock has been altered very little by the ore-forming solutions; this fact among others brands the deposits as epithermal and formed at no great depth below the original surface. Erosion, however, has apparently stripped away all but the very roots of the ore shoots and has concentrated much of the gold in the placers below the outcrops. These lodes, which have contributed generously to the placers, are indirectly the source of the larger part of the gold output in Boise Basin.

The lower Miocene deposits comprise both fissure veins and lodes along more complex zones of fracturing. The lodes trend in a northeast direction—the most important and conspicuous lodes about N. 70° E., and the others N. 10°–30° E. and N. 35°–60° E. The lodes are commonly in or near rhyolite porphyry dikes and other members of the "porphyry belt," and occupy fissures and fracture zones produced by marked horizontal but at the same time some upward components of movement. These lodes, the most productive in the area, have not been as deeply eroded nor have they contributed as much gold to the placers as the early Tertiary (?) deposits.

Unlike the early Tertiary (?) deposits, the Miocene lodes are for the most part dominated by base metals rather than by quartz. The ore in them, however, is valued and has been mined chiefly for the precious metals it contains. These deposits are also structurally complex and reflect two prominent stages of metalization separated by a pronounced structural break during which the earlier filling was in most places thoroughly broken and in part reduced to gouge. During the first stage of metalization base metals including variable amounts of pyrite, sphalerite, tetrahedrite, chalcopyrite, and galena, and locally scant amounts of pyrrhotite, enargite, and siderite were deposited; during the second stage the precious metals were added. The composition of the second-stage solutions varied considerably from place to place, but generally the solutions deposited appreciable amounts of comb and chalcedonic quartz and small but variable amounts of pyrite and dolomitic carbonate (in places manganiferous) and locally arsenopyrite, barite, calcite, and gold. In some veins they also deposited such minerals as boulangerite, matildite, galenobismutite, bismuthinite, native bismuth, and gold, and in others such minerals as miargyrite, pyargyrite, andorite (?), and electrum. The minerals of the precious-metal stage have to some extent penetrated and incorporated the earlier shattered base-metal filling.

Because of the variable proportions of the minerals contributed during each stage of metalization, the deposits may be differentiated on the basis of their mineral content into pyritic lodes, base-metal lodes, gold and base-metal lodes, gold-bismuth lodes, gold-quartz lodes, silver-gold lodes, and silver lodes, each of which has certain other distinguishing features of composition. The gold-bismuth lodes have been the most productive, but appreciable amounts of gold have been recovered from the gold and base-metal deposits and in recent years from the silver-gold deposits. Deposition of ore in all deposits has been accompanied by intensive as well as widespread wall-rock alteration, which is a feature among others that sets the lodes apart from the early Tertiary (?) deposits. The wall rock has in general been thoroughly sericitized, in part highly pyritized, and locally somewhat silicified. Some calcite has also been added.

Most of the deposits are of moderate size, but the lodes are not uniformly mineralized, and the ore shoots are generally discontinuous and the ore spotty. The ore shoots are controlled by the effects of movement directed obliquely upward along irregular fissures and by zones of oblique tension fractures across and along broader zones of shearing. Structural reopening at the end of the base-metal stage of deposition has also been an important factor in the control and distribution of the precious-metal ore. Thermal zoning has apparently limited the vertical range of gold and silver deposition, and few of the ore shoots appear to have extended downward for more than 500 feet. The lodes have the general structural, textural, and mineralogical features of the epithermal precious-metal and base-metal deposits. They were obviously formed at comparatively shallow depths with the precious-metal ore limited to a narrow vertical range in spite of favorable structural openings below the limits of present workable ore bodies.

The ore deposits in Boise Basin lack the great vertical extent of the replacement lodes in the Coeur d'Alene district at the other end of the State, but the outlook is for continued small production from the precious-metal lodes and at times of favorable metal prices also from the base-metal lodes. Development at depths greater than those already reached would more than likely meet with disappointment. Further development, therefore, should be guided by past experience and directed toward the search for continuations of known lodes at present levels and to the discovery of new lodes. Secondary enrichment has played a negligible role in all deposits, except in those with a notably large content of primary silver.

INTRODUCTION

PURPOSE AND SCOPE

Study of the geology and ore deposits of Boise Basin, Idaho, a region better known for its placer than for its lode production, was undertaken by the Geological Survey, United States Department of the Interior, in cooperation with the Idaho Bureau of Mines and Geology to meet the urgent requests for geologic information on the lode deposits and particularly to provide data that might bear on the persistence of the ore with depth. Many of the lodes had notable records of production, but in general the work stopped at relatively shallow depths. The impression gained ground that the ore had a small vertical range, and, because the deposits were in the Idaho batholith or in dikes and stocks thought to be related to the Idaho batholith, that the ore deposits themselves were related to the batholith and were only the stumps of formerly extensive lodes largely stripped away by erosion, their gold content fed to the phenomenally rich placers. When the Gold Hill mine was reopened in 1927 and the ore was found to continue downward to levels not reached in any other mine and to depths of more than 1,500 feet below the highest outcrops on the abandoned Gold Hill lode, interest in the deposits in Boise Basin reached new heights, and the demand for a comprehensive geologic study was increased.

In 1930, Clyde P. Ross of the Geological Survey spent 2 weeks in a study of the lode deposits in the northwestern part of Boise Basin, principally near Quartzburg. In 1932 the writer was assigned the detailed study of a much larger area. A summary of the more general results of Ross' work was published in 1933 and his official report was issued in the following year.[1]

Although his reports corrected many of the misconceptions concerning the local geology and showed that the recently productive lodes were of Miocene age and not the stumps of lodes genetically related to the Idaho batholith, pressure for completion of the investigation covered by the present report continued. This report is the outgrowth of several seasons of field work in the Boise Basin and in nearby localities and is designed to provide the information sought by those who are engaged in mining or who are interested in the future development of the ore deposits in Boise Basin.

FIELD WORK AND ACKNOWLEDGMENTS

Field studies in the district were started the latter part of June 1932 and were continued through July and August, but progress was handicapped through lack of an adequate base map, and most of the time was spent in and around the mines and prospects. Arrangements were then made with the Topographic Branch of the Geological Survey for the preparation of a detailed topographic map of the most important area in Boise Basin, a strip along the Quartzburg-Grimes Pass "porphyry belt," but work on this special map did not get under way until mid-August 1933, and geologic mapping therefore was postponed until 1934. By the end of July 1933 study of the mines and prospects not examined the previous year was brought to a close, and in August, while awaiting the completion of the topographic base map, an investigation of the ore deposits in the Pearl-Horseshoe Bend district was begun and finished within the month. During

[1] Ross, C. P., The lodes deposits in the Boise Basin, Idaho: Econ. Geology, vol. 28, No. 4, pp. 329–343, June 1933; Some lode deposits in the northwestern part of the Boise Basin, Idaho; U. S. Geol. Survey, Bull. 846–D, pp. 239–277, 1934.

July and August 1934 full time was given to the geologic mapping of the Quartzburg-Grimes Pass "porphyry belt," but much information of vital importance in the correlation of surface with underground evidence was not obtained, because relatively few mines were active at the time and most of the underground workings were inaccessible. This obstacle prevented prompt completion of the report. Fortunately, however, a marked revival of interest in mining took place in 1935 and many properties were reopened. The writer, therefore, spent 10 days during July 1938 in a review of the more recent developments and was able to get much necessary information on the subsurface geology.

During 1932 and 1933 the writer was capably assisted in the field and office by Mr. Charles A. Rasor, then graduate student in geology at the University of Idaho School of Mines, and in 1934 by Mr. Austin B. Clayton and Mr. Veral Hammerand, both graduates in geology at the University of Idaho. In 1938 he was accompanied by Mr. Warren R. Wagner, teaching fellow at the University of Idaho School of Mines. Much of the success of the field work is due to the efficient and capable services of these field assistants and the aid and hearty cooperation of the mine owners and operators. This aid is gratefully acknowledged, especially the services of Mr. Rasor, who, in the capacity of resident geologist at the Mayflower mine in the summer of 1938, kindly furnished the writer with surface and subsurface maps of the Mayflower mine and of the two lowest levels of the Gold Hill mine.

PREVIOUS GEOLOGIC WORK

A summary of previous work in the district is given in the publications included in the bibliography that follows. Reports that deal with the general features of the lode deposits are by Lindgren, Jones, Ballard, and Ross. Those by Lindgren and Ballard also contain considerable data on placer deposits.

1897. Hastings, W. L., The Boise Basin in Idaho: Eng. and Min. Jour., vol. 58, p. 56; Sci. Am. Suppl., vol. 38, pp. 15540–15541, Aug. 18. Contains brief geologic description.

1898. Lindgren, Waldemar, The mining districts of the Idaho Basin and the Boise Ridge, Idaho: U. S. Geol. Survey 18th Ann. Rept., pt. 3, pp. 625–736. Discusses the general geology of the Boise Basin, with notes on the lode deposits. Has the most complete published account of the placer deposits.

1900. Nye, Robert, The Boise Basin mining district: Min. and Sci. Press, vol. 81, p. 400, Oct. 6. Contains a summary of the history and geology of the basin.

1910. Scott, W. A., Boise Basin, Idaho: Min. and Sci. Press, vol. 101, pp. 76–78, July 16. Gives data on lode- and placer-mining activity.

1916. Jones, E. L., Lode mining in the Quartzburg and Grimes Pass porphyry belt, Boise Basin, Idaho: U. S. Geol. Survey Bull. 640–E, pp. 83–111. Describes the principal lodes near Grimes Pass and Quartzburg and summarizes the geology of the basin as a whole.

1920. Ballard, S. M., The Boise Basin district in Idaho; Eng. and Min. Jour., vol. 109, pp. 881–882, Apr. 10. A summary of the data given later in Bulletin 9 of the Idaho Bureau of Mines and Geology.

1921. Shannon, E. V., On galenobismutite from a gold quartz vein in Boise County, Idaho: Washington Acad. Sci. Jour., vol. 11, No. 13, pp. 298–300, July 19. Describes a heretofore unrecognized bismuth mineral from the Belshazzar mine, near Quartzburg.

1922. McDermid, A. J., Ore deposits of the Gold Hill mine at Quartzburg, Idaho: Eng. and Min. Jour.-Press, vol. 114, pp. 537–540, Sept. 23. An excellent description of the geology of the Gold Hill mine.

1924. Ballard, S. M., Geology and gold resources of Boise Basin, Boise County, Idaho: Idaho Bur. Mines and Geology Bull. 9, 100 pp. Summarizes the general geology and gives fairly complete reports on the placer deposits and many of the lode mines. Has a generalized geologic map.

1926. Ross, C. P., A disseminated lead prospect in northern Boise County, Idaho: Idaho Bur. Mines and Geology Pamph. 20, 7 pp., Dec. Contains a description of a disseminated lead deposit in the Payette River Canyon at the edge of the Boise Basin along the easterly continuation of the Quartzburg-Grimes Pass "porphyry belt."

1931. Burroughs, A. H., Talache Mines, Inc., operations at Gold Hill mine, Quartzburg, Idaho: Thirty-second Annual Report of the Mining Industry of Idaho for the year 1930, pp. 51–54. Mainly a summary of methods employed and results obtained at the Gold Hill mine under his management. Contains some geologic information.

1931. Ross, C. P., A classification of the lode deposits of south-central Idaho: Econ. Geology, vol. 26, No. 2, pp. 169–185, Mar.–Apr. Lists some of the lodes in Boise Basin as type examples in a regional classification of the ore deposits.

1933. Ross, C. P., The lode deposits in the Boise Basin, Idaho: Econ. Geology, vol. 28, No. 4, pp. 329–343, June. A summary of the data given later in U. S. Geol. Survey Bull. 846–D. Summarizes the characteristics of the lodes in the district, particularly those in active development in 1930, all of which are in the northwestern part of the basin. Establishes Miocene age for the main group of deposits.

1934. Ross, C. P., Some lode deposits in the northwestern part of Boise Basin, Idaho: U. S. Geol. Survey Bull. 846–D, pp. 239–277. Contains a more detailed account of the data summarized in vol. 28 of Economic Geology. The report has more accurate descriptions of the rocks than heretofore published, and has mine maps and a topographic and geologic map of the area near Quartzburg. The most exact account of the structure and genetic relations of the lode deposits in Boise Basin yet published. Corrects many of the erroneous concepts of the geology and mineralization, which have done much to hamper development of the district.

1934. Anderson, A. L., and Rasor, A. C., Composition of a part of the Idaho batholith in Boise County, Idaho: Am. Jour. Sci., 5th ser., vol. 27, pp. 287–294, Apr. Describes the petrography of the granitic rock in Boise Basin and surrounding region. Recognizes two main rock facies.

1934. Anderson, A. L., A preliminary report on recent block faulting in Idaho: Northwest Sci., vol. 8, No. 2, pp. 17–28, June. Describes comparatively recent block faulting (Basin-Range type) in and adjacent to Boise Basin.

1934. Anderson, A. L., and Rasor, A. C., Silver mineralization in the Banner district, Boise County, Idaho: Econ. Geology, vol. 29, No. 4, pp. 371–387, June–July. Describes the silver lodes a short distance east of Boise Basin. Has much information pertinent to geology and mineralization in Boise Basin, with many references to Boise Basin.

1934. Anderson, A. L., Some pseudo-eutectic ore textures: Econ. Geology, vol. 29, No. 6, pp. 577–589, Sept.–Oct. Has descriptions of mineral intergrowths simulating the eutectic occurring in ore of some of the lodes in Boise Basin and the Banner district.

1934. Anderson, A. L., Geology of the Pearl-Horseshoe Bend gold belt, Idaho: Idaho Bur. Mines and Geology Pamph. 41, 36 pp. Dec. Although the report covers an area a few miles west of Boise Basin, the geologic relations are similar, and the region furnishes much information that is necessary for an adequate understanding of the geology and mineralization in the basin. Many references to Boise Basin and much data pertinent to Boise Basin.

1935. Anderson, A. L., The valley of Grimes Creek in the Payette Canyon, Idaho: Jour. Geology, vol. 43, No. 6, pp. 618–629, Aug.–Sept. Describes and explains some of the peculiar topographic features in the district, particularly the unusual course of Grimes Creek where it apparently occupies a part of the Payette Canyon and then turns aside to join the Boise River.

1938. Metzger, O. H., Reconnaissance of placer mining in Boise County, Idaho: U. S. Bureau Mines, Inf. Circ. 7028, Aug., pp. 1–34. Gives a general outline of the available placer deposits in Boise County, Idaho, together with a description of current practices and the recovery costs of the principal producers.

GEOGRAPHY

LOCATION

Boise Basin lies wholly within Boise County, its center about 25 miles northeast of Boise, the State capital. It occupies about 300 square miles, but the study was expanded to cover adjoining parts of the canyon of the South Fork of the Payette River on the north and Summit Flat and Rock Creek on the east. The district lies in the Boise and Payette National Forests and is bounded essentially by meridians 115°35′ and 116°35′ west longitude and parallels 43°45′ and 44°5′ north latitude. The general area described in the report is shown on plate 15, which also shows the main topographic features. The area shown on the special map of Grimes Pass and vicinity (pl. 14), upon which the detailed geologic mapping was done, extends across the northern and northwestern margin of the basin into the canyon of the South Fork of the Payette River.

SURFACE FEATURES

The entire area may be described as mountainous. It is a part of the complexly dissected upland that extends north of the Snake River Plain and covers much of the central and northern part of the State. It lies within the part of the mountainous region drained by the Boise and Payette Rivers and resembles a more or less deeply dissected plateau made up of ridges rising to approximate accordant levels separated by valleys and canyons of considerable depth (pl. 16, *A*). In places the mountainous terrain is interrupted by scattered depressed areas and intermontane basins and by higher blocklike ridges. The mountains within the Boise-Payette drainage basin extend over several thousand square miles and merge with the similarly dissected Salmon River Mountains on the north and with the Sawtooth Mountains on the east. Except for a somewhat higher mass known as the Trinity Mountains, the dissected upland is without official name.

Boise Basin itself may be described as a relatively low, depressed mountainous region bounded by higher slopes on all sides, except on the northwest where it is bordered by the deep canyon of the South Fork of the Payette River. The lowest part of the basin stands at an altitude of about 4,000 feet; the encircling ridges on the west rise above 7,000 feet, those on the south above 6,000 feet, and those on the north and east above 8,000 feet. The basin is somewhat elliptical in plan, and its longest dimension, from northwest to southeast, is about 16 miles; the distance across is 10 to 12 miles. A low broad divide between Grimes Creek and Moore Creek separates the basin into two parts. Except for minor gravel flats along the streams in and near the central part of the basin, the basin is composed entirely of low hills and ridges whose crests, except on the northwest, rise gradually to merge with the hills and ridges of the surrounding uplands. On the northwest, its low ridges abut abruptly against a high, steep, scarplike slope that borders an asymmetrical tilted mountain block known as Boise Ridge, which rises as much as 3,000 feet above the basin. This block has its crest near the margin of the basin, and its longer back slope is tilted to the west.

Many of the ridges of the low mountainous terrain have notably broad summit flats somewhat carved into low hills with intervening shallow valleys much less conspicuous than those occupied by the main streams and tributaries. These ridge summits suggest remnants of a low hilly erosion surface, which may be traced across and up the flanks of the basin into the summit areas of the higher encircling mountains (pl. 16). One of these flats at the head of Grimes Creek, at the east margin of the basin, is known as Summit Flat. The old low hilly surface is one of the most conspicuous features of the topography and may be recognized over a wide surrounding region. It does not reach the same level everywhere but shows evidence of moderate tilting or warping and appears on the highest summits as well as the lowest slopes. It serves as an excellent datum plane for recording fairly recent crustal movements.

The drainage pattern is of more than usual interest and has been described in another publication.[2] The South Fork of the Payette River crosses the mountains in a westerly direction and has carved a canyon as much as 4,000 feet deep north and northeast of the district (pl. 17, *A*) and 2,000 feet below the northwest rim of Boise Basin. Because of a westerly tilt of the mountain-summit surface north and northwest of Boise Basin, the canyon decreases in depth and disappears altogether as the river reaches Garden Valley, an intermontane structural basin several miles northwest of Boise Basin. Below Garden Valley the river enters another deep canyon as it crosses Boise Ridge.

Boise Basin is drained principally by Grimes and Moore Creeks, both of which head near the Payette Canyon and flow in a southerly direction to join the Boise River, Grimes Creek first uniting with Moore Creek a few miles below the district. For part of its course Grimes Creek appears to flow in a shallow valley parallel to and in the upper canyon wall of the South Fork of the Payette River, in topographic nonconformity with the river. The valley of Grimes Creek at this point strongly suggests a man-made or "high-line" ditch. From the opposite canyon wall the valley resembles a trench carved high on the upper slope, appearing as an indistinct line marked by somewhat dense timber growth. (See pl. 17, *B*.) Grimes Creek, a former tributary of Payette River, was captured by the Boise River prior to the uplift that inaugurated the present deep canyon system and has not yet rejoined Payette River. Moore Creek has carved a deep valley in the north flank of Boise Basin and both Moore and Grimes Creeks enter deep valleys across the south rim. Elk Creek is the principal tributary joining Moore Creek within the basin, and Granite and Clear Creeks are the principal tributaries of Grimes Creek. The drainage pattern as a whole is decidedly one-sided, as the tributaries of the Boise River reach far north to the very brink of the Payette Canyon, whereas the tributaries to the Payette likewise extend far north to the headwaters of the Salmon River. Rock Creek, which lies along the northeast border of the district covered in this report, and Alder Creek, in the northwest part of the area, are the only notable streams joining the Payette River from the south.

[2] Anderson, A. L., The Valley of Grimes Creek in the Payette Canyon, Idaho: Jour. Geology, vol. 43, No. 6, pp. 618–629, 1935.

CLIMATE AND VEGETATION

Because of its mountainous nature, the district has a lower annual temperature and receives more precipitation as rain and snow than do other parts of southwestern Idaho. The summers may be classed as cool and the winters as cold. Temperature of −20° F. and lower are not uncommon during December, January, and February but are generally of short duration. Much of the precipitation falls during the autumn, winter, and spring months and generally reaches a maximum during December and January. The summers are usually dry and the fire hazard great. The snowfall is deep on the higher summits, and many of the roads that extend over the rim of the basin are closed to traffic from December to May. Idaho City, in the lower part of the basin, on Moore and Elk Creeks, has an average annual precipitation of 21.32 inches; other parts of the district receive even larger amounts, some of the higher levels receiving as much as 30 inches.[3]

The humid climate of the district is reflected in the vegetation, as all the district, except the southward-facing slope of the Payette Canyon, is covered with a dense growth of Ponderosa pine and Douglas fir. Much of this has been cut over by the Boise-Payette Lumber Co. Most of the timber now consists of second growth, which, though too small for saw logs, is satisfactory for mining purposes.

POPULATION AND INDUSTRIES

The district is sparsely settled, having an aggregate population of about 750. Idaho City, the county seat of Boise County, with a population of 187, is the largest settlement. It and the villages of Centerville, Pioneerville, Placerville, and Quartzburg are the principal mining centers. All except Idaho City are along Grimes Creek or its tributaries, in the northwestern part of Boise Basin (pl. 15). The basin is reported to have had at one time not less than 15,000 people, but the population has fluctuated considerably since the early boom days following the discovery of placer gold in 1862 and has dwindled steadily with decline in mining activities.

Mining has been the principal industry of the district ever since the discovery of placer gold. During the late twenties and early thirties of the present century logging was also a major industry, but with removal of the virgin forest growth mining has again become the single important industry. There is no available agricultural land, and aside from mining, the grazing of sheep, a summer industry, is about the only other occupation. Most of the area is now confined within the Boise and Payette National Forests.

[3] U. S. Dept. Agri., Weather Bur., Climatic summary of the United States, sec. 6, Southern Idaho, 1937.

Power is supplied to the mine operators of Boise Basin by the Grimes Pass hydroelectric plant, on the South Fork of the Payette River, about 5 miles due north of Pioneerville. This power is also available for domestic uses.

ACCESSIBILITY

The district is without rail connection. Boise, in Ada County, 42 miles by highway from Idaho City, is the nearest railroad center. During the summer months some rail shipments are made from Horseshoe Bend, on the Oregon Short Line Railroad in the western part of Boise County. The highways leading to this point, however, are closed during the greater part of the late fall and winter.

The district, however, is well supplied with roads, maintained for the most part by the United States Forest Service, and passable, except when blocked by snow. The highway from Boise to Idaho City was oiled in 1938 and may be rated as one of the best highways in the State. It lies along Moore Creek and the Boise River. Graded and graveled roads extend from Idaho City and connect with Centerville, Placerville, Quartzburg, Pioneerville, Grimes Pass, and other parts of the district. Principal roads leading from the district, other than the oiled highway from Idaho City to Boise, are the Horseshoe Bend road from Placerville to Horseshoe Bend via Harris Creek summit; the Garden Valley road from Placerville to the Payette River and Garden Valley; the Grimes Pass road from Pioneerville over Grimes Pass to the Grimes Pass power plant, where it joins a road on the South Fork of the Payette River with access to Lowman up the River and with Garden Valley, Banks, and Horseshoe Bend (State Highway No. 15) down the river; and an improved graded highway (the Lowman road) from Idaho City to Lowman on the South Fork of the Payette River via Moore Creek summit.

GENERAL GEOLOGY

The area lies far in on the Idaho batholith. It is underlain chiefly by igneous rocks, which include not only the granitic rock of the batholith, which is of Mesozoic age, but also invading dikes and stocks of early Tertiary (?) age and a younger group of porphyritic dikes and stocks of lower Miocene age, the last concentrated along certain zones of structural weakness fittingly designated as "porphyry belts." In places these rocks are concealed by middle Tertiary lake beds and volcanics and in other places by flows of Columbia River basalt of middle or upper Miocene age, by Pleistocene basalt, and by Quaternary bench gravels and stream alluvium.

The area appears to have been one of marked structural weakness, and the Idaho batholith, the oldest exposed rock, has apparently been repeatedly broken by crustal movements, which during early Tertiary (?) and middle Tertiary time facilitated the intrusion of magmas of diverse composition. The injection of the early Tertiary (?) magmas was probably guided by fractures produced by the differential transmission of stress through the batholith during the Laramide orogeny, whereas the intrusion of the Miocene magmas was localized along the earlier zones of weakness in fractures probably produced by doming and collapse. Subsequent crustal movements are more or less directly reflected in the topography and include moderate differential uplift, perhaps in the late Miocene, and more marked uplift, warping, and faulting at the close of Tertiary time and in Quaternary time.

IDAHO BATHOLITH AND ITS FACIES (MESOZOIC)

The Idaho batholith is not uniform in composition but is composed locally of two principal rock facies. One is marginal and has the prevailing composition of quartz diorite, subordinately granodiorite; the other, which forms the larger part of the mass, has the composition of quartz monzonite.[4] Subordinate facies include aplitic quartz monzonite and minor dikes of aplite and pegmatite. There is evidence that the marginal rock consolidated under somewhat greater stress than existed when the main mass of the batholith congealed, and, as contacts between facies are in places sharp and apophyses of the quartz monzonite cut the quartz diorite, that some structural disturbance intervened between the consolidation of the marginal quartz diorite and that of the quartz monzonite.

The age of the Idaho batholith on the basis of evidence from nearby areas is probably late Jurassic or early Cretaceous[5] but may be late Cretaceous, according to a determination of the lead-uranium plus thorium ratio of pitch-blende from a placer in the Warren district. The pitchblends is believed to have come from the batholith.[6]

QUARTZ DIORITE

Most of the quartz diorite occurs west of the district but there is some on Boise Ridge and in the Payette Canyon below Garden Valley. It is rather easily distinguished from the quartz monzonite because of its appreciably darker color, a generally conspicuous gneissic structure, an abundance of yellow-brown sphene crystals, and variable

[4] Anderson, A. L., and Rasor, A. C., Composition of a part of the Idaho batholith in Boise County, Idaho: Am. Jour. Sci., 5th ser., vol. 27, pp. 287–294, 1934.

[5] Ross, C. P., Mesozoic and Tertiary granitic rocks in Idaho: Jour. Geology, vol. 36, No. 8, p. 692, 1928; Some features of the Idaho batholith: 6th Internat. Geol. Cong. Rept., pp. 382–383, 1936.

[6] Reed, J. C., Geology and ore deposits of the Warren mining district, Idaho County, Idaho: Idaho Bur. Mines and Geology Pamph. 45, p. 8, 1938.

amounts of hornblende and epidote. These are features absent in the younger facies.

The rock is moderately coarse-grained, the average light-colored grains ranging in diameter from 4 to 7 millimeters and the dark from 2 to 4. Its component minerals are andesine feldspar (45 to 70 percent), quartz (25 to 35 percent), biotite (8 to 15 percent), hornblende (1 to 5 percent), sphene (1 to 3 percent), and epidote (1 to 2 percent). Microcline is also invariably present but cannot be distinguished, except in thin section; it forms 1 to 10 percent of the rock and is sufficiently abundant in places for the rock to be classed as granodiorite rather than quartz diorite. Other minerals included are less than 1 percent each of zircon, apatite, allanite, magnetite, zoisite, chlorite, muscovite, and sericite.

The mineral relations are of special interest, as most of the quartz, microcline, sphene, allanite, epidote, and biotite and most of the accessory minerals appear to have been added to the rock after its consolidation. (See pls. 18, 19.) Apparently these postconsolidation additions have been accomplished through the action of hydrothermal solutions that emanated from deeper parts of the batholithic mass. The addition of these minerals has changed the original quartz-bearing diorite to a quartz diorite with an unusually high proportion of quartz. These relations have been discussed in another publication.[7]

QUARTZ MONZONITE

The quartz monzonite underlies most of the district and is similar to the rock that forms the main part of the batholith through the central part of the State. Although it has, in part at least, been injected into the quartz diorite, it shows little or no evidence of having consolidated under great stress, such as existed when the marginal facies was emplaced. It has the prevailing composition of a rather calcic quartz monzonite, but some of the rock may be classed as granodiorite. Distinctions can ordinarily be made only upon microscopic study, and variations therefore are not mappable.

This rock is also moderately coarse-grained, like the quartz diorite, but its color is light gray to almost white, as the only dark mineral, biotite, generally forms less than 5 percent of the constituents. The invariable absence of gneissic structure and of sphene, epidote, and hornblende, together with the light color, makes it rather easily distinguishable from the quartz diorite. Some of it is uniformly grained, but in the western and northern part of the district much of it is porphyritic and is studded with widely scattered flesh-colored micro-

[7] Anderson, A. L., Endomorphism of the Idaho batholith. Geol. Soc. America Bull., vol. 53, pp. 1099–1126, 1942.

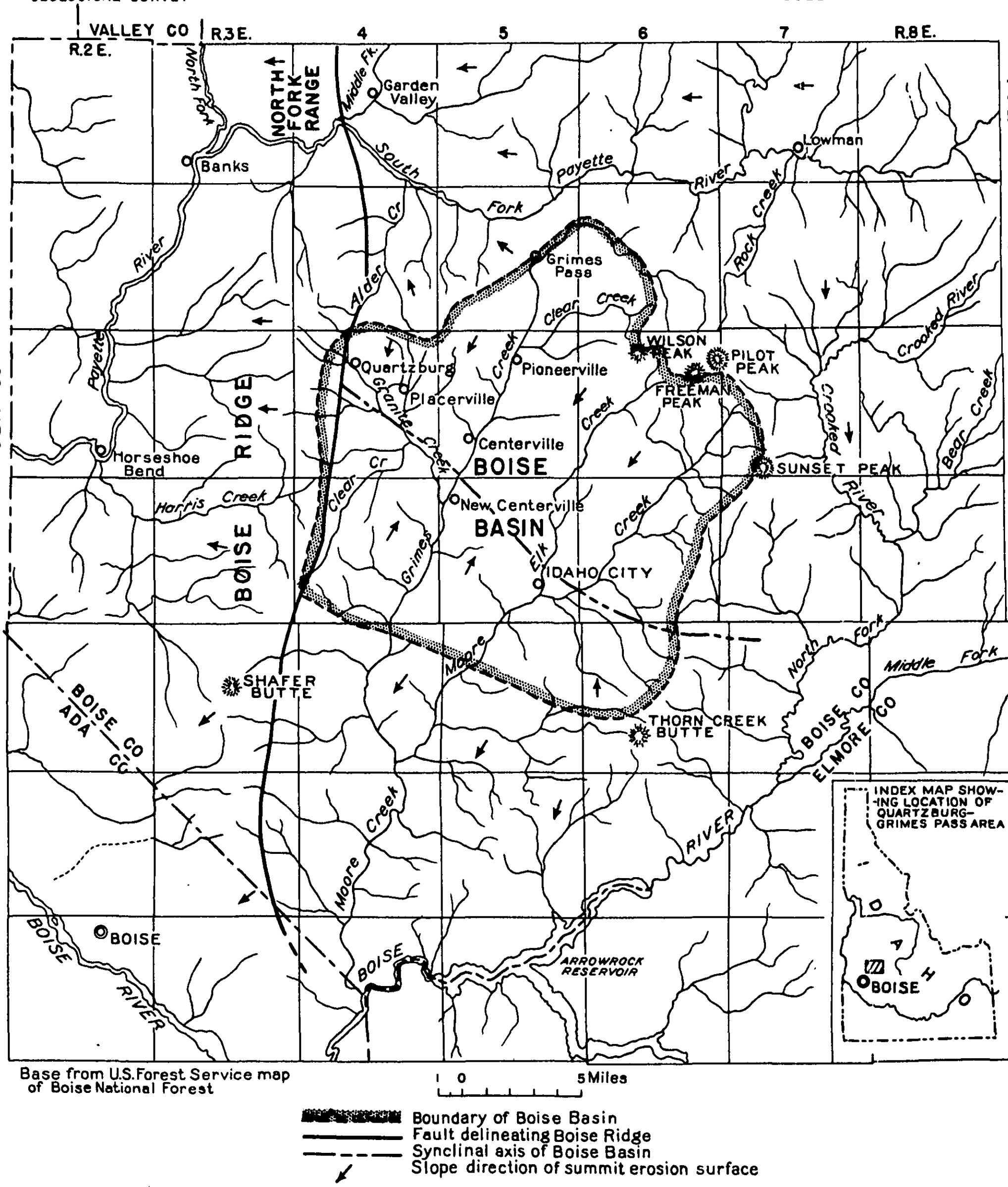
cline phenocrysts as much as 30 millimeters long. These phenocrysts, however, are conspicuously abundant only near Quartzburg. In addition to the biotite, which normally forms 2 to 4 percent, the rock also contains muscovite (1 to 5 percent), oligoclase (25 to 55 percent), orthoclase and microcline (15 to 40 percent), quartz (30 to 45 percent), and negligible amounts of zircon, apatite, garnet, magnetite, allanite, chlorite, and sericite. In much of the rock the muscovite is as abundant as biotite, and its grains in part are larger. It is of interest to note that the plagioclase is oligoclase (Ab_{80} to Ab_{85}), whereas in the marginal quartz diorite it is andesine (Ab_{65}).

The mineral relations are like those of the quartz diorite. The potash feldspar is generally partly filled with included remnants of oligoclase, or shows shadowlike outlines of them, and the quartz commonly permeates the rock as vein and lobate masses (see pls. 18, 19) and appears in wormlike "myrmekitic" masses in the plagioclase grains bordered by orthoclase or microcline. Most of the potash feldspar as well as the quartz and accessory minerals appear to have been added to the rock, after its consolidation, by the action of hydrothermal solutions that emanated from deeper parts of the batholithic mass. Before these additions, the rock must have had the composition of a quartz-bearing diorite and granodiorite, but extensive and minute fracturing of the rock during the late stages of its consolidation apparently permitted the introduction of fluids containing much silicia and potash and minor amounts of other substances, which reacted with the rock and changed the composition to a more silicic and alkalic variety, largely quartz monzonite. The addition of considerable amounts of potash in places induced the formation of large crystals of microcline, which has given some of the rock its marked porphyritic texture.

APLITIC QUARTZ MONZONITE

The aplitic quartz monzonite appears east of Idaho City, on the slopes of Sunset Peak and Thorn Creek Mountain. Its relations to the dominant quartz monzonite are somewhat obscure, but the contact between the two facies is fairly marked, and the evidence suggests that the aplitic variety is slightly younger and represents an upward movement of magma from greater depth. The bodies resemble stocklike or cupola masses.

The aplitic quartz monzonite differs from the normal variety in having a finer grain and a more granular or sugary appearance. Biotite is as abundant as or even more abundant than in the dominant quartz monzonite, and the rock in part is slightly darker. It differs further from the quartz monzonite in that its plagioclase is a somewhat less calcic oligoclase (Ab_{85}–Ab_{88}). Other minerals are like those of the



SKETCH MAP SHOWING LOCATION OF BOISE BASIN, IDAHO AND THE PRINCIPAL GEOMORPHIC FEATURES

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quartz monzonite and are present in about the same proportions, and show similar relationships. The aplitic quartz monzonite has had a post-consolidation history not unlike that of the prevailing rock.

The composition suggests a source in a deeper part of the batholith, which had become somewhat less calcic through continued crystal fractionation, whereas its texture indicates relatively rapid cooling, as though the magma had later been injected above into the solid and cooler part of the batholith.

APLITE

Aplite dikes are conspicuous only in the Gambrinus district, several miles north and northeast of Idaho City. Most of the dikes are small; their thicknesses are usually measured in inches, less commonly in feet. The unweathered rock is light gray to white and fine-grained, but it may contain some coarser pegmatitic streaks. It possesses a distinct sugary appearance, like that of medium-grained to fine-grained light-colored sandstone. Contacts between the aplitic rock and the enclosing quartz monzonite are generally sharp.

The minerals of the aplite include irregular grains of uneven size of quartz, microcline, and sodic oligoclase (Ab_{88}) and a little muscovite, biotite, zircon, apatite, magnetite, garnet, allanite, sericite, chlorite, rutile, leucoxine, zoisite, and calcite. Quartz and microcline are ordinarily the most abundant minerals, but oligoclase predominates in some dikes; the aplite therefore ranges in mineral composition from granite to granodiorite. The more abundant minerals are interlocked, as in typical aplites. Most of the larger grains are rounded or are lobate against their neighbors. The mineral relations are essentially like those of the aplitic quartz monzonite and indicate that much of the quartz and microcline, as well as many of the accessory minerals, was added in large part to the solid rock.

The rock differs from the surrounding quartz monzonite principally in its somewhat less calcic composition and its evidence of more rapid cooling. It is probably related to the magma of the deeper part of the Idaho batholith, which had become less calcic through continued crystal fractionation and, like the aplitic quartz monzonite, was injected upward into the higher parts of the congealed batholithic mass, its position being controlled by deep-seated shearing and fissuring.

PEGMATITE

The pegmatite dikes are widely scattered through the region but are notably conspicuous only east of Boise Basin and on Boise Ridge west and northwest of Quartzburg. The dikes are generally small, most of them less than a foot thick, and are commonly smaller than the closely affiliated aplites. Some of the pegmatites cross the aplite seams, but many occur in and along the aplites as though the fractures that had guided the intrusion of the aplites had been reopened in time to receive the pegmatites. Most of the contacts between pegmatite and the bordering rock are poorly defined and gradational, as though the pegmatite had permeated into and had partly replaced the adjacent walls.

The pegmatites are coarser and more variable in texture than the quartz monzonite and quartz diorite, and their minerals commonly measure from one-half to 3 inches in diameter but locally are as much as 6 inches. Most of them are coarsely granitic in texture, less commonly graphic, but many show combinations of both textures. The bodies near Quartzburg and Idaho City are commonly white or light gray, but those on Boise Ridge below Garden Valley and east of the basin are distinctly pinkish or show a white, black, and pink mottling.

Many of the pegmatites are very feldspathic and are composed largely of mircocline, but most of them contain variable amounts of quartz, and some consist predominantly of quartz. They also contain considerable oligoclase or andesine, and albite and minor quantities of biotite, muscovite, garnet, zircon, magnetite, apatite, sericite, chlorite, and pyrite. Some of the oligoclase and andesine has clearly been inherited from the invaded country rock and occur as remnant grains and shadowlike inclusions in the microcline. That introduced with the pegmatite is more sodic than the older oligoclase or andesine. Some of the quartz, like the plagioclase, has also been inherited from the confining country rock, but most of it was added later and penetrated into and through the microcline and older minerals. With it were introduced the garnet, zircon, apatite, magnetite, and scant pyrite.

The pegmatites clearly show a replacement origin and have apparently been formed from solutions of later age, of greater fluidity, and probably from deeper sources than those that produced the aplites. They have apparently been produced largely by replacement of the quartz diorite, quartz monzonite, and aplite.

ROCKS YOUNGER THAN THE IDAHO BATHOLITH

EARLY TERTIARY (?) INTRUSIVE ROCKS

The early Tertiary (?) dikes and stocks have clearly in part been emplaced along structural zones of weakness in the batholith, and, as they bear evidence of fairly rapid cooling contingent upon consolidation at fairly shallow depth, they were evidently intruded after the batholith had been considerably eroded. They commonly have the composition of pyroxene-hornblende-biotite diorite, but some bodies have the composition of granodiorite. The diorite and granodiorite are probably related genetically, though their outcrops are separated by a number of miles. Both have been invaded by dikes and stocks of Miocene age, and both, therefore, had consolidated prior to the middle Tertiary crustal disturbance. Their intrusion occurred long after the consolidation of the Idaho batholith but before the Miocene igneous activity, and so it is altogether likely that they were intruded during the period of widespread vulcanism that occurred at the close of the Laramide disturbance in the early part of the Tertiary, and that their intrusion was locally guided by fractures produced during the Laramide orogeny.

Lamprophyric dikes are also conspicuous in the mineralized areas, and some of those that appear underground associated with veins and lodes of probable early Tertiary age in the Gambrinus district are probably related to the early Tertiary (?) magmas and are described with the early Tertiary (?) intrusives. These dikes are not to be confused with the young dark-colored dikes that are concentrated in the Miocene "porphyry belts," which have a somewhat different composition.

Subsequent study in the Rocky Bar district in 1938 disclosed some porphyritic dikes that are older than the early Tertiary ore deposits and therefore probably belong with the group of early Tertiary (?) intrusives. It is possible that some porphyritic dikes of rhyolite and granite and quartz monzonite porphyry north and east of the Gambrinus district and some of the rhyolite and fine-grained dikes in the Cold Springs district several miles below Idaho City might be earlier than Miocene and belong to the early Tertiary (?) group, but until the relations of these intrusives are more fully understood they are described with the petrographically similar rocks of known lower Miocene age.

PYROXENE-HORNBLENDE-BIOTITE DIORITE

The bodies of pyroxene-hornblende-biotite diorite are found in and along the "porphyry belt" that extends through Quartzburg and Grimes Pass, and they are cut by dikes and stocks of the younger "porphyries." (See pl. 14.) Most of the dioritic dikes extend transversely across the "porphyry belt" in a west-northwest direction, but the larger stocklike bodies are elongated in a northeast direction, or in the long direction of the "belt" itself. The largest body has been invaded by a stock of Miocene porphyritic quartz monzonite, but its general outline may be traced by means of detached remnant masses from a point a mile southeast of Quartzburg to a point at least 2 miles east of Grimes Pass, a total distance of 11½ miles. Its width reconstructed is as much as 1½ miles. Fully two-thirds of the body has disappeared in the invading porphyritic rock. The largest remaining remnant may be traced for a distance of 5 miles, the last 2 miles of which is along the south border of the porphyritic stock. In places this remnant is 1¼ miles wide. Other bodies of smaller size lie to either side, one between Ophir and Muddy Creeks about 3 miles northeast of Placerville, another on the Payette slope at the head of Alder Creek, and others in the Payette Canyon ½ to 3 miles northeast of Grimes Pass. Additional bodies also lie southeast of Grimes Pass in the Clear Creek drainage area.

The dikes have more tabular outlines than the stocks and are more widely distributed. They are most numerous in the southeast quadrant of the "porphyry belt" and near Quartzburg. The dikes range from a few feet to more than 100 feet in width and may exceptionally be traced for as much as three-fourths of a mile. Some appear in mine workings and have commonly been mistaken for younger "diabase" dikes.

Much of the rock has a composition near that of gabbro, but its plagioclase is a calcic andesine rather than labradorite, and it is placed, therefore, in the diorite family. Practically all of it contains quartz which in some places is sufficiently abundant for the rock to be classed as quartz diorite. Some also contains almost enough orthoclase for it to be classed as granodiorite. The prevailing composition, however, is that of a quartz-bearing pyroxene-hornblende-biotite diorite, the more calcic variations being confined to the dikes and border facies and the more alkalic and silicic variations to the inner parts of stocks.

Most of the rock is moderately dark gray and medium-grained, the average grains ranging in diameter from 2 to 3 millimeters, but in marginal zones and smaller dikes the color is dark gray to black and the grain size a millimeter or less. Exceptionally the rock is somewhat porphyritic. Because of its dark color and small grain size there is generally little likelihood of confusing the rock with the lighter colored and coarser-grained rock of the Idaho batholith, particularly as the weathered rock contributes large amounts of biotite to the soil. The dark minerals normally form 15 to 35 percent of the rock.

The rock everywhere has a rather distinctive mineral assemblage characterized by hornblende, biotite, augite, hypersthene, zoned andesine, and generally minor amounts of orthoclase and quartz. Its accessory minerals include magnetite, zircon, monazite, and apatite; its secondary products epidote, chlorite, sericitic mica, and calcite. The hornblende and biotite are commonly the most abundant of the darker minerals, the hornblende content ranging from 8 to 30 percent (average 15 percent) and the biotite from 5 to 10 percent. The augite commonly amounts to no more than 5 percent of the rock, though locally it may increase to 20 percent. Hypersthene is invariably less abundant than the augite, and in no section did it exceed 12 percent of the rock. The content of plagioclase feldspar ordinarily ranges from 65 to 70 percent, but limits of 40 and 80 percent were observed. Orthoclase and quartz each generally forms less than 5 percent of the rock, except in the more alkalic rock where the orthoclase content may increase to 20 percent, and in the more silicic rock where the quartz content increases to 10 percent.

The minerals show interesting reaction relations (see pls. 20, 21). The plagioclase grains are highly zoned (pl. 20 *A*) and in places have cores as calcic as sodic labradorite and margins as sodic as calcic oligoclase, though commonly the core is a calcic andesine (about Ab_{55}). The average composition varies somewhat among the separate intrusives and appears to be most calcic in the small stock between Ophir and Muddy Creeks and in some of the smaller dikes. The dark minerals likewise show striking effects of reaction during crystallization, and the pyroxenes, both augite and hypersthene, are invariably either cores within crystals of pale greenish hornblende or have narrow to broad rims of hornblende, and ragged mantles of biotite (pl. 20, *B*). The biotite occurs most commonly around the hornblende crystals, but it also appears as a mantle on pyroxene, especially hypersthene. Some independent biotite crystals are also present, intimately associated with quartz and orthoclase. The quartz and orthoclase commonly occur as wedge-shaped grains between the plagioclase and hornblende crystals, but in places they also occur as micropegmatitic intergrowths (pl. 21, *A*). Less commonly the orthoclase occurs as large grains enclosing the plagioclase crystals and dark minerals poikilitically (pl. 20, *A*). The zircon, monazite, magnetite, and other accessory minerals accompany the orthoclase and quartz and are generally alined along grain contacts and cleavages.

The rock affords a striking example of the type of crystallization-differentiation discussed by Bowen,[8] in which failure of complete reaction between early crystals and remaining liquid, as reflected in marked zoning and mantling, has brought about the formation of a liquid residue of granitic composition from which orthoclase, quartz, and some biotite crystallized. In some places, particularly west of Quartzburg, the partly crystalline magma was apparently injected into minor fractures in the batholithic rock where more rapid cooling produced a second generation of small crystals giving rise to small dikes of porphyriic rock.

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[8] Bowen, N. L., The evolution of igneous rocks, pp. 63–85, Princeton University Press, 1928.

GRANODIORITE

The granodiorite is confined to small stocklike bodies in the Idaho batholith on Warm Springs ridge, about 5 miles southwest of Idaho City, and on the upper slope of Thorn Creek Butte, several miles to the east. The Warm Springs body occupies several square miles; those on Thorn Creek Butte are smaller. The bodies show chilled margins against the coarse-grained rock of the batholith.

The granodiorite is much finer-grained than the invaded batholithic rock and is somewhat darker colored. Its grains ordinarily are between 2 and 3 millimeters in diameter and those of light color are no larger than those of dark color. The dark-colored minerals, hornblende and biotite, are about equally abundant and together constitute 8 to 12 percent of the rock. Other abundant minerals in the prevailing rock include zoned plagioclase (about 55 percent), orthoclase and microcline (10 to 15 percent), and quartz (20 to 25 percent). Accessory minerals are sphene, apatite, magnetite, zircon, and allanite; and secondary products are epidote, chlorite, and sericite.

This rock, like the diorite along the Quartzburg-Grimes Pass "porphyry belt," shows striking reaction relations (see pl. 21, *B*). The plagioclase, an andesine, is highly zoned and generally has cores of Ab_{65} composition and margins of oligoclase, about AB_{75}. In places, however, the average composition is somewhat less calcic. The hornblende commonly has partial mantles of biotite, but each mineral may also appear as independent crystals, the biotite ordinarily as grains between the plagioclase laths. Associated with the independent biotite crystals are grains of orthoclase and quartz. In addition to the reaction phenoma that characterize the diorite near Quartzburg and Grimes Pass, the granodiorite shows end-stage modifications of essentially the same kind as those that characterize the older batholithic rock. Some unzoned oligoclase and biotite have been added by replacement of the earlier minerals, but the most notable contributions are of microcline and quartz. Remant inclusions of quartz and older minerals are conspicuous in the microcline, occurring for the most part in shadowlike outline. The microcline, as well as the other minerals, is intricately penetrated and veined by lobes of quartz. Most of the accessory minerals appear to be associated with the younger quartz.

LAMPROPHYRE

The lamprophyric dikes that occur in the areas of early Tertiary (?) ore deposits generally occupy the same fracture and fissure zones as the lodes and veins. These bodies are commonly 1 to 5 feet thick and swell and pinch abruptly. Few appear to be continuous for any distance.

They are dark-colored, porphyritic, and generally have large conspicuous crystals of biotite and less conspicuous crystals of hornblende embedded in dark-gray to grayish-black fine-grained to aphanitic groundmasses. In most dikes the hornblende is actually more abundant than the more conspicuous biotite. Only minor amounts of biotite ordinarily show in groundmasses, which otherwise are composed largely of hornblende needles, sodic plagioclase, minor amounts of orthoclase, and much apatite and magnetite. The hornblende is either greenish or brownish. The plagioclase is a highly zoned oligoclase or andesine. In only one of the many dikes examined was orthoclase more abundant than the plagioclase. Because of the usual preponderance of hornblende and plagioclase the dikes for the most part may be classed as lamprophyric diorites and less commonly biotite-bearing vogesites and hornblendic minettes. These rocks are usually much altered, and the primary minerals are obscured by secondary calcite and chorite.

INTRUSIVE OF THE LOWER MIOCENE "PORPHYRY BELTS"

The "porphyry belt" that extends through Quartzburg and Grimes Pass is the only one that was mapped and studied in detail. It is the dominant structural feature of the region and perhaps one of the largest known "porphyry belts" in the State. It has been traced for not less than 35 miles, but the mapping was confined to a strip about 16 miles long. The belt is 1 to 2 miles wide across the area mapped but apparently becomes much wider eastward across Summit Flat, where it may incorporate several smaller dike zones. Other belts of smaller size lie to the south, one midway between Idaho City and New Centerville, another across Grimes Creek near Holcomb and through the Cold Springs district southwest of Idaho City, and another across the head of Moore Creek over Freeman and Pilot Peaks.

The "porphyry belts" contain an interesting assortment of dikes and stocks of variable size and composition. The instrusives along the belt that extends through Quartzburg and Grimes Pass are most numerous and show the greatest range in composition. The prevailing types, listed in the order of intrusion, may be classed as dacite porphyry, quartz monzonite porphyry (variations from granodiorite to granite porphyry), granophyre, rhyolite porphyry, granodiorite porphyry, rhyolite, and lamprophyre. They were apparently injected from a deeper-seated magma undergoing differentiation. Other belts contain the same members but in less complete sequences.

These intrusives have been correlated by Ross[9] with similar rocks that invade the Challis volcanics (late Oligocene or early Miocene)

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[9] Ross, C. P., Some lode deposits in the northwestern part of the Boise Basin, Idaho: U. S. Geol. Survey, Bull. 846-D, pp. 249-251, 1937.

along the Middle Fork of the Salmon River. They are also in part similar to dikes in the Challis volcanics studied by the writer [10] in the Lava Creek district, Butte County, Idaho. Their intrusion, therefore, evidently occurred no earlier than in late Oligocene or early Miocene time. That they are not younger than lower Miocene is indicated by their relations to the Columbia River basalt and Payette formation (middle or upper Miocene), which covered the belts after they had been rather deeply truncated by erosion.[11]

DACITE PORPHYRY

The bodies of dacite porphyry are most numerous in the vicinity of Quartzburg but are found along other parts of the "porphyry belt." Those near Quartzburg are grouped in clusters, one on the ridge north of the Belshazzar mine between Fall Creek and the West Fork of Granite Creek, another north-northeast of Quartzburg extending into the upper drainage basin of the West Fork of Alder Creek, another about 2 miles north of Placerville on the east side of Wolf Creek, and another near the junction of the two main forks of Granite Creek less than a mile below Quartzburg. Another cluster of considerable size lies several miles northeast of Pioneerville. The bodies within the clusters near Quartzburg are rather closely spaced, but those northeast of Pioneerville are scattered.

The dacite porphyries occur as dikes, which are 10 to 200 feet wide and 200 to 4,500 feet long. The dikes have somewhat diverse trends and cut both the batholithic rock and the bodies of pyroxene-hornblende-biotite diorite. They are not as numerous nor as conspicuous as some of the other members of the "porphyry belt," but are, nevertheless, well represented. Much of the rock is fairly resistant to weathering, and dikes may be traced with little difficulty, especially along ridge crests, owing to their ledge-forming tendencies.

The dacite porphyries form a well-defined group. Most of the rocks are dark greenish gray and spotted by numerous phenocrysts of white feldspar, fewer phenocrysts of hornblende and biotite, and in places widely scattered grains of quartz and augite, all embedded in aphanitic groundmasses. The rock has been locally termed diorite porphyry, but the aphanitic rather than granitoid character of the groundmass and the presence of quartz prompted Ross [12] to redesignate the rock dacite porphyry. The feldspar phenocrysts, which generally make 40 to 60 percent of the rock, average about 2 millimeters

[10] Anderson, A. L., Geology and ore deposits of the Lava Creek district, Idaho: Idaho Bur. Mines and Geology Pamph. 32, p. 22–25, 1929.

[11] Anderson, A. L., Geology of the Pearl-Horseshoe Bend gold belt, Idaho: Idaho Bur. Mines and Geology Pamph. 41, p. 19, 1934

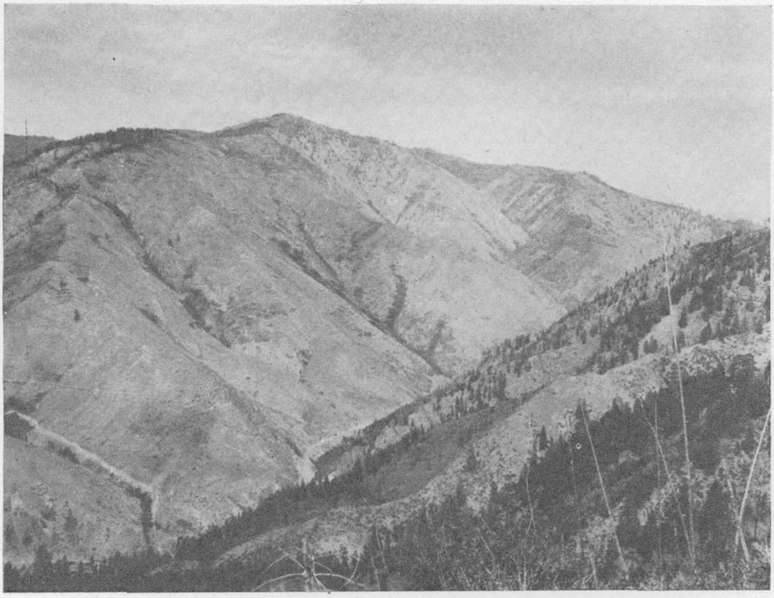
[12] Ross, C. P., op. cit., p. 246.

A. UPLAND SURFACE EAST OF THORN CREEK BUTTE.

Shows a notably broad remnant of the somewhat hilly erosion surface that forms the upland areas in and around Boise Basin. The deep canyons of the Boise River and its tributaries lie in the background.

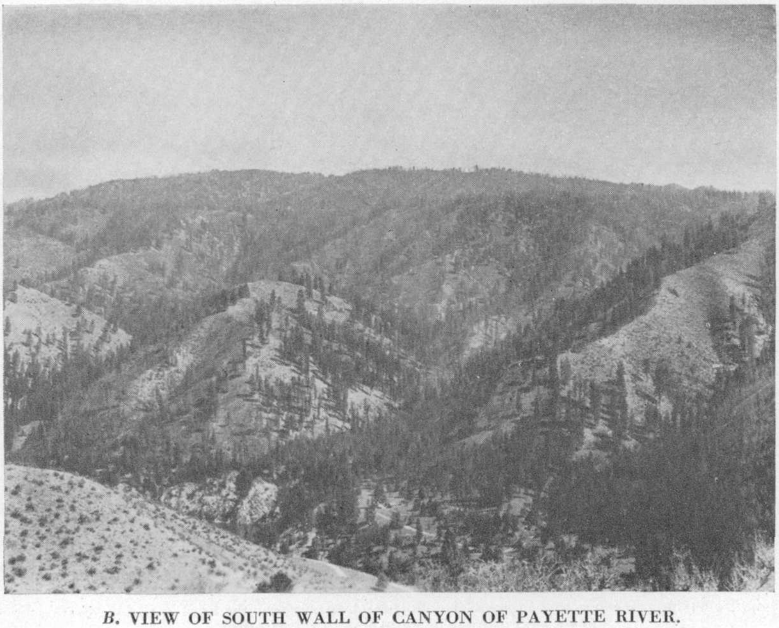
B. UPLAND SURFACE NEAR THE EDGE OF PAYETTE CANYON.

Shows the low flat-topped ridges that compose the old upland surface near the head of Grimes Creek adjacent to the deep canyon of south fork of Payette River.



A. CANYON OF SOUTH FORK OF PAYETTE RIVER.

Shows the canyon of the river deeply entrenched in the high upland surface shown in plate 16, *B*.



B. VIEW OF SOUTH WALL OF CANYON OF PAYETTE RIVER.

Shows trenchlike valley of Grimes Creek apparently suspended high on the upper slope, in topographic nonconformity with the river.

in diameter, though in some dikes a few reach 10 millimeters. Their composition is that of sodic to calcic andesine, and they are generally zoned, particularly near margins. The dark-colored phenocrysts commonly form less than 15 percent of the rock, and of these the biotite crystals invariably predominate. Quartz phenocrysts occur as widely scattered, rounded grains, in part rimmed by micropegmatite. The andesine and dark minerals are, for the most part, considerably altered, the andesine to sericitic white mica and the dark minerals to chlorite, epidote, and calcite.

The aphanitic groundmasses are made up largely of sodic andesine, or oligoclase, accompanied by variable but small amounts of biotite, magnetite, orthoclase, and quartz, and such accessory minerals as widely scattered small crystals of apatite, and zircon (pl. 22, *A*). The quartz content of the groundmass ranges from 2 to 15 percent in the different dikes, and that of orthoclase is as much as 5 percent. The magnetite is notably abundant, in some dikes amounting to 3 percent of the rock. Some of the magnetic grains are large enough to be classed as phenocrysts. The groundmasses are commonly granular, and rocks with appreciable quantities of orthoclase may contain patches of micrographically intergrown quartz and orthoclase. Sericite, chlorite, epidote, and locally calcite are secondary minerals in the groundmass. The altered condition is a conspicuous feature of the dacite porphyries and is similar to that described by Singewald in intrusive sills on Loveland Mountain, Park County, Colo.,[13] where the alteration resulted from the action of hydrothermal solutions associated with the consolidation of the dikes.

QUARTZ-HORNBLENDE-BIOTITE MONZONITE PORPHYRY

Bodies of quartz-hornblende-biotite monzonite porphyry are among the largest and most numerous as well as among the most conspicuous members of the various porphyry belts. One of the largest, a stock less than half a mile to more than a mile wide, extends for 10 miles through Grimes Pass and over nearly two-thirds the length of the area shown on plate 14, and continues eastward beyond the mapped area an undetermined distance. Two other stocks of quartz monzonite porphyry lie along the southeast margin of the "porphyry belt" that extends through Quartzburg-Grimes Pass, but only parts of each are within the borders of the area mapped. Dikes of quartz-hornblende-biotite monzonite porphyry are also widely but not uniformly distributed throughout this "porphyry belt." Many are grouped north of Placerville from the end of the main stock southwest almost to

[13] Singewald, Q. D., Alteration as an end phase of igneous intrusion in sills on Loveland Mountain, Park County, Colo.: Jour. Geology, vol. 40, pp. 16–29, 1932.

Quartzburg. Another group extends past the Belshazzar mine parallel to the cluster of dacite porphyry dikes. Many others occur in the northeast part of the district in and along the Payette Canyon. Most of the dikes are little larger than the dikes of dacite porphyry, ranging from 50 to 500 feet in width (average 100 to 200 feet) and attaining a mile or more in length. Some of the dikes are short, and some of apparent great length actually comprise several closely overlapping dikes. The dikes and stocks ordinarily have inconspicuous outcrops, except along ridge crests, and may be traced largely from weathered fragments in the soil. Massive outcrops with the rounding more or less characteristic of weathered granitic rock were observed in a shallow basin on the Grimes Creek slope near the head of Charlot Gulch.

The quartz-hornblende-biotite monzonite porphyry resembles the rock of similar composition described by Ross in the Casto quadrangle.[14] It is a mottled pink, white, and green, fine-grained to moderately coarse-grained porphyritic rock, containing in the aggregate somewhat more plagioclase than orthoclase. It is readily recognized by its mottled appearance, which has locally prompted the use of the term "birdseye porphyry." The mottling results from the admixtures of numerous white plagioclase phenocrysts and fewer dark green to black hornblende and biotite crystals in pinkish to pinkish-gray groundmasses, which are more distinctly granular than the groundmasses of most of the other porphyries of the same belts. Weathering has obscured the pinkish color of the groundmasses in some of the dikes north and west of Placerville and has modified the mottling in such a way as to make the rock resemble dacite porphyry. In some dikes the rock shows transitions into dacite porphyry, both in composition and appearance, but in places quartz monzonitic dikes cut sharply across the dacitic dikes. Some of the dikes near Quartzburg contain notably fewer plagioclase phenocrysts than the dikes elsewhere and are not so conspicuously mottled, but they are more distinctly reddish than the typical rock because of the proportionately larger amount of pinkish groundmass. Because of the relatively larger amount of orthoclase, the rock might be classed more precisely as granite porphyry. Several dikes a few miles east of Grimes Pass also differ from the type in containing rather numerous quartz phenocrysts and comparatively few dark minerals in a light-gray groundmass of about the same color as the none too numerous plagioclase phenocrysts. This variety appears to be intermediate between the typical quartz-hornblende-biotite monzonite porphyry and the rhyolite porphyry. On

[14] Ross, C. P., Geology and ore deposits of the Casto quadrangle, Idaho: U. S. Geol Survey Bull. 854, p. 61, 1934.

the other hand some dikes have such a preponderance of plagioclase that they might be classed as granodiorite porphyry.

The phenocrysts in order of their abundance include plagioclase (andesine to oligoclase), biotite, and hornblende, commonly a little quartz, and in some dikes a little augite and orthoclase. Together, these phenocrysts make up about half the rock, those of plagioclase 35 to 45 percent, biotite about 10 percent, hornblende about 5 percent, and the augite, orthoclase, and quartz each less than 2 percent. The plagioclase phenocrysts are the most conspicuous and are generally not less than 3 millimeters long and may be as much as 8 millimeters. The crystals are uniformly large in the stocks and most of the dikes (average 5 millimeters) but are rather small in a few of the bodies in which the rock resembles dacite porphyry. The biotite crystals are also among the most conspicuous minerals of the rock. Ordinarily black, they are also represented by greenish chloritic pseudomorphs. Their crystals generally measure 1 to 3 millimeters in diameter. The hornblende has a dull greenish-black color, and its crystals are slender and about as long as the plagioclase phenocrysts. Of the less conspicuous phenocrysts, quartz is most easily recognized, its crystals and grains (in part corroded and embayed) ranging from 1 to 8 millimeters in length. The orthoclase crystals, which are generaly somewhat corroded, are a little smaller than the plagioclase crystals.

The minerals of the groundmass include mostly orthoclase and quartz, minor amounts of biotite and hornblende, and here and there a little sodic oligoclase. Accompanying accessory minerals are apatite, zircon, magnetite, and in some dikes a little allanite, and sphene. These groundmass minerals are generally arranged in finely granular to coarsely granular masses, but the quartz and orthoclase may also occur in micrographic or micropegmatitic intergrowths (pls. 22, *B*, 23, *A*, *B*, 24, A.) In some bodies the groundmass appears to be entirely granular; in others it is largely micropegmatitic; however much of the rock shows combinations of the granular and mircopegmatitic textures. Subdivisions of the intrusives into quartz-hornblende-biotite monzonite porphyry and granophyric, or micrographic, quartz-hornblende biotite monzonite might be made on the basis of these groundmass textures, but such grouping could be made only on detailed microscopic study. The size of the groundmass grains is largely determined by the size of the intrusive body itself, and the chief grains range from less than 0.1 millimeter in the smaller more quickly chilled bodies to nearly 1 millimeter in the larger ones (pls. 22, *B*, 23, A). In parts of the main stock the groundmass grains are nearly as large as the phenocrysts. The micropegmatitic intergrowths likewise reflect the size of the body and its rate of consolidation. In the larger bodies

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the intergrowths are coarsely graphic (pl. 23, *B*) ; in the smaller ones rather finely graphic. In places the intergrowths have assumed the microspherulitic form (pl. 24, *A*), and where cooling apparently was most rapid, appear as confused, indistinct intergrowths, seemingly in poorly defined granules, each granule made up of minute graphic or spherulite combinations, or perhaps combinations of the two. The orthoclase in all groundmasses is estimated to form 20 to 35 percent of the rock and quartz 10 to 25 percent. The accessory minerals occur as euhedral crystals in the orthoclase and quartz, or along cleavages and fractures of the other minerals. Magnetite is the most abundant of these minerals and in places constitutes as much as 2 percent of the rock.

Secondary minerals, such as sericite, chlorite, epidote, and calcite, are rather abundant in all but the largest bodies. The plagioclase grains invariably contain irregular patches of sericitic mica or have irregularly sericitized borders bounding clear centers. The orthoclase in turn is clouded by a fine sericitic dust. The hornblende and biotite as a whole are partly or completely altered to chlorite, epidote, or both, and in places may be recognized only by crystal outline. Some of the larger epidote grains and grain aggregates may also extend into the plagioclase crystals. The chlorite and epidote are commonly accompanied by variable though small amounts of magnetite and calcite. The alteration appears to have been independent of weathering and changes produced by mineralizing solutions, but seems to have taken place closely upon the consolidation of the rock itself, probably by the action of hydrothermal end-stage solutions.

GRANOPHYRE

Bodies of micropegmatite, or granophyre, of variable size are scattered along parts of the "porphyry belt" that passes through Quartzburg and Grimes Pass and are fairly numerous in the dike zones south of Idaho City. Those along the "porphyry belt" are associated with and occur in and around the main quartz-hornblende-biotite monzonite porphyry stock as minor seams a few inches thick and a few feet long in joints and other fracture planes in the quartz monzonite porphyry and as much larger dikelike bodies near the southwest end of the stock. One of the dikes is about 2,300 feet long and as much as 350 feet wide and forms a conspicuous outcrop on the ridge and knoll above the Mineral mine on upper Ophir Creek (see pl. 14). Smaller dikes and seams are fairly numerous in the vicinity of these larger bodies and are numerous on the ridge above Charlot Gulch southeast of Grimes Pass. The distribution of the minor seams along fracture and joint planes within the stock of quartz-hornblende-biotite monzonite porphyry suggests aplitic relationships and implies a close genetic relationship between the quartz monzonite porphyry and the micropegmatite. The micropegmatite shows some textural and compositional variations but may be easily distinguished from all other rocks of the "porphyry belt."

In the larger dikes the rock is light gray to pinkish brown, buff where weathered, and shows a few inconspicuous phenocrysts in what is otherwise a fine-grained, apparently granular groundmass. The phenocrysts comprise a sprinkling of quartz, feldspar, and biotite crystals, which together form less than 5 percent of the rock, enclosed in and corroded by a micropegmatitic groundmass. Some of the feldspar crystals (sodic oligoclase to ablite) are as much as 8 millimeters long, but most of them, as well as the quartz and biotite crystals, are 1 to 3 millimeters long. The micropegmatitic groundmass varies in detail. Much of it shows typical micrographic quartz-orthoclase intergrowths, but some of it is represented by sheaflike and dendritic intergrowths (pl. 24, *B*) and also by hemispherulitic forms. The quartz content is estimated at 25 to 50 percent; the remainder is largely orthoclase. Other minerals present include accessory grains of apatite, zircon, magnetite, and allanite, and some chlorite and muscovite, the latter mostly pseudomorphous after biotite.

In the small dikes and seams the rock is pinkish to pinkish gray, fine-grained, and resembles fine-textured sandstone. Some of the rock, however, contains coarser streaks of pegmatitic character. Most of the rock is made up of nearly equal amounts of quartz and orthoclase in interlocking anhedra, as in aplites, or partly intergrown, as in micropegmatite. Some of the intergrowths show striking sheaflike and dendritic forms. Less than 2 percent of fresh and altered biotite is present, and only a few albite crystals may be scattered through the rock. Other accessory minerals include magnetite, zircon, apatite, and allanite. The only secondary minerals are sericite and epidote.

The granophyre in the joint and fracture planes in the quartz monzonite porphyry stock has a composition and texture identical with the composition and texture of the groundmass of the quartz-hornblende-biotite monzonite porphyry. The occurrence in joint planes and minor fractures suggests that the granophyre has been derived from late liquid residues squeezed from the nearly crystalline quartz monzonite porphyry into nearby openings during slight structural adjustments. The larger granophyric bodies also have a composition and texture that corresponds to the composition and texture of the quartz monzonite porphyry. The occurrence of the micropegmatite in the largest dikes suggests movement of the residual magma from deeper sources within the quartz monzonitic porphyry stock into larger openings above produced by more pronounced structural adjustments.

RHYOLITE PORPHYRY

The bodies of rhyolite porphyry are more widely and uniformly distributed along the "porphyry belts" than those of any other members. They exceed all others in number, though not altogether in size or volume. Their intrusion appears to have attended a rather general reopening of the entire zone of structural weakness, and the dikes along the "porphyry belt" that extends through Quartzburg and Grimes Pass are about as abundant at one place as another (pl. 14) and cut the quartz-hornblende-biotite monzonite porphyry and all earlier rocks indiscriminately. Most of the bodies are 25 to 200 feet thick and 200 to 5,000 feet long, but two near the east margin of the area mapped, composed of rock intermediate between the typical quartz monzonite porphyry and the typical rhyolite porphyry, are as much as 400 feet thick and more than a mile long. Most of the dikes are comparatively narrow in proportion to their length, particularly those southwest of Quartzburg, but some near Quartzburg, though narrow, are relatively short, and one is expanded into a pluglike body 400 feet across. From Quartzburg to Grimes Pass the dikes are for the most part longer and thicker than the dikes in other parts of the "belt," but east and northeast of Grimes Pass, where they are spread over a much wider area, they are short and oval shaped as well as long and narrow. Most of the dikes have fairly conspicuous outcrops, as they are more resistant to weathering and erosion than the less silicic rocks.

The rhyolite porphyries form a well-defined group and are classified as rhyolite porphyries, because aphanitic groundmasses give them a greater resemblance to rhyolite than to granite and because the designation accords with local usage. Most of the dikes have the composition of rhyolite, as most of the rock has somewhat more potash feldspar than plagioclase, but some dikes in which the quantity of plagioclase equals or exceeds that of potash feldspar might perhaps be more appropriately classed as quartz latite porphyry. Subdivision into a group of quartz latite porphyries is not made, however, as such distinctions are difficult to make without microscopic examinations and would hinder rather than aid the layman.

The rhyolite porphyries are generally studded with prominent quartz crystals and less conspicuous crystals of plagioclase and orthoclase set in bleached, nearly white aphanitic groundmasses. The prominence and abundance of the quartz crystals, which range from 1 to 15 millimeters (average 5 to 8 millimeters) in diameter and from 5 to 15 per cent of the rock, give the rhyolite porphyry its most distinctive character and serve to identify it in the field. Orthoclase is also a diagnostic mineral, although in most of the dikes its crystals are so widely scattered as to escape notice, but in several dikes at and near Quartzburg and in many east of Grimes Pass and on Summit Flat its crystals are so large and abundant that they are more conspicuous than the quartz grains. In many of these dikes the orthoclase phenocrysts are as much as 30 millimeters in length and form more than 15 percent of the rock. The plagioclase phenocrysts, though fairly numerous, are inconspicuous, because their color matches that of the groundmass. The plagioclase crystals are 2 to 8 millimeters long and normally make up 10 to 20 percent of the rock, though in the quartz latite porphyries the proportion may nearly double that. In rocks not as bleached as the typical rock small crystals of biotite and fewer crystals of hornblende measuring less than 2 millimeters and forming less than 5 percent of the rock may also be distinguished (pl. 25, *A*).

The quartz phenocrysts are generally wellshaped crystals, commonly surrounded by narrow reaction rims composed of minute penetrations of groundmass orthoclase. These rims are apparently a reaction intergrowth simulating the micrographic (pl. 25, *B*). The quartz crystals occur either as scattered individuals or are grouped in clusters. The plagioclase phenocrysts are mainly oligoclase, ranging from sodic oligoclase to sodic andesine in different dikes. The crystals are euhedral, ordinarily uncorroded, and show albite, carlsbad, and in places baveno twinning. The crystals, however, are generally so thoroughly sericitized even in the least altered dikes that the twinning is only faintly visible. The orthoclase phenocrysts are also euhedral but are not as highly altered as the plagioclase crystals. Biotite is ordinarily indicated in outline; in most dikes it has been bleached or changed to muscovite.

The groundmass forms a larger part of the rock than the phenocrysts and consists mainly of orthoclase and quartz, accompanied in places by subordinate amounts of oligoclase and invariably by accessory magnetite, apatite, and zircon. The constituents of the groundmass are exceedingly minute in comparison with the phenocrysts and ordinarily are less than 0.1 millimeter in diameter (pl. 25, *A*). In most of the dikes the quartz and orthoclase form finely granular aggregates (pl. 25, *A*) but in some the granular aggregates are accompanied by granules of rather poorly defined micropegmatitic intergrowths (pls. 25, *B*, 26, *A*) or by patches of hemispherulitic intergrowths. In some rocks the relations are two confused for precise interpretation, perhaps because of the tendency for the quartz and orthoclase to occur in exceedingly minute intergrowths, probably micrographic. The orthoclase is estimated to form 45 to 60 percent of the rock, the groundmass quartz 15 to 20 percent.

The rock in most of the dikes shows the effects of marked alteration and is in general much sericitized. The alteration has apparently not been materially guided by fractures, nor has it been directly affiliated with sulfide mineralization, although the alteration is more intensified near lodes than elsewhere. The alteration appears to have accompanied the intrusion and consolidation of the rock itself and is probably a postmagmatic effect resulting from end-stage hydrothermal solutions. The conditions are similar to those described by Singewald in the sills on Loveland Mountain, Park County, Colo.[15] The dikes of rhyolite porphyry have been more extensively endomorphosed than any of the other porphyries, and there appears to be a close relation between the end-stage alteration and the closely following stage of mineralization and associated hydrothermal alteration.

RHYOLITE

Rhyolite dikes, which differ materially in textural and compositional characters from the rhyolite porphyry, are conspicuously concentrated along the northeast part of the "porphyry belt," east and northeast of Grimes Pass. These dikes are more or less oval in shape and are individually small, generally no more than 25 feet thick or more than 50 to 100 feet long, and are confined to a zone that starts about 1¼ miles south-southeast of Grimes Pass and trends about N. 30° E., diagonally across the main "porphyry belt." This zone crosses Grimes Creek near Branson's ranch, about 3 miles above Grimes Pass, and extends across the Payette River about a mile above Gallager ranger station. The dikes southeast and east of Grimes Pass are widely scattered but are probably more numerous than indicated on the surface, for of all the different kinds of dikes these have the most inconspicuous outcrops, and, except in the Payette Canyon, are more commonly encountered underground than on the surface. Northeast of Grimes Pass, however, their number greatly increases, and dike clusters become more closely spaced. They are so closely spaced on the north side of Grimes Creek that it is not possible to separate the individual members, and the entire zone, except for certain prominent rhyolite porphyry dikes and a small mass of invaded pyroxene- hornblende-biotite diorite, is mapped as intrusive rhyolite. Near the Payette River the dike swarm appears to merge into a single body as broad as the dike zone.

The rhyolite dikes are composed of a rock that is much more silicic than the rhyolite porphyry and that has much less plagioclase and dark

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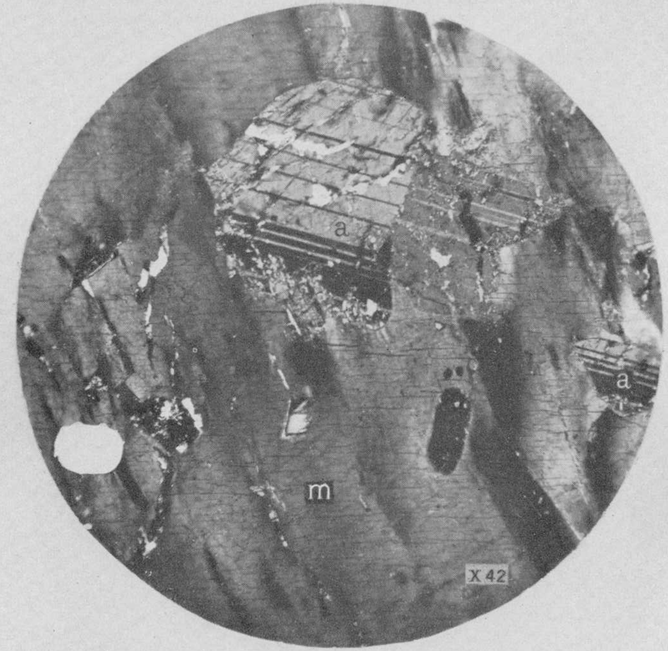
[15] Singewald, Q. D., op. cit., pp. 16–29.

A. BIOTITE (b) WITH TONGUES PROTRUDING INTO AN ANDESINE CRYSTAL (a) IN A MANNER INTERPRETED AS REPLACEMENT.

Quartz diorite facies. Crossed nicols.

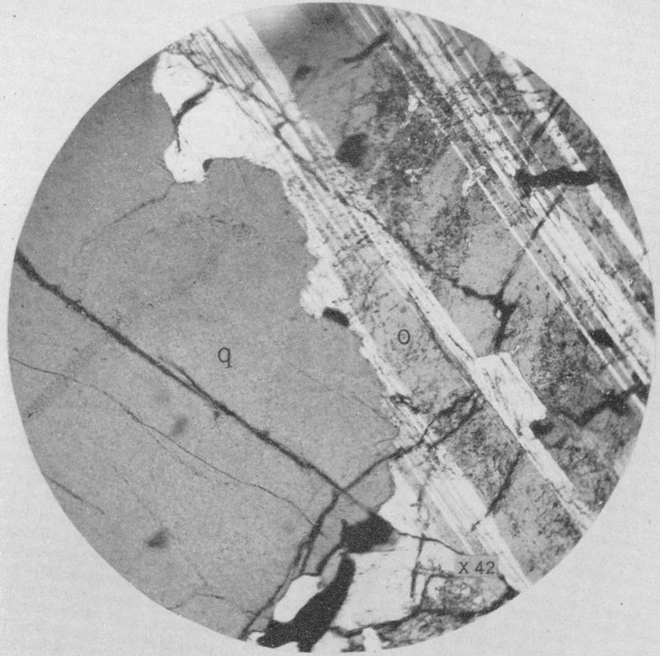


B. ORIENTED REMNANTS OF A POLYSYNTHETICALLY TWINNED ANDESINE CRYSTAL (a) ENGULFED IN A LARGE GRAIN OF MICROCLINE (m).

The andesine remnants are interpreted as residuals of replacement. Quartz diorite facies. Crossed nicols.

PHOTOMICROGRAPHS OF THIN SECTIONS OF THE GRANITIC ROCK OF THE IDAHO BATHOLITH

Show mineral relations attributed to postconsolidation endomorphism.



A. POLYSYNTHETICALLY TWINNED OLIGOCLASE CRYSTAL (o) IRREGULARLY EMBAYED AND INVADED BY QUARTZ (q).

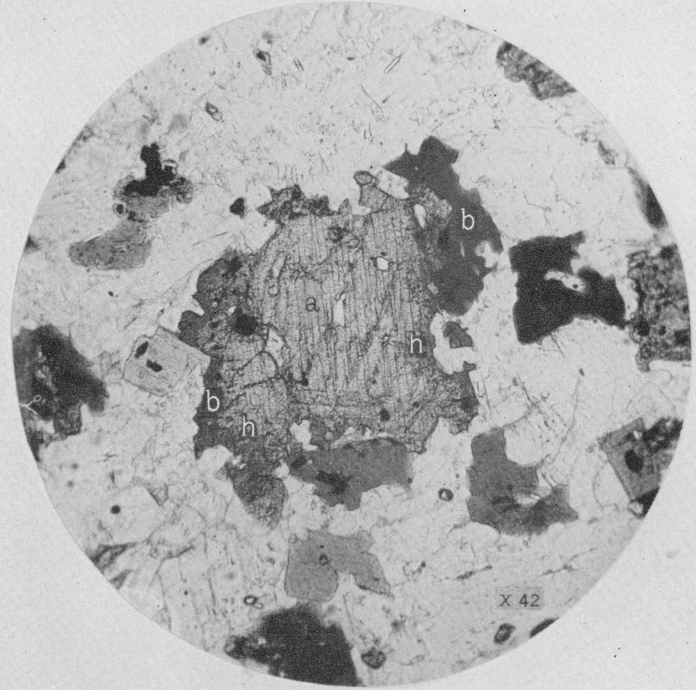
Much of the quartz in the granitic rock of the Idaho batholith shows similar penetration or lobate relations, which are interpreted as an effect of late replacement associated with general and widespread silicification of earlier consolidated rock. Quartz monzonite facies. Crossed nicols.

B. OLIGOCLASE CRYSTALS (o) INVADED BY QUARTZ OF TWO GENERATIONS, A SEAM OF THE YOUNGER QUARTZ (q) CUTTING ACROSS A SEAM OF THE SOMEWHAT OLDER QUARTZ (q_1).

The general silicification of the batholithic rock has taken place in two stages and has been the most active process associated with the end-stage endomorphism. Potash was also added to the rock in considerable quantity. Quartz monzonite facies. Crossed nicols.

PHOTOMICROGRAPHS OF THIN SECTIONS OF THE GRANITIC ROCK OF THE IDAHO BATHOLITH

Show mineral relations attributed to postconsolidation endomorphism.



A. PYROXENE-HORNBLENDE-BIOTITE DIORITE COLLECTED FROM STOCK NEAR GRIMES PASS.

Shows the typical zoning of the andesine feldspar and the mantling of augite (a) by hornblende (h), also the poikilitic character of some of the orthoclase (c). Crossed nicols.

B. PYROXENE-HORNBLENDE-BIOTITE DIORITE FROM THE SAME STOCK AS *A*.

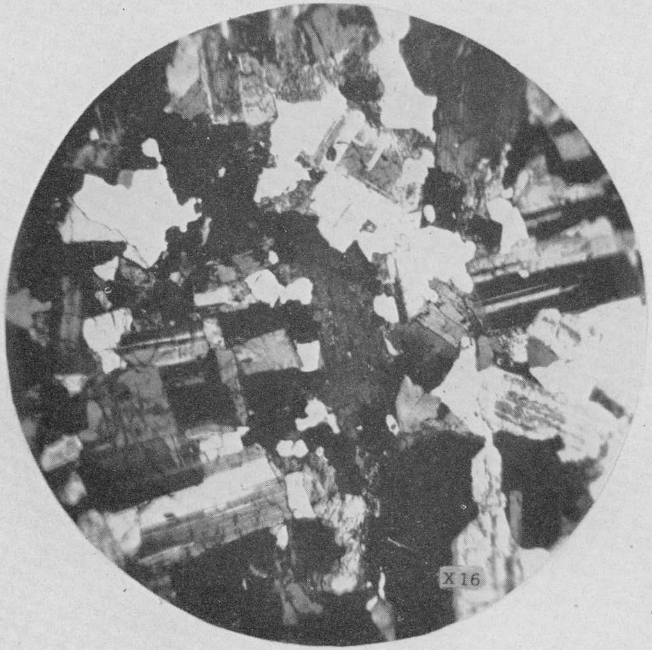
Shows partial mantles of hornblende (h) and biotite (b) on a crystal of augite (a). The mantling indicates the incomplete reaction between early crystals and liquid during consolidation of the magma. Uncrossed nicols.

PHOTOMICROGRAPHS OF THIN SECTIONS OF THE EARLY TERTIARY(?) GRANODIORITE AND PYROXENE-HORNBLENDE-BIOTITE DIORITE.

Show typical mineral and textural relationships.

A. PYROXENE-HORNBLENDE-BIOTITE DIORITE WITH SCATTERED PATCHES OF MICROPEGMATITE.

The final consolidation product o the magma undergoing differentiation by crystal fractionation. Crossed nicols.



B. GRANODIORITE.

Intrudes the Idaho batholith on Warm Springs Ridge about 5 miles southwest of Idaho City. Crossed nicols.

PHOTOMICROGRAPHS OF THIN SECTIONS OF THE EARLY TERTIARY(?) GRANODIORITE AND PYROXENE-HORNBLENDE BIOTITE DIORITE.

Show typical mineral and textural relationships.

minerals. In composition and general appearance it is much like extrusive rhyolite. It cannot be distinguished from ordinary extrusive rhyolite in the hand specimen, particularly as the dike rock commonly shows flow banding parallel to the dike walls and curving of fluxion lines around the small widely scattered phenocrysts. The rock, however, is not conspicuously porphyritic and is chiefly a fine-grained light gray to pink rock, easily distinguished from the rhyolite porphyry. Much of the rhyolite has less than 5 percent of phenocrysts, which are made up largely of quartz crystals and grains commonly less than 1 milimeter in diameter but exceptionally as large as 2 millimeters. In places the quartz is accompanied by small even more widely scattered crystals of feldspar. The scattered quartz crystals are generally somewhat embayed and corroded by the groundmass and commonly have a border zone of minutely interpenetrated orthoclase and quartz, which might be described as micropoikilitic with the quartz the host for the minute feldspar laths (pl. 26, *B*). The few widely distributed feldspar phenocrysts are similar to the quartz grains in size and comprise orthoclase and in some rock scant amounts of somewhat altered sodic plagioclase, near albite in composition. These phenocrysts are scattered in finely granular groundmasses of micropoikilitic habit made up of small quartz granules, in each of which appear to be minute orthoclase laths and microlites (pl. 26, *B*). There are also granules of pure quartz. On the whole the groundmasses are more quartzose than feldspathic. Accessory minerals include magnetite and small scattered crystals of zircon. Most of the dikes have been somewhat sericitized, very thoroughly so in places, and locally silicified and impregnated with pyrite.

GRANODIORITE PORPHYRY

Only a single body of granodiorite porphyry has been found, and it crops out on the low Grimes Creek-Payette River divide, about 4 miles northeast of Grimes Pass, near the margin of the main swarm of rhyolite dikes. The body is bow-shaped in outline, concave to the southeast. It is about 1,500 feet long and as much as 200 feet wide, forming a low but prominent outcrop, in part covered by angular fragments of rock.

The granodiorite porphyry is light gray and superficially resembles the rhyolite porphyry and rhyolite in the outcrop, but it is coarser-grained, suggesting the granitoid texture, and is made up largely of chalky feldspar crystals, which average about 3 millimeters in length. The rock is composed of more than 60 percent of plagioclase phenocrysts (sodic oligoclase) in a finely granular groundmass of interlocking quartz and orthoclase grains. The oligoclase (about Ab_{88}) is eubedral, although many crystals are irregularly indented by the quartz grains of the groundmass, and some are broken and the fractures filled with groundmass minerals (pl. 27, *A*). The textural relations suggest a crystal net in which the interstices between the crystals are occupied by the finer-grained mosaics of quartz and orthoclase and scattered accessory grains of magnetite, zircon, and allanite. The rock is moderately altered, the oligoclase being extensively sericitized and the biotite or hornblende, which may have formed between 5 and 10 percent of the rock, being replaced by epidote, chlorite, and sericite.

The body of granodiorite porphyry appears to be intimately associated with the swarm of rhyolite dikes. Its plagioclase has the same sodic composition as the plagioclase of the rhyolite, and its net of plagioclase crystals, in part crushed and broken, suggests that the body is a product of crystal sorting, that the crystals had accumulated, through settling at depth, and had been intruded as a crystal mush, or that the crystals had been carried along in the highly liquid rhyolite magma and the liquid filter-pressed from the crystals during the intrusion.

LAMPROPHYRE

Lamprophyric dikes are widely scattered along the "porphyry belts" but are ordinarily visible only in underground workings, where they commonly lie in or across the fissures occupied by the lodes. They range from a few inches to 10 feet or more in thickness and pinch and swell abruptly. They may occupy the lode fissures for short or long distances or may cut sharply across the lodes. Where a dike is in contact with a lode it is usually somewhat altered but unmineralized. In places it contains small inclusions of ore. As the dikes cut all the other intrusives of the "porphyry belts" as well as the lodes, it is evident that lamprophyric dikes were the last of the intrusives injected from the magma body and the final product of differentiation. These lamprophyres are somewhat porphyritic and contain rather inconspicuous phenocrysts of dark minerals in a groundmass of dark minerals and plagioclase. Most dikes have been so extensively altered that original dark minerals are not easily identified and do not stand out sharply as in the usual lamprophyric types. These dikes have been classed as diabase and basalt by Ballard [16] and diabase by Ross,[17] although the rock shows no clearly defined ophitic or diabasic texture and apparently contains no plagioclase as calcic as labradorite.

Where unaltered, the rocks are dark gray to black, fine-grained, and inconspicuously porphyritic, but in and near lodes they are bleached

[16] Ballard, S. M., Geology and gold resources of Boise Basin, Boise County, Idaho: Idaho Bur. Mines and Geology Bull. 9, p. 24, 1924.

[17] Ross, C. P., Some lode deposits in the northwestern part of the Boise Basin, Idaho: U. S. Geol. Survey Bull. 846–D, pp. 248–249, 1933.

and appear even less porphyritic than in the fresh rock. In thin section the small scattered phenocrysts commonly comprise augite and brown hornblende, or calcite pseudomorphs after augite and hornblende, and chloritic pseudomorphs after biotite. Augite is predominant in only a few of the dikes examined. In most dikes it is accompanied by as much hornblende and generally by somewhat smaller quantities of biotite. These phenocrysts are not much larger than the groundmass grains in the larger dikes but stand out prominently in the smaller finer-grained bodies.

The groundmasses are composed of fairly well shaped plagioclase laths and considerable amounts of altered hornblende and biotite, possibly augite, and relatively large amounts of magnetite and apatite (pl. 27, *B*). The plagioclase forms no more than half of the rock, although, because of its less conspicuous alteration, it appears to be more abundant than the dark minerals. Its laths are highly zoned and the twinning lines rather widely spaced. Its composition ranges from oligoclase to calcic andesine in different dikes.

Secondary calcite is abundant in most of the dikes, and chlorite and epidote generally occur in variable but lesser amounts. In some altered zones the rock is cut by thin seams of calcite and may contain small widely scattered crystals of pyrite.

TERTIARY LAKE BEDS AND VOLCANICS (LOWER MIOCENE)

Scattered patches remain of what must have been once a continuous blanket of lake beds and volcanics, preserved only where infaulted against the granitic rock of the Idaho batholith and carried to levels not yet reached by erosion. The largest patch of these strata covers an area of about 7 square miles at and around Idaho City, separated from the granitic rock of the batholith by marginal faults. Smaller remnants remain along Grimes Creek near Old Centerville and New Centerville and on Muddy Creek, a tributary of Grimes Creek about 4 miles above Pioneerville. The strata on Muddy Creek are concealed beneath terrace gravels and alluvium and therefore are not shown on the geologic map of the Quartburg-Grimes Pass area.

Most of the material consists of fine, well-stratified lake beds, but some fluviatile deposits are included, and near Idaho City the unit contains considerable volcanic ash and an intercalated flow of basalt. Not less than 850 feet of beds remain at Idaho City.[18]

The lake beds consist largely of white to gray somewhat consolidated sand and clay derived from the weathering and erosion of the granitic rock of the batholith. The beds within a short radius of Idaho City

[18] Lindgren, Waldemar, The mining districts of the Idaho Basin and the Boise Ridge Idaho: U. S. Geol. Survey 18th Ann. Rept., pt. 3, p. 668, 1898.

are composed mainly of well-stratified gray clay, with sandy streaks and intercalated beds of black clay, lignitic shale, and locally thin seams and lenses of gravel. From 1 to 2 miles below Idaho City most of the beds are of coarse-grained yellow sandstone, the quartz and feldspathic grains being cemented by opaline material deposited from hot springs. Near Warm Springs the cemented sandstone forms a bluff about 300 feet high. Several beds of volcanic ash 10 to 30 feet thick are intercalated in the series about a mile above Idaho City. This ash is light gray, like the lake beds, and is also well-stratified and in places admixed with considerable clay. Otherwise it is composed of fairly coarse rather well compacted glass fragments, in places mixed with fragments of fossil plants.

The basalt member is intercalated in the lower part of the lake beds and extends across Moore Creek about 2 miles above Idaho City. It appears in faulted segments at altitudes 400 feet above the creek near Pine Gulch and other gulches across from Idaho City. The flow appears to be about 100 feet thick and consists of a medium-grained to fine-grained dark-gray to dark-green in part amygdaloidal rock, in places somewhat porphyritic with phenocrysts of olivine and magnetite. Its minerals, as seen under the microscope, include also lavender-tinted augite, small laths of twinned labradorite, and much brownish-red iddingsite and greenish chlorite. The labradorite laths are commonly engulfed in the much larger augite grains. The rock is moderately altered, and practically all the olivine (about 5 percent of the rock) has been converted partly or wholly to iddingsite and much of the augite to chlorite, which commonly shows a striking radial structure.

The exposures along Grimes and Muddy Creeks show only the well-stratified fine-grained sandy and clayey beds composed of arkosic and clayey materials, also derived from the weathering and erosion of the older granitic rock.

Some of the lake beds at Idaho City are fossiliferous and contain a flora that was interpreted as upper Miocene by Knowlton and prompted Lindgren to correlate the strata with the Payette formation.[19] This correlation was accepted more recently by Kirkham,[20] who in his review of the subject assigns the bed to the Payette, his summary of the fossil evidence indicating that the formation is not older than middle Miocene and is probably mainly upper Miocene. Roland W. Brown, who visited the Idaho City locality in 1934 and made more extensive collections than those made by Lindgren and

[19] Lindgren, Waldemar, op. cit., p. 666.
[20] Kirkham, V. R. D., Revision of the Payette and Idaho formations: Jour. Geology, vol. 39, No. 3, pp. 232–235, 1931.

figured by Knowlton, obtained a flora that he assigned to the lower Miocene. These collections were from two localities half a mile northeast of Idaho City—one from sandy-clayey beds in an exposure about 75 feet above the level of and on the north side of the road leading to Lowman and the other from the same beds on the other side of the valley. The flora as figured by Brown include the following:

Equisetum sp.
Sequoia langsdorfii (Brongniart) Heer
Pinus sp.
Populus eotremuloides Knowlton
Salix sp.
Betula heteromorpha Knowlton
Quercus cognatus Knowlton
Juglans oregoniana Lesquereux
Ulmus brownelli Lesguereux
Acer osmonti Knowlton
Trapa americana Knowlton
Celastrus lindgreni Knowlton
Rhamnus spokanensis Berry

According to Brown,[21] Knowlton had rightly pointed out the striking resemblance of the plants to those of the Bridge Creek flora in the John Day Valley, Oreg., but erred in assigning them to an upper Miocene age, as the Bridge Creek flora is now generally conceded on both stratigraphic and paleontologic grounds to be either upper Oligocene or Lower Miocene, more likely the latter. Brown also wrote that the lake beds at Idaho City are apparently somewhat younger than the Challis volcanics in the vicinity of Challis, Idaho, which he states contain a flora with some species heretofore ascribed to the Eocene and Oligocene and which he believes are of upper Oligocene, or, at most, of lower Miocene age. He infers, however, that the beds at Idaho City are about contemporaneous with the upper strata of the Challis volcanics.

Along the Middle Fork of the Salmon River and in other localities the Challis volcanics are invaded by the "porphyries," of which those of the "porphyry belt" that extends through Quartzburg and Grimes Pass are believed to be representative, but Boise Basin affords little evidence of the relations between the lower Miocene beds and the Miocene intrusives. As the faults that affect the beds at Idaho City conform in kind and trend with those that appear along the "porphyry belt," the lower Miocene strata were probably deposited shortly before the intrusive epoch or perhaps more or less contemporaneously with it.

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[21] Brown, R. W., Written communication.

EXTRUSIVE IGNEOUS ROCKS

COLUMBIA RIVER BASALT (MIDDLE OR UPPER MIOCENE)

Minor patches of basalt, apparently remnants of a formerly continuous cover, are scattered over the western part of the district from Grimes Creek to and beyond the western border of the area. Farther west the patches become larger and more numerous and finally merge into a single continuous cover. The most easterly remnant is several hundred yards west of Grimes Pass and rests on the eroded surface of a part of the quartz-hornblende-biotite monzonite porphyry stock (pl. 14). Either the basalt did not extend much east of Grimes Pass, or subsequent erosion has stripped away all record of its presence. Another remnant caps a conical hill about 1½ miles northeast of Quartzburg and overlies the beveled tops of several dacite porphyry dikes (see pl. 14). Several others remain between Quartzburg and Placerville. Others not shown on the geologic map lie at the base of Boise Ridge, about 3½ miles southwest of Placerville. Still another blankets about 3 square miles in the Clear Creek drainage area south of Holcomb. The basalt also appears in the crest of Boise Ridge northwest of Quartzburg and from there extends down the west slope of the ridge to Jerusalem Valley and Horseshoe Bend, about 5 miles to the west.

The basalt was apparently spread over a deeply eroded surface, which had been cut across the "porphyry belts" and infaulted blocks of lower Miocene beds. Locally this surface had the features of a peneplain, for wherever the basalt flows have been examined they appear to rest on nearly level ground. Traced westward, the flows in Jerusalem Valley and Horseshoe Bend lie beneath and are intercalated in the Payette formation, which Kirkham regards as no older than Miocene and most likely upper Miocene.[22] He correlates these flows with the Columbia River basalt.

Within Boise Basin the basalt has apparently been eroded to its basal flows, and less than 100 feet remain within the area mapped. On the ridge above Quartzburg, however, the rock is as much as 600 feet thick and has 300 feet of flows at the base, covered by 200 feet of tuff and scoria, which are capped by 100 feet of massive basalt. Westward the series of flows exceeds 1,000 feet in thickness.

All flows examined, except one, consist of olivine basalt, with differences between flows no more marked than differences within the flows. The rock is dark gray to black, brownish where weathered. It is generally somewhat vesicular, especially near flow tops, but is otherwise fine-grained. The rather widely spaced vesicles are less

[22] Kirkham, V. R. D., op.cit., pp. 232–235.

than one-fourth inch in diameter. The rock is ordinarily somewhat porphyritic and has a few scattered inconspicuous plagioclase crystals less than 2 millimeters long, less commonly as much as 5 millimeters long, and some crystals of olivine distinguishable only with the microscope. The phenocrysts form less than 15 percent of the rock and in the more central zones where the rock has its coarsest grain are little larger than the grains of the groundmass. In the fine-grained marginal rock the phenocrysts appear conspicuously larger.

The plagioclase phenocrysts are of calcic labradorite and, along with the smaller olivine grains and crystals, are embedded in a groundmass of smaller sodic labradorite laths, faintly tinted titaniferous augite, magetite, and ilmenite. The olivine-free basalt also contains some brownish glass. In the more coarsely crystalline basalt the augite occurs in large grains enclosing swarms of the labradorite laths, but in the chilled marginal rock the augite forms small grains between the plagioclase crystals. The olivine crystals are commonly partly altered to reddish-brown iddingsite. Many of the labradorite phenocrysts, particularly in the olivine-free basalt, contain groundmass inclusions along cleavages and are, therefore, strikingly mottled.

SNAKE RIVER BASALT (QUATERNARY)

Basalt covers the valley bottoms of lower Grimes and Moore Creeks and the main Boise River, and the flows extend upon and are contemporaneous with those of the Snake River Plain near Boise. The vent from which the basalt was extruded is apparently concealed by lava, but probably lies a mile or two above the mouth of Grimes Creek. When the basalt was extruded the valleys had been eroded nearly to their present depths, but the streams have since trenched the basalt, leaving lava-flooded terraces 100 feet high on both sides. Because the columnar joints of the basalt favored the formation of vertical cliffs, the streams flow in a canyon within a valley. As the basalt-floored valleys are believed to have been carved in response to late Pliocene and early Pleistocene uplift, and as the basalt was extruded during a late stage of valley cutting, the flows are probably Pleistocene.

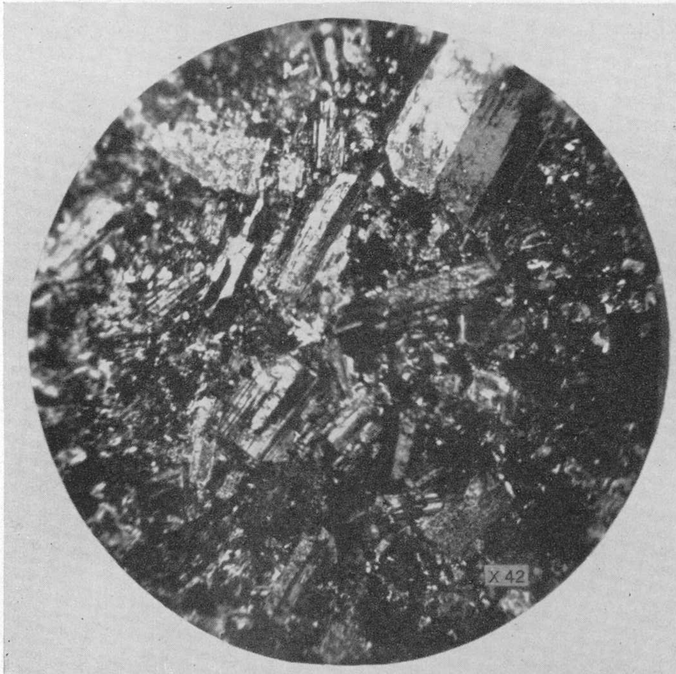
The basalt is identical with that which covers much of the Snake River Plain and may be classed as olivine-rich basalt, somewhat lighter colored and not as dull in appearance as the older Columbia River basalt. It is highly vesicular, and the vesicles are especially large and numerous near the tops and the bottoms of the individual flows. The rock is distinctly crystalline and has numerous yellowish-green olivine crystals and granules 1 to 2 millimeters in diameter and scattered plagioclase (labradorite) crystals of somewhat larger size in a comparatively coarse-grained groundmass of sodic labradorite, augite, olivine, magnetite, and ilmenite. The labradorite laths in the groundmass are commonly engulfed in large augite grains, except at flow margins where more rapid cooling and consolidation permitted only small augite grains to form between the plagioclase laths. The augite is distinctly titaniferous and has a deep purplish-lavender color in thin section. The olivine occurs both as rounded and as well-shaped crystals grouped in part in clusters. These crystals and grains amount to not less than 20 percent of the rock, and their size and abundance give the rock a distinctly crystalline and almost granular as well as somewhat mottled appearance. The ilmenite and magnetite lie among the plagioclase and augite grains, the ilmenite in the form of well-defined laths. The ilmenite, the more abundant of the two minerals, apparently forms about 3 percent of the rock.

OLDER ALLUVIUM (PLEISTOCENE)

The older alluvium is widely distributed over many parts of the district, mainly along valley sides and low ridge crests in rather well-defined terraces. Some terraces are not much above the bottoms of the present valleys; others lie at levels several hundred feet above, in a place or two as much as 600 feet, above them. Some of these terraces are not easily recognized, for placer miners have washed much of the material down the slopes, destroying some terraces and concealing others beneath tailings. These deposits are most widespread in the lower part of Boise Basin, particularly along Moore and Grimes Creeks, where they have been extensively washed. They have yielded much of the placer gold mined in the district. There are also terrace deposits in the lower part of the Payette Canyon and in other parts of the district.

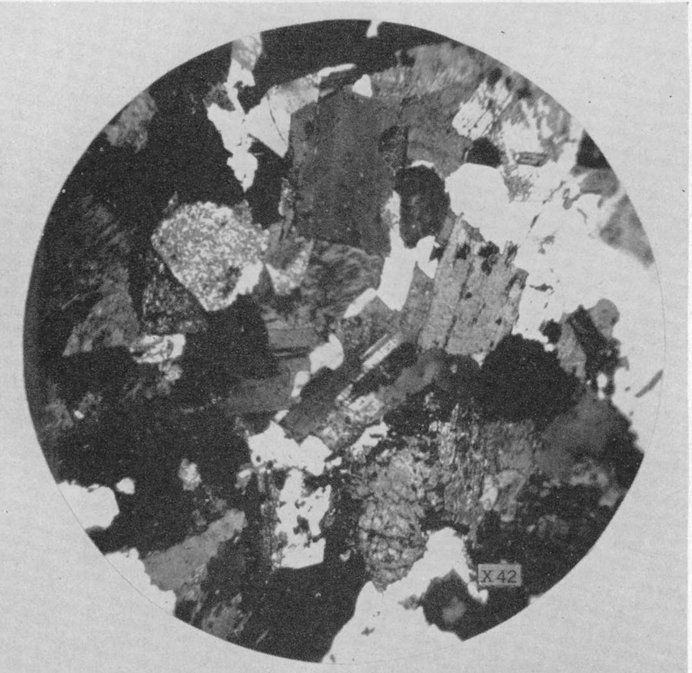
The deposits along Moore and Grimes Creeks have been described in considerable detail by Lindgren,[23] and there is nothing pertinent to add to the published data. Several terraces cover the slopes for a few miles above and below Idaho City at levels ranging from the valley floor to 300 feet above it. Some of these deposits are as much as 100 feet thick. Most of the gravel has been worked, but high remnants of considerable size remain near Idaho City. Other deposits extend down Moore Creek for a number of miles, some of them on ridge slopes 600 feet above the creek, others beneath the basalt in the lower valley. Placer tailings also indicate low terraces along Grimes Creek, particularly near New Centerville and Old Centerville and on the slopes between Old Centerville and Placerville. These deposits are also widespread on the slopes north and west of Placerville and on the low ridges below Quartzburg, where they are as

[23] Lindgren, Waldemar, op. cit., pp. 659–676.



A. DACITE PORPHYRY.

Phenocrysts of andesine feldspar in a fine-grained crystalline groundmass composed largely of andesine associated with subordinate quartz. Mayflower Mine. Crossed nicols.



B. QUARTZ-HORNBLENDE-BIOTITE MONZONITE PORPHYRY, COARSE-GRAINED FACIES.

Shows the coarse crystallization of the groundmass quartz and orthoclase near the center of the large stock at Grimes Pass. Crossed nicols.

PHOTOMICROGRAPHS OF THIN SECTIONS OF PORPHYRITIC MIOCENE DIKES AND STOCKS OF THE "PORPHYRY BELT" IN THE QUARTZBURG-GRIMES PASS AREA.

Show typical mineral and textural relationships.

A. QUARTZ-HORNBLENDE-BIOTITE MONZONITE PROPHYRY.

Shows normal porphyritic texture characteristic of the rock near the margin of the stock and in many of the larger dikes. Crossed nicols.

B. QUARTZ-HORNBLENDE-BIOTITE MONZONITE PORPHYRY.

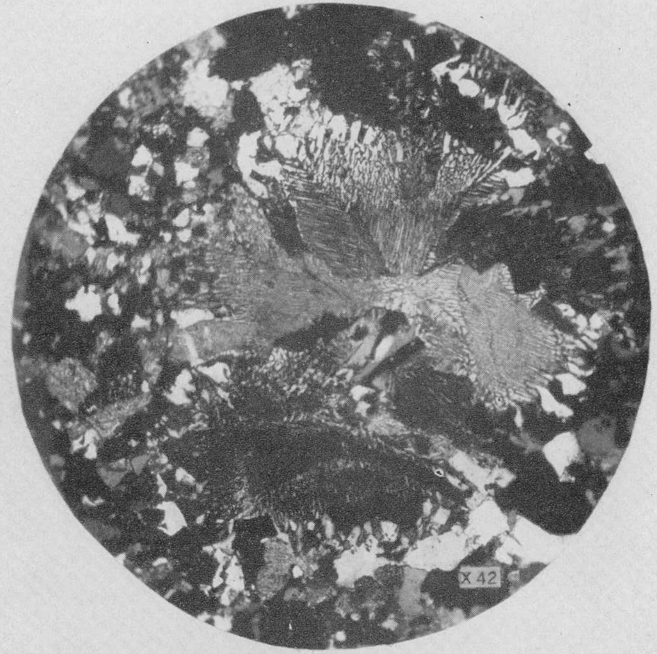
Shows micropegmatitic groundmass, which is typical of much of the rock of the dikes and stocks. Crossed nicols.

PHOTOMICROGRAPHS OF THIN SECTIONS OF THE PORPHYRITIC MIOCENE DIKES AND STOCKS OF THE "PORPHYRY BELT" IN THE QUARTZBURG-GRIMES PASS AREA.

Show typical mineral and textural relationships.

A. QUARTZ-HORNBLENDE-BIOTITE MONZONITE PORPHYRY.

Shows the microspherulitic type of groundmass so typical of many of the dikes. Crossed nicols.

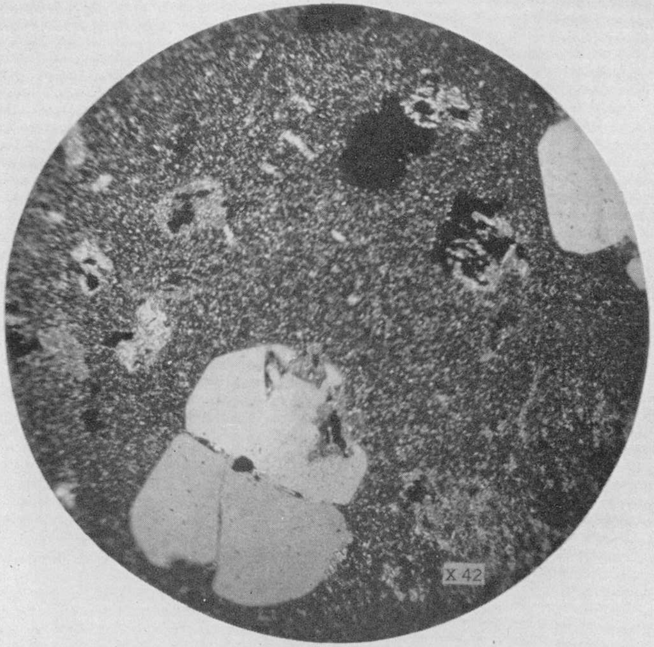


B. GRANOPHYRE.

Dike near Mineral Hill, about midway between Quartzburg and Grimes Pass. Shows the sheaflike pattern of some of the micropegmatitic intergrowths. Crossed nicols.

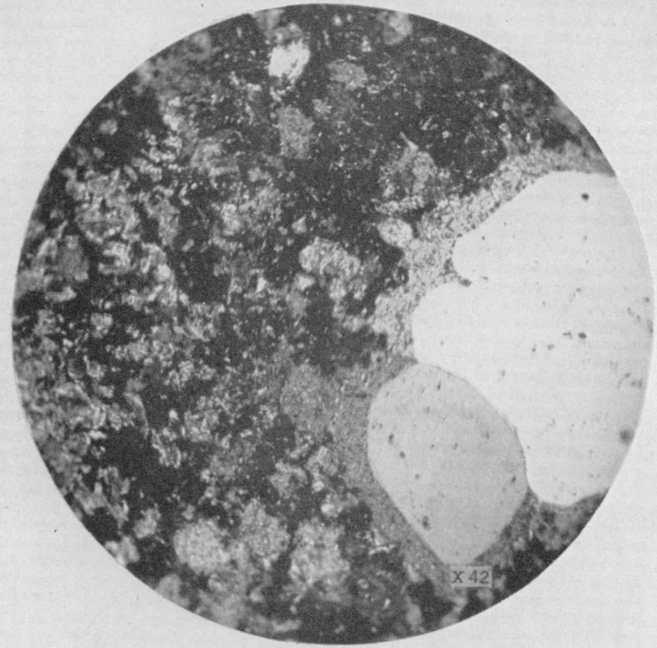
PHOTOMICROGRAPHS OF THIN SECTIONS OF THE PORPHYRITIC MIOCENE DIKES AND STOCKS OF THE "PORPHYRY BELT" IN THE QUARTZBURG-GRIMES PASS AREA.

Show typical mineral and textural relationships.



A. RHYOLITE PORPHYRY.

Dike at Gold Hill Mine. Shows clear quartz phenocrysts and sericitized biotite and plagioclase crystals in a finely granular partly sericitized groundmass. Crossed nicols.



B. RHYOLITE PORPHYRY.

Oro Mine. Shows reaction rims on quartz phenocrysts, which are embedded in a groundmass composed of indistinct granules of orthoclase and quartz. Crossed nicols.

PHOTOMICROGRAPHS OF THIN SECTIONS OF THE PORPHYRITIC MIOCENE DIKES AND STOCKS OF THE "PORPHYRY BELT" IN THE QUARTZBURG-GRIMES PASS AREA.

Show typical mineral and textural relationships much as 200 feet above the valley bottoms (pl. 14). Other patches of the older alluvium also occur along Grimes Creek, at and below Grimes Pass and about 3 miles above. Another large patch, which conceals about a square mile of the "porphyry belt" and a remnant of the lower Miocene beds, occurs on Muddy Creek not far north of Pioneerville. Deposits that perhaps are in part as old as some of the terrace accumulations are spread out conelike from the mouths of the canyons of Canyon and Trail Creeks southwest of Placerville. These piedmont deposits extend nearly 3 miles from the base of Boise Ridge. Alluvium is being added to them at the present time.

Three fairly well-defined terraces remain in the Payette Canyon. The lowest or youngest occupies the main floor of the canyon and forms an interrupted strip about one-fourth of a mile wide. This deposit is comparatively thin and apparently represents a former graded flood plain left behind as the river carved a narrow rock-walled gorge 50 to 100 feet deep in the underlying granitic rock. The intermediate terrace is the most conspicuous and may be traced almost continuously on each side of the river. It rises as much as 200 feet above the younger graded flood plain. The deposits are as much as 200 feet thick and are in part made from still older deposits, remnants of which rise 50 to 100 feet above the level of the intermediate terrace. These terraces present steep embankments from the valley sides. All are even better displayed in Garden Valley. A fourth occurs about 600 feet above the river.

These older deposits are composed of fairly coarse sand and gravel and have much material of cobble size. Much of the sand and gravel is derived from the weathering and erosion of the granitic rock of the batholith, but a liberal admixture of "porphyry" pebbles and boulders is included. The "porphyry" admixture is especially abundant below the "porphyry belts" and may locally form the larger part of the gravelly material. Much of the gravel is auriferous, and the placers have been worked, except in the Payette Canyon. The gold content of the gravels is notably higher below the mineralized zones than above, and a large part of the placer production in Boise Basin has been obtained from deposits below the lodes. The sands and gravels are all of stream origin, and there is little difference in the size and character of the materials in the terraces at the different levels.

These deposits blanket all rocks of the district, except possibly the flows of Snake River basalt on lower Moore and Grimes Creeks. They rest unconformably on the lower Miocene beds at Idaho City and on Muddy Creek and are clearly younger than the disturbance that infaulted the Miocene beds against the Idaho batholith. There is probably some difference in the ages of gravels in different parts of the district, but all are obviously younger than or are related to the crustal disturbance of late Pliocene or early Pleistocene time. Gravel deposition has apparently been confined to Pleistocene valleys and to basins produced by the crustal disturbance at the close of the Tertiary. Some of the terraces at high levels probably record a pause in the general uplift of the region during the early part of the Pleistocene when the streams were permitted to widen their valleys and scatter their deposits over the valley floors. Some of the terraces along Moore and Grimes Creeks within Boise Basin are probably a reflection of the basin subsidence, the gravels accumulating near the center of the downwarp where the lessened stream velocities were unable to handle the load carried down over the steepened grades above. Some of the lowest terraces on the other hand, may have resulted from the damming action of the basalt on lower Moore and Grimes Creeks.[24] Deposits on the lower ridges at the east base of Boise Ridge probably reflect the faulting by which the ridge has been delineated from Boise Basin and the rest of the mountainous area (pp. 169–170) and are probably accumulations resulting from the abrupt change in stream grade at the base of the fault scarp. As the structural adjustments must have covered a considerable period of time and have been intermittent rather than continuous, recurrent acceleration and retardation of erosion have yielded deposits that probably range in age from early to late Quaternary.

YOUNGER ALLUVIUM (RECENT)

The younger alluvium is confined to present valley floors, and most of it is distributed along the streams in the lower, central parts of Boise Basin where the valleys are comparatively broad and shallow and the streams have lessened gradients. These deposits are most conspicuous along Moore Creek for several miles above and below Idaho City, along Grimes Creek between Old Centerville and New Centerville and for several miles above and below, and along Granite Creek and tributaries near Placerville. At these places the streams flow in broad gravel-filled channels of low gradient, whereas above and below them the valleys are narrow and the stream grades steep. For a mile and a half above and below Idaho City the gravel strip is about 1,000 feet wide and the deposits from 15 to 30 feet deep. The valley floor is nearly as wide and the gravel as deep for almost a mile up Elk Creek. The strip along Grimes Creek from a mile below New Centerville to several miles above Old Centerville is 500 to 1,000 feet wide and for a short distance below and above Pioneerville more than 500 feet wide. Granite Creek between New Centerville and Quartzburg has a gravel floor, much of it less than 200 feet wide, except near the mouth of the

[24] Lindgren, Waldemar, op. cit., p. 636.

Creek and its middle course south and west of Placerville, where the strip is as much as 1,000 feet wide.

Much of the younger alluvium consists of reworked terrace gravels, overlain in most places by a layer of placer tailings. The gravels were auriferous and were those first worked during early placer operations, but because of the low stream gradients and the depth of the gravel below water level a considerable part of them remained untouched until more recent years. Since 1935 dredges have been at work on the gravel flats along Moore, Grimes, and Granite Creeks, in part re-treating the tailings left by earlier dredges and draglines.

STRUCTURE

GENERAL FEATURES

The geologic structure of the district is complicated and difficult to decipher because of the uniform character of the Idaho batholith and the presence of but few reliable stratigraphic markers. The record of its complicated structural development, however, is reflected in complex dike and lode patterns, in widespread and intricate fracturing, in faulting, and in abnormal drainage patterns and other features of the topography. The area apparently has been one of marked structural weakness ever since the closing stages of consolidation of the Idaho batholith, and the rock of the batholith has been repeatedly disturbed by crustal movements of one kind or another. The main periods of crustal unrest are fairly easily distinguished, as each structural failure acted somewhat independently of others and each produced its own characteristic features influenced only in part by earlier deformation. It is convenient to treat the structural features in the order of origin and relate them to the specific orogenies.

Some of the structural features are associated with the batholith itself and are related to forces active during the closing stages of consolidation of the batholith. Such structures are reflected in an intricate system of fractures and a well-defined pattern of aplite and pegmatite dikes. Some of the structural features are apparently affiliated with early Tertiary (?) diastrophism and are reflected in the position and relation of the early Tertiary (?) dikes and stocks and in the pattern of the early Tertiary (?) veins and lodes. Some of the structural features are apparently associated with lower Miocene crustal unrest and are indicated by the presence of the "porphyry belt," by Miocene lode patterns, and by faults outside the "porphyry belts." Further disturbances in the Miocene are indicated by a post-Columbia River basalt uplift. The structural features associated with the Pliocene and Quaternary diastrophism are the products of faulting, warping, and intermittent uplift.

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STRUCTURAL FEATURES ASSOCIATED WITH THE IDAHO BATHOLITH (MESOZOIC)

FRACTURES

The fracturing is the most noticeable and widespread structural feature associated with the Idaho batholith. Fractures along which there has been no movement are conspicuous underground and wherever bedrock is exposed on the surface, but, as much of the region has a thick mantle of disintegrated rock and soil, the fracturing can be studied only in mine workings and on the steeper slopes west of Placerville and Quartzburg and around the north and east flanks of Boise Basin. Scattered exposures are also available in the Payette Canyon and in road cuts.

The fracturing associated with the consolidation of the batholith was not studied in detail, because the fractures have had less direct influence on the mineralization than the subsequent faulting. Over much of the district the most conspicuous and the most persistent fractures trend northwest and dip southwest. Those on Boise Ridge strike between N. 60° W., and, although the usual dip is 78° to 80° S., many dip as steeply north. Near Quartzburg and Placerville the trend is more nearly east, but elsewhere the strike is northwest to north-northwest, locally north of Idaho City N. 20°–30° W. The fracture set is in places reflected in the topography, particularly from Placerville to and beyond Pioneerville, where the short ridges of northwest alinement are in part an effect of erosion along fracture planes of the same trend. In most places the fractures are rather widely spaced, but in some localities they are so closely placed as to produce a fairly conspicuous sheeted structure. Some of the fracture planes have polished and slickensided surfaces, which indicate slippage under pressure, probably during later epochs of deformation. A less conspicuous fracture set trends slightly east of north at about right angles to the northwest set. A nearly horizontal set is also visible underground and in weathered outcrops.

There are also many other fractures, especially along the "porphyry belts." Some of these define prominent zones of sheeting in which most of the fractures trend east-northeast, locally northeast, and dip either northwest or southeast. They presumably are related to the shearing along the "porphyry belts" during the Tertiary and are, therefore, independent of the consolidation of the batholith.

APLITES AND PEGMATITES

The pegmatite dikes are widely distributed through the region, but most of the aplite dikes are confined to a belt that extends through the Gambrinus district in a northeasterly direction. The high concentration of dikes in that part of the district may be regarded as one of the striking geologic features of the region and at the same time one of the most conspicuous elements of its structure. Both aplite and pegmatite dikes strike west-northwest in the same direction as the most conspicuous fractures in the granitic rock. Most of them occupy reopened fractures, but the aplites in the Gambrinus district also appear to be alined by planes of shearing in part at least independent of the earlier fracturing. The fractures that served to guide the movement of the fluid aplite and pegmatite strike for the most part N. 80° W. to N. 50° W. and dip 40° to 60° SW. On Summit Flat the strike is more directly east and even slightly north of east.

The pattern of the dikes is such as to suggest that the controlling fractures have in large part been produced by deep-seated shearing, acting mainly in a northeasterly direction. Some of the west-northwesterly fractures were apparently reopened and new fractures or fissures of similar trend were produced. The aplite and pegmatite patterns are practically identical, and, as the pegmatites are somewhat younger than the aplite, the stresses active during the later stages of consolidation of the batholith must have been recurrent and have acted over a considerable period of time.

STRUCTURAL FEATURES ASSOCIATED WITH THE EARLY TERTIARY (?) DIASTROPHISM

RELATION OF THE EARLY TERTIARY (?) DIKES AND STOCKS

The dioritic dikes and stocks are largely confined to the major zone of structural weakness that extends through Quartzburg and Grimes Pass and contains most of the younger Miocene porphyry intrusives (pl. 14). The zone of weakness trends about N. 55° E., and the larger dioritic bodies extend in the same direction, but most of the smaller dikes strike obliquely across the zone in a west-northwest direction. The igneous intrusion was apparently guided by two sets of fractures (probably faults), a subordinate set of west-northwesterly fractures and a major set of northeasterly fractures parallel to the direction of the fracture zone. The larger bodies invaded the more central parts of the structural zone and were guided largely by the main set of northeasterly fractures, but those at the margin apparently preferred the minor west-northwesterly set. Some of the larger marginal bodies were influenced by both sets; they occupy the west-northwesterly set for the most part but change to the northeasterly set toward the center of the structural zone. Some of them, therefore, possess marked curvature.

The dike and stock patterns are significant and suggest a zone of weakness produced by horizontal shearing stresses acting in the form of a northeast-southwest couple, the batholith on the northwest side of the structural zone having been displaced to the northeast relative to that on the southeast side. The northeasterly fractures may be explained as shear fractures parallel to the direction of shearing and the oblique west-northwesterly fractures as tension fractures resulting from the elongation of the rock mass incidental to but related to the shearing. Differential transmission of stress through the massive rock of the batholith against the weak trough of sediments on the east, which was undergoing deformation by folding and faulting during the Laramide disturbance of late Cretaceous and early Tertiary time, is offered as the cause of the local shearing and the resulting fracture pattern.

RELATION OF THE EARLY TERTIARY (?) VEINS AND LODES

Most of the early Tertiary (?) veins and lodes, which also mark a complex set of fault and fracture zones, are concentrated along a belt that extends through the Gambrinus district from Grimes Creek near New Centerville east-northeastward to Sunset Peak and Summit Flat, but others are also scattered over the district, some on the north side of the "porphyry belt" of the Quartzburg-Grimes Pass area and others along a belt several miles south of Idaho City from Holcomb northeastward through the Cold Springs district to Moore Creek (pl. 28).

All the faults and fracture zones show a marked parallelism, and, except for a few at or near New Centerville, in the Cold Springs district, and on Summit Flat, strike west-northwest about parallel to the west-northwesterly set of diorite dikes and also about parallel to the west-northwesterly set of fractures. Most of them trend from about N. 80° W. to N. 60° W. and with few exceptions dip southwest at angles of from 40° to 60°. Many of the fault and fracture zones have been mineralized for a mile or more, and further continuation of the guiding fractures is commonly suggested in the alinement of gulches and ridges of similar trend.

The fault and fracture zones are generally marked by zones of broken rock from a few inches to as much as 40 feet in width. Some consist of single fractures, but most are accompanied by subsidiary parallel and also oblique fractures, and many occupy wide shattered zones made up of a multitude of fractures of diverse trend, or broad bands of sheeted granite, each sheet broken by minor fractures. Wherever these faults and fracture zones have been observed underground they show evidence of a reverse movement, indicated by vertical grooves and striations, by chatter marks and plucked hollows, or by the distribution of the ore in lenses along the flatter parts of the fissure or fracture zones. The faulting is probably of much wider extent than the vein and lode pattern indicates, for, unless mineralized, the fractures are not readily recognized in the massive rock of the batholith. In places the early fracturing in the batholithic rock has been considerably accentuated by slippage presumably related to the same stresses that caused the faulting.

The vein and lode pattern apparently has much in common with earlier structural patterns. The general west-northwest trend of the fissure and fracture zones not only conforms with the trend of most of the diorite dikes but also with the trend of the prominent northwest fractures and the aplite dikes. The mineralized fissues and fracture zones also show a more notable concentration in the area where aplite dikes are most abundant, and much of the faulting is in and along the aplite dikes. These relations suggest that the older trend lines and zones of weakness initiated during the later stages of consolidation of the batholith have had an important influence in directing a part of the later deformation and that much of the faulting associated with the later deformation was localized along the earlier lines of faulting and fracturing that had guided aplite intrusion.

STRUCTURAL FEATURES ASSOCIATED WITH THE LOWER MIOCENE DIASTROPHISM

"PORPHYRY BELTS"

The porphyry belt that extends through Quartzburg and Grimes Pass is the largest and most complex and, if projected, would probably join a zone of even greater deformation and intrusion along the Middle Fork of the Salmon River.[25] Other dike zones, one of which passes a short distance north of Idaho City and another several miles south, are much smaller and have been traced for only a few miles. Similar belts are numerous throughout the region. One has been described in some detail in the Pearl-Horseshoe Bend district[26] and another at Atlanta,[27] but none appear to equal the Quartzburg-Grimes Pass belt in size and persistence and in the abundance and complex relations of dikes and stocks.

Most of the dike zones are parallel and appear to have a staggered alinement, each trending N. 50°–60° E., in part overlapping on neighboring dike zones. The "porphyry belt" that extends through Quartzburg and Grimes Pass strikes about N. 55° E. and occupies perhaps the most pronounced zone of structural weakness of the region, the

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[25] Ross, C. P., Geology and ore deposits of the Casto quadrangle, Idaho: U. S. Geol. Survey Bull. 854, pp. 54–67, 77–82, 1934.

[26] Anderson, A. L., Geology of the Pearl-Horseshoe Bend gold belts, Idaho: Idaho Bur. Mines and Geology Pamph. 41, pp. 7–12, 1934.

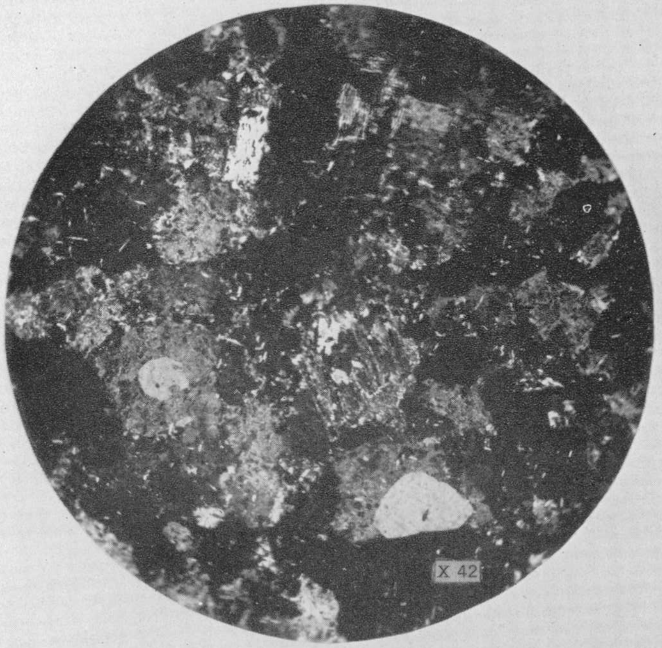
[27] Anderson, A. L., Geology and ore deposits of the Atlanta district, Elmore County, Idaho: Idaho Bur. Mines and Geology Pamph. 49, 1939.

one occupied by the dikes and stocks of the early Tertiary (?) diorite. The structural relations of the Miocene porphyries are, however, notably different from the relations of the early Tertiary (?) intrusives.

Although the "porphyry belts" trend about N. 55° E., the faults and fractures that guided the partly crystallized magmas strike for the most part across the belts at somewhat oblique angles but largely in a northeast direction (pl. 14). Only a few of the dikes trend west-northwest and conform with the older sets of fractures. Most of those guided by west-northwesterly fractures are on Boise Ridge and in areas about a mile south and about 1½ miles northeast of Quartzburg. The position of most of the others is apparently uninfluenced by the early Tertiary (?) system of fractures, and the dikes trend N. 70° E. and N. 10°–45° E. Dikes having a trend of N. 70° E. are particularly conspicuous between Quartzburg and Grimes Pass and for several miles east of Grimes Pass. In the same areas are also other dikes that are elongated N. 60° E. and locally many that strike N. 20°–45° E., particularly in and near Grimes Pass. A few are partly directed by one set of fractures and partly by another. Apparently only the larger stocks extend in the direction of the dike zone, but even the largest stock of quartz monzonite porphyry is deflected diagonally across the "porphyry belt" a short distance east of Grimes Pass. Most of the controlling fractures appear to have had steep dips, and most of the dikes dip steeply north to vertical, but a few at least dip steeply in the other direction.

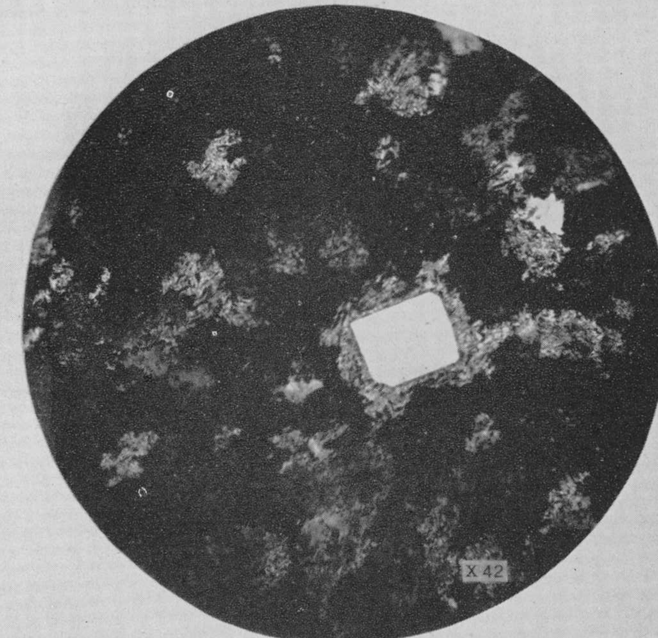
The close relation between faulting and igneous intrusion is clearly indicated by the crosscutting relationships of the dikes and stocks and is evidence that faulting was recurrent throughout the period of igneous activity. During the early stages of igneous intrusion there was a tendency for the magmas to occupy apparently reopened west-northwest fractures, as most of the dacite porphyry dikes are alined in that direction. The west-northwest set was also reopened at later times, particularly on Boise Ridge, and younger porphyritic quartz monzonitic and rhyolitic magmas were admitted. Later adjustments, however, tended to favor fractures of northeast bearing rather than northwest, except in the instances noted. The northeast fractures, however, were by no means confined to later adjustments, for dacitic dikes south of Quartzburg and for more than a mile to the northeast are alined along the east-northeast and even sharply north-northeast sets.

The "porphyry belt" appears to be in part a composite of several rather well-defined dike patterns, each differing somewhat in age from the others and each controlled by its own particular set of guiding



A. RHYOLITE PORPHYRY.

Oro Mine. Shows minute micropegmatitic intergrowths of quartz and orthoclase grouped to form ill-defined groundmass granules. A textural relationship common in many of the rhyolite porphyry dikes. Crossed nicols.

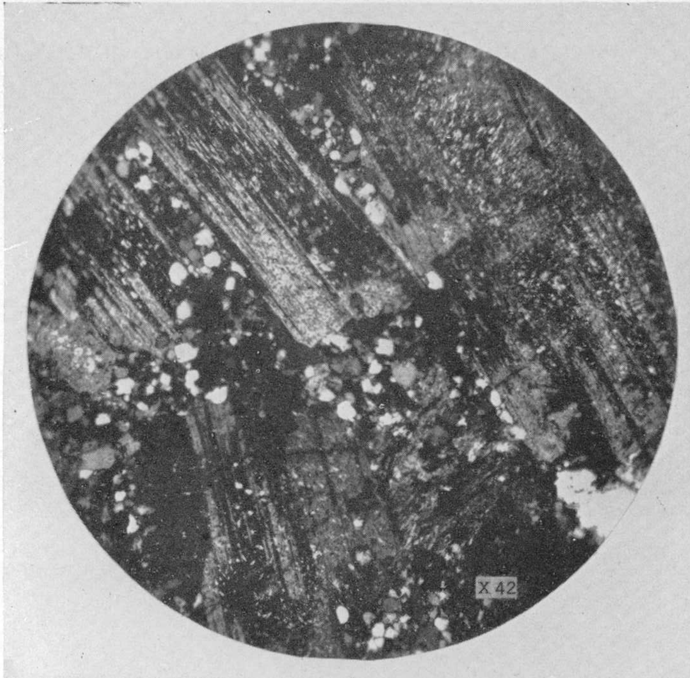


B. RHYOLITE.

Intrusive dike that has small widely scattered quartz phenocrysts bordered by reaction rims and contained in an abundant groundmass of micropoikilitic quartz with minute embedded orthoclase microlites. Crossed nicols.

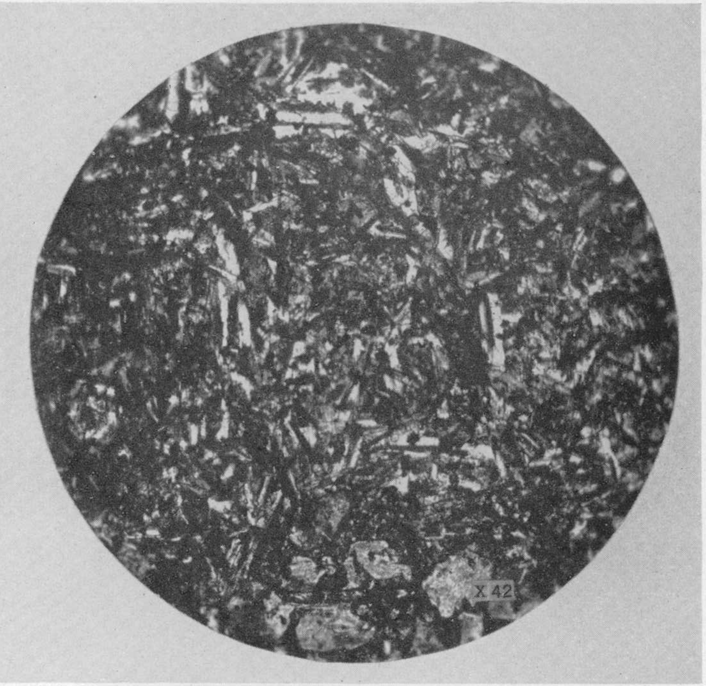
PHOTOMICROGRAPHS OF THIN SECTIONS OF THE PORPHYRITIC MIOCENE DIKES OF THE "PORPHYRY BELT" IN THE QUARTZBURG-GRIMES PASS AREA.

Show typical textural relationships.



A. GRANODIORITE PORPHYRY.

Grimes Creek-Payette divide near Branson's ranch. Shows sodic plagioclase phenocrysts in a scant groundmass mosaic of small anhedra of quartz and orthoclase. Crossed nicols.



B. LAMPROPHYRE.

Dike in Mountain Chief Mine. Dark minerals have largely altered to chlorite but the sodic plagioclase laths remain little altered. In most of the lamprophyric dikes calcite is also abundant and much of the feldspar is thoroughly altered. Crossed nicols.

PHOTOMICROGRAPHS OF THIN SECTIONS OF THE PORPHYRITIC MIOCENE DIKES OF THE "POPHYRY BELT" IN THE QUARTZBURG-GRIMES PASS AREA.

Show typical textural relationships.

fractures. The irregular concentration and distribution of rhyolite porphyry dikes clearly show the irregularity of the fracturing and the complex relations of the faults along the zone of weakness during crustal movements and adjustments. Presumably renewed fracturing along a zone diagonal to the main belt extending northeastward from a point south of Grimes Pass, to the Payette River permitted intrusion of the swarms of rhyolite dikes. Deforming stresses obviously were not everywhere equally and uniformily applied in either intensity or direction.

The amount and direction of displacement along the guiding faults cannot be closely determined because of the absence of markers in the massive rock of the batholith. The faulting that continued recurrently through the period of igneous activity apparently produced fractures of little displacement, for the earlier dikes are scarcely offset by the later. Such relations can only mean that the rock was intricately fractured rather than broken by faults of marked displacement.

The fracture pattern is too complex to be explained by horizontal shearing stresses, for only a few of the porphyry dikes have the requisite strike to fit tensional fractures incidental to horizontal shearing. Such dikes probably occupy reopened fractures originally produced by the early Tertiary (?) deformation. Most of the guiding fractures are, on the contrary, alined in the general direction of the "porphyry belt," and the pattern does not conform clearly with any systematized shearing.

The close association of faulting and igneous activity suggests, on the other hand, a dependence of faulting on igneous activity.

Perhaps the fault (dike) pattern might be explained by the upthrust and collapse of a broad dome produced by intrusion of magma in the manner that Ross postulates for the related and perhaps coextensive dike zone in the Casto quadrangle.[28] There he points out that intrusion of Miocene pink granite has apparently arched Tertiary volcanic strata into a broad dome elongated northeast, and that collapse of the dome has produced longitudinal and transverse faults along which porphyritic magmas were injected into the openings caused by the faulting. The relations along the "porphyry belt" of the Quartzburg-Grimes Pass area suggest that the Miocene magma has taken advantage of an earlier zone of weakness and that the porphyritic injections were guided by openings produced by collapse of the rock mass above the underlying magma reservoir. In this way the general alinement of the "porphyry belt" would be localized by the earlier zone of structural weakness; but the dike pattern would be a consequence of quite a different set of forces.

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[28] Ross, C. P., op. cit. (Bull. 854), pp. 81–83.

LODE PATTERNS

The pattern of the mineralized fissure and fracture zones of the "porphyry belt" is much like the dike patterns. The strikes of the largest and most persistent of the mineralized fissures and fracture zones approach but rarely coincide with the strike of the belt as a whole: instead the fractures tend to cross the belt, and, like most of the dikes, are directed in the northeast quadrant. The most conspicuous of these fractures strike about N. 70° E. and commonly dip 60°–80° S., but some dip vertically and steeply north, and some reverse their direction of dip with depth. The N. 70° E. set of mineralized fissure and fracture zones is prominent throughout the "porphyry belt," but another set equally prominent in the Grimes Pass area strikes N. 10°–20° E. and dips steeply southeast. Fracture zones of other trend are in general subordinate and are less regular and more variable. Most of them strike between N. 30° E. and N. 60° E., the more persistent ones about N. 35° E. Some of these dip northwest, but more of them dip southeast at angles of 70° to 90°. Most of the subordinate fracture sets are confined to the Quartzburg area. Some of the productive lodes in the Gold Hill mine at Quartzburg were actually mineralized shear zones, the ore occurring in tension fractures trending N. 30°–60° E., arranged oblique to the direction of shearing.

The mineralized fissure and fracture zones are of variable lengths, from a few feet in the subordinate sets to more than 3,500 feet in the more prominent ones. In places the walls are smooth and persistent for short intervals, but for the most part the rock has been so softened by alteration that the fracture zones are indistinctly bounded and are most readily traced by noting the distribution of altered rock and gouge.

The displacements along most, if not all the fissures and fracture zones, have apparently been of small magnitude, measurable in inches or a few feet—hardly enough to cause appreciable offset in encountered dikes. Many apparent offsets in the dikes may result from original irregularities in shape rather than from subsequent fracturing. Wherever offsets occur they appear to be largely in a horizontal direction. Grooves and striations in gouge on the bordering fracture surfaces also show the nearly horizontal direction of movement, and the grooves and striations commonly dip about 25° to 35° SW. The evidence is clear that the wall on the west or north side of the fissure or fracture zone has moved toward the northeast relative to the wall on the other side, a direction of movement also revealed further by the position of tension or gash fractures along well-defined zones of shearing.

Most of the fracturing preceded, and, in different ways, controlled the ore deposition, but some adjustments continued concurrent with deposition, and some continued even after the lodes had been formed. The postmineral movements have nowhere been large enough to introduce any complication in the search for ore. These later adjustments also provided for the intrusion of lamprophyric dikes after the ore had been deposited, and some adjustments continued weakly even after dike intrusion.

The distribution of the lodes along the "porphyry belts" indicates a close relationship between dike intrusion and ore deposition and implies that the fractures that guided the ore-forming solutions had resulted from recurrent adjustments along the major zones of crustal weakness that had earlier facilitated the intrusion of the porphyritic dikes. As the mineralized fractures were formed during the closing stages of igneous activity, even before dike intrusion had ceased, and, as the fracture pattern so closely accords with the dike pattern, there can be little doubt that the mineralized fracture pattern and the dike pattern were controlled by similar structural conditions. During the time the mineralized fractures were formed, however, the active stresses were shearing and were applied obliquely toward the surface at a rather low angle. Such obliquely directed shearing stresses as existed at the time of ore deposition may have acted earlier to produce the openings for the diagonally directed swarms of rhyolite porphyry and rhyolite dikes. Stresses of this kind might have been related to magmatic adjustments during a late stage of igneous activity, or to regionally directed stresses.

FAULTS OUTSIDE THE "PORPHYRY BELTS"

Fractures unfilled by igneous rock or ore are in general difficult to recognize but are apparently present in other parts of the district and are readily recognized in the Idaho City area, where blocks of lower Miocene strata are faulted against the granite rock of the batholith. That the faults are not confined to the "porhyry belts" and the Idaho City area but are widespread is suggested further in drainage alinements, which in so many places accord with the directions of the observed Miocene trend lines.

The fault pattern at Idaho City is not unlike the structural pattern of the "porphyry belts." The block of lower Miocene strata is separated from the batholith by normal faults—on the north and south by faults that strike about N. 70° E. and on the east and west by faults that strike about N. 40° E. These faults may be traced by the straight, sharp contacts between beds and the granitic rock and by the linear alinement of saddle and gulches, except near Warm Springs, 2 miles southwest of Idaho City, where silica deposited by thermal springs ascending along the fault plane has cemented the sandstone and has made it more resistant to erosion than the batholitic rock alongside. The beds bounded by these fault planes are inclined to the west-northwest at angles as steep as 15°. The displacement along the fault planes cannot be accurately estimated but has been sufficient to preserve a thickness of about 850 feet of the lower Miocene beds. Inclined beds of similar rock in other parts of the district, as along Muddy Creek within the "porphyry belt" of the Quartzburg-Grimes Pass area, might also have been similarly faulted, but as the exposure on Muddy Creek is almost entirely concealed beneath terrace and younger gravels its attitude and relation to fault planes and dikes cannot be determined. The fact that the fault pattern at Idaho City conforms with the fracture pattern of the "porphyry belts" and that the faults are normal may be supporting evidence that the general Miocene structure is one of collapse.

Further evidence of the regional distribution of the faults is suggested by the alinement of Moore and Elk Creeks. The course of Moore Creek across the basin parallels the trend of the "porphyry belts" and conforms with the strike of the northeast faults that block out the lake beds and volcanics at Idaho City. Elk Creek is similarly alined, and it is probable that other streams and intervening ridges of northeast trend have also been influenced by mid-Tertiary faults which facilitated stream erosion.

PRE-COLUMBIA RIVER BASALT UNCONFORMITY

The unconformity separating the Columbia River basalt from the older rocks must also be regarded as an important structural feature, for it records the large amount of erosion that took place after the lower Miocene disturbance. Wherever the basalt is observed in the west part of the basin and on the west slope of Boise Ridge it rests on a surface that was practically level, although now it and the basalt above are locally tilted at moderate angles, principlly to the west.[29] These occurrences, together with the larger areas that have been uncovered by erosion of the overlying basalt, trace out an old erosion surface, locally a peneplain, that truncates the granitic rock, dike zones, and faulted lake beds. This unconformity not only assists in the interpretation and timing of the lower Miocene disturbance but is also helpful in deciphering later folding, faulting, and uplift.

[29] Kirkham, V. R. D., Erosion surfaces in southwestern Idaho: Jour. Geology, vol. 38, No. 7, pp. 652–656, 1930.

POST-COLUMBIA RIVER BASALT UPLIFT

Moderate uplift to the north of the district where the succession of Miocene basalt extrusions ended is suggested in the drainage patterns (pl. 15) and the maturely dissected appearance of the upland surface. As pointed out in an earlier section, the main streams cross the region in a westerly direction, but each of them has tributaries reaching far to the north; those of the Boise River extend to the very brink of the Payette Canyon, and Grimes Creek even flows partly within its southern slope.[30] Tributaries of the Payette River likewise extend northward to the Salmon River. The unsymmetrical drainage patterns are evidence that uplift occurred along an approximate east-west axis beyond the present heads of the northward-reaching tributaries of the South Fork of the Payette River and that from this axis the region sloped to the south.

This old surface must once have been notably flat. In the eastern part of the district it was a surface beveled by erosion and in the western part a basaltic plain. Its inclination caused the tributaries to reach up the tilted slope toward the axis of uplift and to flow nearly at right angles to the trunk streams which maintained their courses parallel to the uplift. The amount of uplift was apparently not great but sufficient to cause the streams to cut several hundred feet into the tilted granitic and basaltic surface and to carve it into a system of low hills and wide, flat-topped ridges so characteristic of the upland surface (pl. 16).

The exact time of this differential uplift cannot be precisely determined, except that it took place after the middle or upper Miocene basaltic extrusions and before the crustal disturbance that is believed to have begun at the close of the Tertiary. It is possible that the uplift came at the close of the Miocene and created the erosional unconformity that separates the Payette formation (middle or upper Miocene) from the Idaho formation (Pliocene and Pleistocene) farther west.[31]

STRUCTURAL FEATURES ASSOCIATED WITH THE LATE PLIOCENE AND QUATERNARY DIASTROPHISM

FAULTS

Several faults of fairly recent date are present in the district, and one which lies along the east base of Boise Ridge and at the base of the North Fork Range, the continuation of Boise Ridge north of the Payette River, is among the most prominent structural features of

[30] Anderson, A. L., The valley of Grimes Creek in the Payette Canyon, Idaho: Jour. Geology, vol. 43, No. 6, pp. 618–626, 1935.
[31] Kirkham, V. R. D., op. cit., pp. 656–659.

the west-central part of the State.[32] Its partly dissected scarp forms the east slope of the two tilted block mountains, Boise Ridge and North Fork Range, and delineates them on the east from two structural basins, Boise Basin and Garden Valley. The scarp has been traced the entire length of the two mountains to Round Valley, a distance of about 45 miles, and may continue along the west side of Round and Long Valleys to and beyond McCall for another 45 miles. Its general course is nearly north, but the fault trace is considerably warped. The Boise Ridge scarp is sharply incised by short canyons occupied by streams with steepened gradients, and the tilted upper surface of the tilted mountain block is marked by longer valleys. The base of the scarp is flanked locally by alluvial cones similar to those of the Basin and Range scarps. These cones extend from the mouths of the canyons of Canyon and Trail Creeks southwest and west of Placerville.

The faulting has displaced well-defined datum planes, namely, the summit erosion surface, flows of Columbia River basalt, and the "porphyry belt" of the Quartzburg-Grimes Pass area. The summit erosion surface not only appears at the crest of Boise Ridge and on its west slope but also lies at the base of the scarp and forms the floor and low ridges of Boise Basin and the tilted slope bordering the east side of Garden Valley. Remnant flows of the Columbia River basalt, which cap the crest of the ridge, also appear at the base of the scarp, and the "porphyry belt" itself shows an abrupt dislocation along the line of the fault (see pl. 14). As the basalt flows and the summit erosion surface appear on both the crest of the Boise Ridge and at its base, the fault is normal, the mountain and basin segment on the east depressed relative to the higher block on the west. The displacement has been variable, and west of Placerville its vertical component has not been less than 2,000 feet, but on the divide between Granite Creek and Alder Creek the vertical component of displacement has been about 1,200 feet, and along the west border of Garden Valley it has been about 3,000 feet. The dislocation along the "porphyry belt" also suggests that the displacement may have had a considerable horizontal component, perhaps as much as 2 miles (see pl. 14).

Another fault of similar kind lies along the other margin of the district, at the east base of Sunset and Pilot Peaks, and may be traced from the Boise River northward across the South Fork of the Payette River and along the west side of Deadwood River and Deadwood Basin and for an undetermined distance beyond. It likewise reveals a displaced upland surface and a prominent scarp and has caused some

[32] Anderson, A. L., A preliminary report on recent block faulting in Idaho: Northwest Sci., vol. 8, pp. 23, 1932.

minor drainage adjustments. The fault is normal, and the higher block is on the west. The displacement is about 2,000 feet.

Still another fault lies along the northeast flank of Boise Basin and extends in part across and north of the Gambrinus district. This fault, unlike the others, strikes northwest, and its scarp, as much as 500 feet high, faces the southwest. The fault is not large, and its reflection in the topography cannot be traced for more than 6 miles. Smaller faults in other parts of Boise Basin are suggested by linear topographic features, including alined saddles and stream courses and low scarps, but these cannot be examined critically without detailed mapping.

The youngest rocks involved in the faulting appears to be those of the Columbia River basalt flows. A drainage system along the present lines had been established, and the present summit topography was carved out of the basalt and older rocks before the faulting. The scarp is in general little dissected; therefore the faulting probably took place between the late Pliocene and the present. It is probably largely Pleistocene.

WARPS

Moderate crustal warping appears to have accompanied the faulting and uplift and has produced the marked topographic depression, Boise Basin, extending east-southeast from the Boise Ridge scarp west of Placerville to and beyond Idaho City. The warp is as much as 12 miles across, but the apparent subsidence has not been uniform and the basin floor is irregularly depressed, the lowest parts occurring along Grimes Creek at New Centerville and Moore Creek at Idaho City. The warping has changed the altitude of the summit erosion surface from 8,000 feet on the north side of the basin to 4,200 feet at Idaho City and 5,100 feet on the broad divide between Idaho City and New Centerville. The broad sweeping curve of the warp is most strikingly displayed on the broad divide. East of Idaho City, between Thorn Creek and Sunset Peaks, the warping has not been so marked but may be recognized and the axis traced far to the east beyond the district.

The warping has been as recent as the block faulting, and adjustments to it are clearly shown in the drainage. Erosion on the northeast flank has been accelerated, and the streams on it have carved deep, narrow valleys, which decrease in size toward the center of the basin where deposition rather than erosion has prevailed. On crossing the southwest flank and rim of the basin both Grimes and Moore Creeks have been forced to carve deep narrow valleys more or less similar to those on the northeast side.

The cause of the warping is not apparent, but it is probably linked with the regional uplift. The axis of the warp is parallel to the margin of the Snake River Plain, about 25 miles south-southwest, and is separated from the plain by a broad arch, or upwarp. The structure of the Snake River Plain has been explained as a broad downwarp.[33] There may be a close relation between the Snake River downwarp and the markedly subordinate warp of Boise Basin, but it is also possible that Boise Basin may have been produced by differential upwarping, its flanks being parts of upwarps rather than downwarps. Differential upwarp would perhaps be a more integral part of regional uplift than would downwarping.

UPLIFT

While faulting and warping were under way regional uplift was also in progress, but the total movement due to uplift, relative to that due to warping and faulting, cannot be readily determined. The aggregate of all movement must have been several thousand feet, as the old erosion surface appears at levels above 8,000 feet as well as at altitudes of 3,000 feet, whereas the canyon of the South Fork of the Payette River locally has been eroded to depths exceeding 3,000 feet. The entire canyon system has apparently been evolved in response to the general uplift, but the canyon depths have been modified in part by faulting and warping.

The regional uplift was not steady but intermittent, with at least three pauses, each reflected by valley widening and preserved in dissected rock terraces. The latest movement has been very recent and may still be in progress. As a result of this movement the major streams are now rapidly deepening their channels. The main Boise and Payette Rivers occupy steep-walled inner gorges 50 to 100 feet deep in the floors of wider valley bottoms. This latest movement is independent of the faulting and is reflected in general rejuvenation in drainage in all parts of the region.

HISTORICAL GEOLOGY

The geologic record goes back no farther than the intrusion of the Idaho batholith in late Jurassic or early Cretaceous time, as all rocks older than the granite rock of the batholith have been removed by long-continued erosion. Deformed strata of Permian, Triassic, and Jurassic age[34] are exposed along the western margin of the State,

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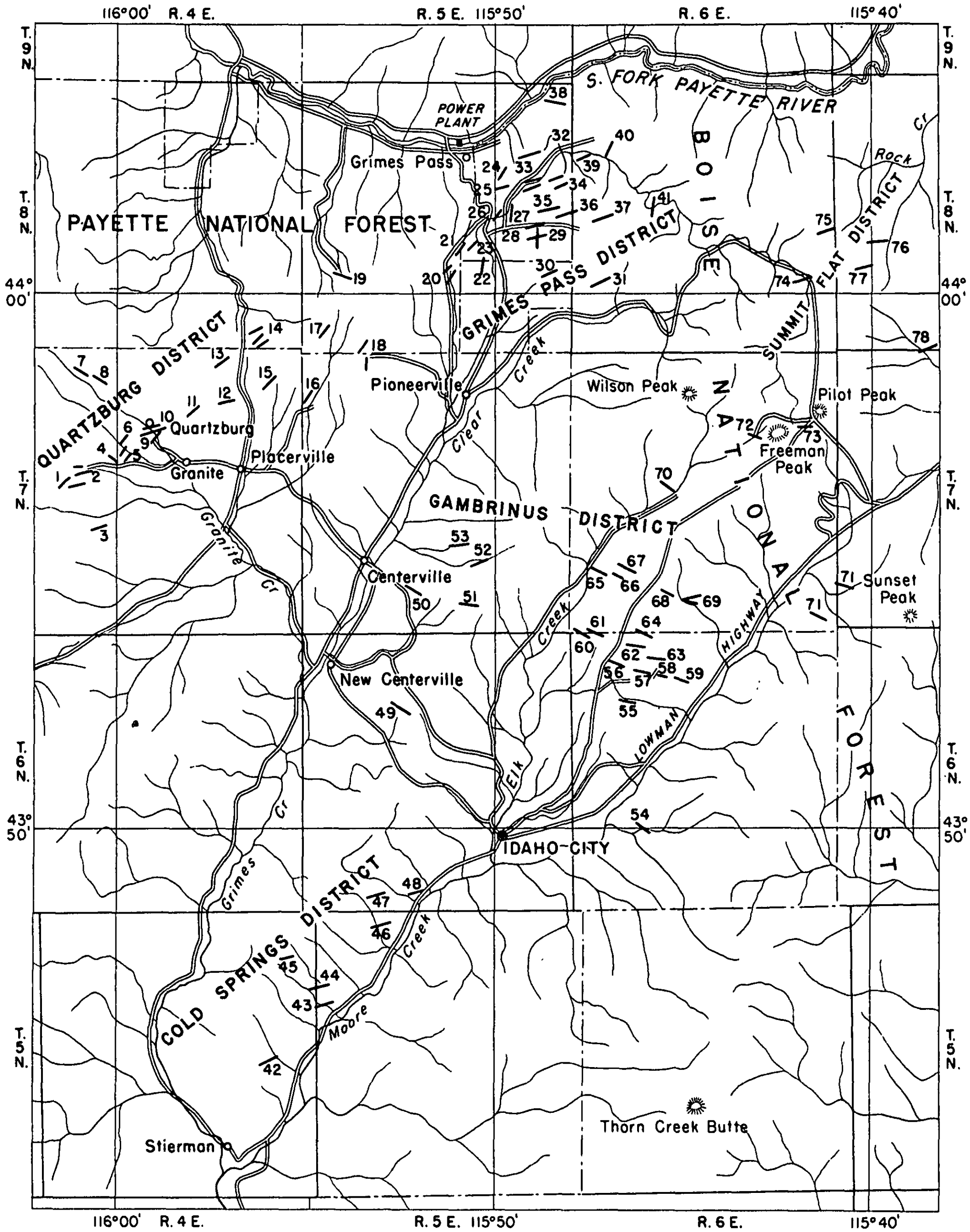
[33] Kirkham, V. R. D., Snake River downwarp: Jour. Geology, vol. 39, No. 5, pp. 456–482, 1931.

[34] Livingston, D. C., A major overthrust in western Idaho and northeastern Oregon: Northwest Sci., vol. 6, No. 2, pp. 31–36, 1932.



1. Mountain Chief
2. Belshazzar
3. Crown Point
4. Newburg
5. Silver Star
6. Mayflower
7. Blue Rock
8. Silver Hill
9. Gold Hill
10. Last Chance
11. Coin Bond
12. Hartford
13. Black Bear
14. Gold Dollar
15. Silver Bell
16. Saunders
17. Mineral Hill
18. Buckskin
19. Grandview
20. Missouri
21. J. S.
22. Oro
23. Mountain Queen
24. Silver Gem
25. Missing Link
26. Bruser
27. Golden Age
28. Smuggler
29. St. Clair
30. Comeback
31. Clear Creek
32. Coon Dog
33. Independence
34. Grimes Homestake
35. Mohawk
36. Enterprise
37. Overlook
38. K. C.
39. Gray Eagle
40. Branson
41. Black Jack
42. McKinley
43. K. M.
44. Big Gulch
45. Bert Day
46. Boomer
47. Blue Bird
48. Mud Springs
49. Mattie
50. Twin Sister
51. Summit
52. Big Ben
53. Cash Register
54. Antimony Lode
55. Blaine
56. Illinois
57. Lucky Boy
58. Mascot
59. Eureka
60. Texida
61. Cleveland
62. Orphan
63. Accident
64. Gambrinus
65. Boulder
66. MacCarthy
67. Forest King
68. Subrosa
69. Washington
70. Elkhorn
71. Hayfork
72. Red Lode
73. Smiths
74. Mammoth
75. Slopers
76. Golden Cycle
77. Golden Chariot
78. Edna

Base from S. M. Ballard, Idaho Bur. Mines and Geology Bull. 9, pl. 4, 1924.
Additions and corrections by A. L. Anderson, 1933.

1 0 10 Miles

INDEX MAP SHOWING THE DISTRIBUTION OF THE EARLY TERTIARY(?) AND MIOCENE LODES AND VEINS, BOISE BASIN, IDAHO and at least the oldest of these has been invaded by part of the batholith. Xenoliths and isolated roof pendants east of Yellow Pine, Valley County,[35] and near Casto, Custer County,[36] consist in part of rocks whose lithologic character suggests correlation with beds to the southeast believed to be mainly of Ordovician age. In the same region are also other roof pendants and other remnants believed to belong to the Belt series (pre-Cambrian).[37] Some of these older rocks must have been present in the Boise Basin region when the batholith was emplaced. As the area now underlain by the granitic rock in the central part of the State appears to have been a persistent positive element in the earth's crust, which has, for the most part, been above sea level since the end of the pre-Cambrian,[38] the strata were probably largely pre-Cambrian. Whatever their character and age, they must have been greatly disturbed during the late Jurassic (?) orogeny and highly altered by the invading magma.

The late Jurassic (?) disturbance probably caused marked elevation by early Cretaceous time, and the character of the Lower Cretaceous (?) beds in southeastern Idaho indicates that these mountains were being vigorously eroded.[39] Sedimentation continued in southeastern Idaho well into the Cretaceous, when the region was subjected to mountain-building stresses and the strata in the Laramide trough to the east were folded, overturned, and overthrust.[40] Stresses responsible for the folding of the strata in the trough at the close of the Mesozoic were from the west and were in part transmitted through the massive rock of the Idaho batholith. The batholith acted perhaps as a buttress, but, as the stresses were probably not transmitted uniformly against the trough, the batholith was itself sheared and complexly fractured along certain transverse zones which served to guide and localize the intrusion of dioritic magmas during the early part of the Tertiary and still later to influence early Miocene diastrophism and igneous activity.

The region must have been considerably eroded at the beginning of the Laramide disturbance at the close of the Mesozoic but probably stood high at the close of deformation. By Oligocene time the mountains produced by the disturbance had been greatly reduced and the batholithic rocks not only exposed but considerably eroded. Erosion

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[35] Schrader, F. C., and Ross, C. P., Antimony and quicksilver deposits in the Yellow Pine district, Idaho: U. S. Geol. Survey Bull. 780, pp. 140–142, 1926.

[36] Ross, C. P., op. cit. (Bull. 854), p. 28.

[37] Ross, C. P., op. cit. (Bull. 854), pp. 15–26.

[38] Ross, C. P., Correlation and interpretation of Paleozoic stratigraphy in south-central Idaho: Geol. Soc. America Bull., vol. 45, pp. 996–1000, 1934.

[39] Mansfield, G. R., Geography, geology, and mineral resources of part of southeastern Idaho: U. S. Geol. Survey Prof. Paper 152, p. 194, 1927.

[40] Idem, pp. 198–199.

was then greatly hampered by volcanic activity, and much of south-central Idaho was buried beneath a blanket of lava and tuff of silicic and intermediate composition.[41] This volcanism continued into early Miocene time and, locally, as in Boise Basin, lake beds also accumulated in and above the volcanic strata.

The accumulation of volcanics and lake beds was interrupted in the early Micocene time by a marked crustal disturbance. Magma was intruded along transverse zones of weakness initiated perhaps by Laramide shearing. The intrusion of the magma along these older zones of weakness probably caused doming of the strata above. Collapse of the dome during intrusion and later probably produced longitudinal and oblique faults, which facilitated the injection of the porphyritic magmas from the deeperseated parent magma and later the movement of ore-forming solutions.

Domed and fault-block mountains were probably produced during the early Miocene disturbance, but erosion soon gained the ascendency, and by the middle or later part of the Miocene the region had been greatly reduced, locally peneplaned. During this time the blanket of lower Miocene strata was stripped away, except where infaulted against the batholith, and the "porphyry belts" were beveled. Erosion was then again hampered by further volcanic activity, this time by flows of basalt that spread eastward into the district, burying the older topography and changing part of the region to a basaltic plateau. The streams continued their reduction of the higher land to the east, and by the close of the Miocene the district was a part of a nearly featureless plain, in part constructional, built up by the basalt, in part erosional by reduction of the older landscape. Waste from the erosion of the higher lands at this time was carried westward by the streams and deposited as lake beds between flows of basalt, probably giving rise to the widespread Payette formation.[42]

Apparently as the basaltic extrusions died away near the close of the Miocene, the igneous activity was succeeded by a mild crustal disturbance involving differential uplift to the north. The low, essentially flat surface that characterized the general region then became a tilted plain, sloping gently to the south. The differential uplift renewed the cutting power of the streams and produced marked changes in the drainage patterns. The ancestral Boise and Payette Rivers continued to flow in a westerly direction as at present, parallel to the axis of uplift, but the tributaries on the north sides of the main Boise

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[41] Ross, C. P., Ore deposits in Tertiary lava in the Salmon River Mountains, Idaho: Idaho Bur. Mines and Geology Pamph. 25, pp. 7–8, 1927.

[42] Kirkham, V. R. D., Revision of the Payette and Idaho formations: Jour. Geology, vol. 39, No. 3, p. 234, 1931; Igneous geology of southwestern Idaho: Jour. Geology, vol. 39, No. 6, pp. 570–578, 1931.

and Payette Rivers had the advantage of increased gradients and rapidly cut back far up the slope. These streams, favored by slope, successfully competed against the tributaries of greatly reduced gradients that joined the trunk streams from the south and that had to flow against the slope to maintain their courses. Capture of the drainage basins of the handicapped streams by those favored by surface slope was imminent, and in this way the tributaries of the Boise River robbed the Payette River of most of its drainage area, except to the north, and those joining the Payette from the north worked far up the slope against the headwater of the Salmon River. A very one-sided drainage pattern was thereby evolved. During these adjustments one of the tributaries of the Boise River captured Grimes Creek near where it entered the Payette River and has maintained this capture to the present day.

Adjustment of the drainage to the tilted slope probably required much of Pliocene time for its completion. During this interval the tilted surface was carved into a system of low hills and flat-topped ridges separated by relatively shallow valleys, in places as much as several hundred feet deep. The products of erosion were carried westward and probably deposited on the somewhat eroded Payette formation and basalt as beds of the Idaho formation.[43] In the later part of the Pliocene the region stood low, and its surface resembled that of the present upland areas.

The region was then subjected to another crustal disturbance beginning at the close of the Pliocene epoch and continuing intermittently to the present day. Elongated segments of the crust were broken by faults and the segments tilted into block mountains, of which Boise Ridge stands as a conspicuous example. The region was also differentially warped, and such intermontane depressions as Boise Basin and Garden Valley were produced partly as a result of faulting and partly as a consequence of differential uplift. The region as a whole was elevated to the levels at which it stands today.

The general uplift greatly increased the cutting power of the main streams, and the elevated erosion surface was deeply and intricately dissected. The South Fork of the Payette River rapidly deepened its channel, particularly in the high upland east of Garden Valley and across the mountain block to the west. Grimes Creek, because of its distant connection with the Boise River, was not so materially affected by the uplift and continued on as before; but the Payette, in consequence of its steepened gradient produced by the tilting of the faulted

[43] Kirkham, V. R. D., Revision of the Payette and Idaho formations; Jour. Geology, vol. 39, No. 3, p. 201, 1931; Erosion surfaces in southwestern Idaho: Jour. Geology, vol. 38, No. 7, pp. 656-659, 1930.

crustal segment against the base of Boise Ridge west of Garden Valley, carved its canyon far below the level of Grimes Creek and at the same time undercut and moved back the divide, separating the two until the creek now appears to flow for nearly 3 miles in a narrow, one-sided trough high on the canyon wall.[44]

The warping of the low, hilly surface in Boise Basin steepened the gradients of the streams flowing down the flanks of the basin, causing them to erode deep valleys and canyons and to carve canyons of even greater depth in order to maintain their courses across the brim on the opposite side. Conditions, locally, as in Boise Basin, favored the accumulation of valuable placers but did not promote deep weathering, and most of the weathered material previously formed during the Pliocene, when erosion was not nearly so active, was eroded. After Moore Creek and lower Grimes Creek had carved their canyons nearly to their present depths, basalt poured out from a vent just above the junction of the two streams and flowed southward, eventually reaching and spreading over the margin of the Snake River Plain. The district escaped the Pleistocene glaciation, but degradation was interrupted several times, probably because glaciers at the headwaters of the main rivers freed so much material that the streams could not carry all of it away and alluvium accumulated along the valley bottoms, later to be partly removed as the stream load returned to normal. The mountains thus carved out of the uplifted, faulted, and warped Tertiary erosion surface are now in the process of being worn away.

ORE DEPOSITS

HISTORICAL SKETCH

Lode mining in Boise Basin began within a year after the discovery of the famous placers in 1862. Many of the lode deposits were uncovered during the placer operations and, as soon as the placer rush had subsided, were worked. One of them, the Gold Hill, located in 1863, was worked almost continuously from its discovery until 1938. By 1867 and 1868 at least 10 stamp mills were treating the free-milling ores, but after a period of activity and considerable production the exhaustion of the ore amenable to stamp amalgamation caused many plants to be dismantled. Interest in the lode deposits then dwindled, and little mining was carried on during the seventies and eighties, except at the Gold Hill, but as placer production declined in the nineties interest in the lodes was revived, partly because of many new discoveries made about that time and partly because of improvements in milling methods.

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[44] Anderson, A. L., The valley of Grimes Creek in the Payette Canyon, Idaho: Jour. Geology, vol. 43, No. 6, pp. 619–629, 1935.

Since the nineties the activity in lode mining has been more or less sporadic, particularly in the Gambrinus and Grimes Pass districts. Few attempts were made to reopen the mines in the Gambrinus district after the nineties until rather recently, but the Grimes Pass area was active intermittently, especially after 1915 when the Diana Mines Co. acquired control of most of the claims at Grimes Pass. This company suspended operations 2 years later, but work was carried on in the district by the Golden Age Mining Co. until 1928. The Comeback mine, discovered in 1924, became 4 years later one of the most active and productive mines in Boise Basin. Other properties in the Grimes Pass district, particularly the Missouri and the Enterprise, were also active. Mining in the Quartzburg region had been less sporadic than in the other districts, largely because of the almost continuous work at the Gold Hill, Belshazzar, and Mountain Chief mines. The Belshazzar and Mountain Chief mines had been discovered about 1870, and work at the Belshazzar was rewarded in 1926 by the discovery of a rich shoot from which a large production was made during the next 5 years.

Increased activity at the Gold Hill mine in the late 1920's and the important production at Belshazzar mine about the same time did much to revive interest in lode mining throughout Boise Basin. Mining received a severe blow in 1931, however, when a forest fire swept along the "porphyry belt" through Quartzburg and Grimes Pass and destroyed numerous surface plants, including the surface plant of the Gold Hill mine, and much of Quartzburg. Interest in the lode deposits lagged for a time, although some work continued at the Mountain Chief, Mayflower, and Comeback mines, whose plants had not been destroyed in the fire. Another mining "boom" did not get underway until 1935, when probably more attention was given the lode mines than at any time since the early days. In the meantime the mine plant and mill of the Gold Hill mine had been rebuilt, and production had been resumed. The Mayflower mine after suspension of operations in 1932 also renewed work. The Silver Gem mine at Grimes Pass was also active for a while, and the Comeback mine continued operation with little interruption. Interest in the Gambrinus district was also revived, and exploratory work was carried on at several of the old properties that had been inactive since the nineties.

Another episode in lode mining was ended in 1938 when the Gold Hill mine, one of the oldest and largest producing gold mines in the State, suspended operations and dismantled its plant. The Cloverleaf Mining Cos. in the Gambrinus district also suspended operations because of failure to find ore of commercial grade, and work at the

Comeback mine near Grimes Pass was virtually at a standstill because of exhaustion of all known ore bodies. The Golden Cycle mine, on Rock Creek east of Summit Flat, which had uncovered some rich ore the previous year, continued active, and work was carried on at the old Grandview mine, in the Payette Canyon, about 2 miles west of Grimes Pass. Much active exploration was also done by Grimes Homestake Gold Mines Consolidated on the Coon Dog and adjoining claims near Grimes Pass. With suspension of work at the Gold Hill mine the adjoining Mayflower mine became Boise Basin's largest and most productive mine.

PRODUCTION

The amount of gold and silver mined in the Boise Basin has long been a subject of dispute, for records of output in the early days are incomplete. The accompanying tables, however, are believed to afford the most reliable record, as they have been compiled by C. N. Gerry, who has given much time to the history of mining in Idaho and has consulted reports of the Director of the Mint, old smelter records, and other sources of information. In the table of annual production the figures for 1863 to 1884 inclusive are identical with those given by Lindgren in 1898.[45] The figures for 1905 and subsequent years are based on annual canvasses of the lode and placer office by Mr. Gerry through the Salt Lake City office of the Geological Survey (1905–24) and the Bureau of Mines (1925–40). Placer gold from the beginning of mining has amounted to nearly three-fourths of the total output of gold.

Production of gold in Boise County, Idaho (chiefly Boise Basin region), 1863–1940

[Compiled by C. N. Gerry, Bureau of Mines, U. S. Department of the Interior. Production as given is for metal recovered, stated in whole ounces. Separate placer production, 1863–1900, is estimated]

Year	Lode gold		Placer gold		Total gold	
	Fine ounces	Value	Fine ounces	Value	Fine ounces	Value
1863–70	151, 414	$3, 130, 000	1, 362, 724	$28, 170, 000	1, 514, 138	$31, 300, 000
1871–80	133, 166	2, 752, 780	247, 307	5, 112, 306	380, 473	7, 865, 086
1881–90	106, 737	2, 206, 452	87, 330	1, 805, 279	194, 067	4, 011, 731
1891–1900	93, 143	1, 925, 444	62, 096	1, 283, 630	155, 239	3, 209, 074
	484, 460	10, 014, 676	1, 759, 457	36, 371, 215	2, 243, 917	46, 385, 891
1901–10	46, 351	958, 155	67, 673	1, 398, 932	114, 024	2, 357, 087
1911–20	84, 033	1, 737, 122	120, 629	2, 493, 625	204, 662	4, 230, 747
1921–30	64, 463	1, 332, 571	14, 094	291, 350	78, 557	1, 623, 921
1931–40	54, 079	1, 732, 584	109, 580	3, 783, 530	163, 659	5, 516, 114
	248, 926	5, 760, 432	311, 976	7, 967, 437	560, 902	13, 727, 869
Total	733, 386	15, 775, 108	2, 071, 433	44, 338, 652	2, 804, 819	60, 113, 760

[45] Lindgren, Waldemar, The mining districts of the Idaho Basin and the Boise Ridge, Idaho: U. S. Geol. Survey 18th Ann. Rept., pt. 3, pp. 653–656, 1898.

Gold production, Boise Basin, 1863–1940

[Compiled by C. N. Gerry, Bureau of Mines, U. S. Department of the Interior]

Year	Lode	Placer	Total	Year	Lode	Placer	Total
1863			$3,000,000	1900	$206,470	$162,212	$368,682
1864			4,000,000	1901	292,270	81,973	374,243
1865			5,000,000	1902	142,131	130,504	272,635
1866			5,000,000	1903	28,372	130,895	159,267
1867			4,300,000	1904	90,321	229,408	319,729
1868			4,300,000	1905	20,858	131,287	152,145
1869			3,000,000	1906	91,332	137,692	229,024
1870			2,700,000	1907	69,066	166,210	235,276
1871			2,000,000	1908	81,499	117,808	199,307
1872			1,000,000	1909	72,539	143,492	216,031
1873			800,000	1910	69,767	129,663	199,430
1874			700,000	1911	87,697	265,767	353,464
1875			600,000	1912	52,513	449,764	502,277
1876			600,000	1913	90,177	529,893	620,070
1877			500,000	1914	128,535	472,692	601,227
1878			500,000	1915	171,866	383,259	555,125
1879			400,000	1916	174,889	295,171	470,060
1880			300,000	1917	179,146	38,340	217,486
1881			300,000	1918	175,255	51,538	226,793
1882			290,000	1919	412,843	5,607	418,450
1883			565,000	1920	264,201	1,594	265,795
1884			400,000	1921	245,469	10,625	256,094
1885			619,600	1922	140,391	8,393	148,784
1886			390,904	1923	84,330	10,398	94,728
1887			502,246	1924	74,010	2,539	76,549
1888			283,000	1925	34,851	11,635	46,486
1889			274,522	1926	44,586	37,191	81,777
1890			386,459	1927	95,080	57,169	152,249
1891			356,651	1928	190,513	42,894	233,407
1892			376,413	1929	206,668	53,086	259,754
1893			280,041	1930	216,673	57,420	274,093
1894			327,835	1931	183,979	22,576	206,555
1895			339,617	1932	26,272	28,216	54,488
1896			326,995	1933	38,548	44,178	82,726
1897			233,054	1934	150,103	177,207	327,310
1898			206,884	1935	277,641	176,532	454,173
1899			393,902	1936	325,101	433,531	758,632
				1937	249,025	691,705	940,730
				1938	223,265	747,285	970,550
				1939	114,030	655,025	769,055
				1940	144,620	807,275	951,895
					[1] 5,966,902	[1] 8,129,649	59,649,673

[1] 1900–1940.

GENERAL CHARACTER OF THE DEPOSITS

Most of the lode deposits in Boise Basin are gold deposits, but considerable silver has been produced, largely as a byproduct of gold mining, and a few of the deposits have produced nominal amounts of copper, lead, and zinc. Some of the deposits occupy fissures and have the tabular shapes characteristic of fissure veins, but most of them are contained in complex fissure and fracture zones and have the structural characteristics of lodes, the ore being in numerous rather closely spaced fractures, which may be mined collectively. Much of the ore in both veins and lodes was deposited as fillings in open spaces, but in places some of the ore has also entered into and replaced a part of the confining walls.

The deposits show considerable variation in substance and in structural and textural characteristics but appear to fall naturally into two well-defined groups of early Tertiary (?) and early Miocene age.

Those of early Tertiary (?) age are found only in the rock of the Idaho batholith in fissures and fracture zones produced by early Tertiary (?) deformation and are characterized by a dominance of quartz, variable but in general scant amount of sulfides, a distinctive paragenetic mineral sequence, and feeble wall-rock alteration. The deposits of early Miocene age are contained in the Miocene porphyry dikes and stocks as well as in the rock of the batholith in fissure and fracture zones produced by the early Miocene disturbance and are characterized by the presence of relatively abundant sulfides, generally subordinate quartz, distinctive mineral assemblages and mineral paragenesis, and widespread and conspicuous wall-rock alteration. As the two groups of deposits are so notably unlike, except in contained metals, they are given separate treatment.

EARLY TERTIARY (?) DEPOSITS

CHARACTER

The early Tertiary (?) deposits are dominantly gold-quartz deposits, although there is at least one antimony deposit and two base-metal deposits. The gold-quartz deposits have contributed perhaps less than $2,000,000 directly but have been the source of a large part of the gold concentrated in the placer sands and gravels and, therefore, have been indirectly the source of a large part of the gold production in Boise Basin. No antimony has been obtained from the antimony deposit, and no zinc, lead, and copper have been obtained from the two base-metal deposits.

The early Tertiary (?) deposits consist entirely of fillings of fissures and complex fracture zones and may be classed as fissure veins and lodes. Few of them have been mined to depths of more than 200 feet below the present surface, and much of the production has come from ore less than 100 feet below the surface. The deposits appear to have the features of the epithermal deposits—those formed at shallow depths below the original surface and at moderate to low temperatures.[46]

DISTRIBUTION

The veins and lodes are confined to those parts of the region that were subjected to faulting during early Tertiary (?) time, and most of them, therefore, are concentrated in a belt that stretches eastward from Grimes Creek near Old Centerville and New Centerville through the old Elkhorn and Gambrinus mining districts to and beyond Summit Flat. (See pl. 28.) Some of the deposits on Summit Flat and on

[46] Lindgren, Waldemar, Mineral deposits, 4th ed., pp. 444–513, New York, McGraw-Hill Book Co., 1933.

Rock Creek, a short distance east of Summit Flat, may be contained in smaller, separate belts. Other deposits are grouped in the Cold Springs district about 5 miles southwest of Idaho City and extend southwestward from Moore Creek to Holcomb on Grimes Creek. Deposits are also widely scattered over other parts of Boise Basin and in the Payette Canyon, especially along the northwest margin of the "porphyry belt" near Quartzburg and both northeast and southwest of Grimes Pass. The distribution of the deposits apparently bears no geographical relation to intrusive dikes and stocks in the Idaho batholith but depends entirely on the distribution of the early Tertiary (?) fractures.

STRUCTURAL RELATIONS

Most of the early Tertiary (?) veins and lodes occupy fissure and fracture zones of west-northwest trend, but some near New Centerville and on Summit Flat and many in the Cold Springs district are contained in easterly and east-northeasterly fractures. All of these fissures and fractures were formed in early Tertiary (?) time, as shown on page 162. All the early Tertiary (?) veins differ from the Miocene lodes in that they occupy fissures produced by reverse faulting in which the vertical component of movement dominated, whereas the Miocene lodes have been localized along fissure and fracture zones produced largely by nearly horizontal movement. Most of the early Teritary (?) veins dip to the south at moderate to steep angles.

As most of the deposits have been formed by deposition of ore in open spaces, the structural features of the guiding fissure and fracture zones are reflected in the structural characteristics of the veins and lodes. Where simple fault fissures were filled, veins were formed, but where filling also occurred in fractures in the country rock alongside the fissures, or along complicated zones of rather closely spaced fractures, or along closely spaced parallel fractures in shear zones and zones of sheeted granite, lodes rather than simple veins were produced. The deposits, therefore, form three well-defined structural groups: (1) simple fissure veins, (2) lodes consisting of a fissure vein with irregular stringers of ore alongside, and (3) lodes in wide zones of sheeted and fractured rock containing thin ore seams and stringers and in places small lenticular veins along the larger and better-defined fractures.

The simple fissure veins are commonly of small size, many of them less than a foot thick and no more than 30 to 200 feet long. Exceptionally, some of the veins expand to 4 feet in thickness, but few veins are uniformly thick and persistently long. The veins are characteristically lenticular and swell and pinch on both strike and dip. The lenses commonly occur along the less steeply inclined parts of the fissures and fracture zones. Some of the fissures contain only a single lens, but others have recurrent lenses 30 to 40 feet long separated by equal distances of barren ground. Most of the mining in the past has been confined to individual lenses, and in many places little attempt was apparently made to prospect beyond a single lens along either the dip or strike of the fissure.

Some of the lodes of the second group are not much different from the simple fissure veins, except for the occurrence of seams of ore in the fractured rock alongside the lenses. Other lodes consist of simple lenses, which break into zones of minor nearly parallel seams and irregular stringers on dip or strike. Some lodes contain two veins, one along the hanging wall of the fissure zone and the other along the footwall, and have seams and stringers of ore in the fractured rock between. The lodes composed of fissure veins with ore seams and stringers alongside may range from a few inches to as much as 8 feet in aggregate thickness and from 20 to 200 feet in length. The seams and stringers may either parallel the lens or extend out for short distances at diverse angles. Lodes of this kind are probably more numerous and more widely distributed than the simple fissure veins and the larger more complex lodes.

The lodes of the third group are by far the largest and are as much as 40 feet thick. They consist of sheeted and complexly fractured rock with numerous seams between the joints of the sheets and ramifying through the broken rock. The fractures have diverse trends, but the most prominent ones parallel the direction of the fracture zone and commonly hold narrow veins and seams, some of them as long and thick as those in the simple fissures. These lodes are generally long and may be traced for as much as 2 miles, but the ore bodies compose comparatively small narrow shoots, commonly no more than a few feet thick nor more than 100 to 200 feet long, though exceptionally they are as much as 400 feet long.

The veins and lodes have been considerably disturbed by faults, in part by renewed movement along the guiding fissures and fracture zones and in part by a set of younger cross faults. The renewed movement along the veins and lodes has led to the formation of considerable gouge along either the foot or hanging wall and has shattered much of the rock alongside. The cross faults offset the veins and lodes from a few inches to as much as 150 feet in a horizontal direction. These faults strike N. 10° E. and N. 40°–60° E., and most of them dip steeply southeast. Grooves and striations on slickensides dip 20° to 30° southwest. The structural relationships of the cross faults are characteristic of the lower Miocene faults. In some places, as at the Cleveland and Mascot mines, dacite porphyry and dark-colored dikes have been intruded along the faults and sharply across the veins and lodes. An understanding of the Miocene shearing is useful, therefore, in searching for displaced segments of these older deposits.

MINERALOGY

The mineralogy of the early Tertiary (?) deposits is comparatively simple, as the vein and lode fillings are with few exceptions composed principally of quartz accompanied by scant amounts of sulfides, namely, pyrite, arsenopyrite, sphalerite, tetrahedrite, chalcopyrite, galena, and stibnite. Gold, either free in the quartz or associated with the sulfides, is the chief ore mineral. Some of the ore also contains insignificant amounts of calcite and minor quantities of secondary minerals, principally limonitic oxides, scorodite, manganese oxides, and scant anglesite and malachite. Some of the sulfides and the quartz are present in more than one generation.

The quartz was deposited in three successive stages, the last two in breccias of the earlier quartz, and it therefore shows considerable variation in textural relations and in grain size. The earlier quartz is fine-grained to medium-grained and appears to be barren of gold and sulfides. In some deposits it occurs as scattered breccia fragments set in a matrix of younger quartz, in a few it forms the entire filling, and in some it is either absent or present in such widely scattered inclusions as almost to escape detection. The quartz deposited during the second stage is much more widely distributed and is more variable in grain size. Some of it is very fine-grained, in places chalcedonic, and is colored distinctly gray because of dissemination of minute grains of arsenopyrite and pyrite. In most deposits, however, it is medium-grained to fairly coarse-grained, colorless to glassy, and holds scattered medium-sized grains and crystals of pyrite, arsenopyrite, sphalerite, and galena. The youngest quartz, in general the most abundant and in some deposits the only quartz, is rather coarsely crystalline and is largely made up of interlocking crystal aggregates, commonly with minor openings between the crystals and in places enclosing open drusy clefts. These crystals may project inward in some of the smaller seams to produce rough quartz combs, which do not everywhere unite with crystals from opposite walls. In many deposits the quartz crystals project into and through the earlier quartz and sulfide inclusions, in places dividing the sulfide crystals into two or more irregular but oriented pieces. The youngest quartz commonly contains grains of free gold, auriferous pyrite, and in places a little stibnite. It is fundamentally the most important guide to ore.

The sulfides are variable in quantity and distribution and are nowhere conspicuous, except in the two base-metal deposits and in the single antimony vein. The pyrite occurs in rather widely scattered crystals in the second generation quartz and as small scattered cubic crystals one-eighth to one-half inch across in the younger comb and drusy quartz. Most of the grains and crystals in the second-stage quartz are small and commonly microscopic in the fine-grained quartz, but locally crystals half an inch to 1 inch square have been observed. Most of the grains in the second-stage quartz are irregular and are in part engulfed in and penetrated by the sphalerite and galena.

The arsenopyrite is less uniformly distributed. In some deposits it is present in very small quantities, in part as microscopic grains, but in other deposits it may locally be fairly abundant and occur in larger crystals as much as one-half inch long. In a few deposits some of the arsenopyrite is concentrated in seams, and some is widely disseminated.

The sphalerite is not conspicuous in any except the two base-metal deposits. In most places it occurs as widely scattered small blackish granules, in part fractured and penetrated by tetrahedrite and chalcopyrite and cemented by galena. In the two base-metal deposits it forms larger granules and masses, which are pale yellowish green to orange in color, in part distinctly greenish and in part distinctly yellowish. Many grains also shade from orange within the grain to yellow or green at the borders.

The tetrahedrite is relatively abundant only in the two base-metal deposits, where it occurs as granules and small bunches like the sphalerite. In other deposits it commonly occurs as microscopic inclusions in the galena.

Chalcopyrite is visible only as microscopic blebs in the dark-colored sphalerite and in scattered minute grains in the tetrahedrite and galena. Some in the two base-metal deposits occurs in widely scattered minute veinlets cutting and replacing the tetrahedrite.

Like the sphalerite, galena is erratically scattered in small grains and larger granules, but in the base-metal deposits it is locally as abundant as the sphalerite and tetrahedrite. Some of the galena penetrates and partly replaces the sphalerite along fractures and cleavages, and some of it enters and replaces tetrahedrite and cuts sharply across chalcopyrite veinlets contained in the tetrahedrite. These sulfides are associated with and are found only in the second-stage quartz, or as inclusions of residual grains and breccia masses in the third-stage quartz.

The gold is in many places visible in fractures in the comb and drusy quartz and in limonitic pseudomorphs after the essentially contemporaneous pyrite. It is also visible as microscopic grains, which replace some of the second-stage sulfides. The gold is distinctly yellow and does not appear to be alloyed with much silver. The grains range from microscopic to nugget size, the size being inferred from the size of the gold grains recovered from the gravels below the outcrops.

Stibnite is present in many of the deposits, commonly as small inconspicuous needles and blades on and between quartz crystals and in minor fractures in the quartz. It is comparatively abundant in only one deposit, where it forms a massive filling 2 to 8 inches wide between thin walls of comb quartz. In this filling the crystals are coarse and form flattened blades as much as 2 inches long either projecting inward from the walls or forming divergent interlocking aggregates.

Calcite has been reported in thin seams and small masses in some of the deposits but was not observed during the present study. Some quartz younger than the third-stage comb variety was observed in the base-metal deposits in the form of thin films of minute drusy crystals on the surfaces bounding widely spaced fractures cutting the vein filling.

Oxidation of the ores has given rise to little more than traces of anglesite and cerussite in or near galena and no more than widely scattered patches of malachite and azurite in deposits containing tetrahedrite and chalcopyrite. Limonitic iron oxides are commonly the most conspicuous secondary minerals, but ordinarily they are not abundant and are confined to scattered pseudomorphs after pyrite and to lightly iron-stained fractures and ore seams. Scant amounts of black manganese oxides in small patches and thin films occur among the limonitic products. Small patches of greenish scorodite ($FeAsO_4.2H_2O$) are also present in deposits containing arsenopyrite.

PARAGENESIS

The deposition of minerals was apparently not continuous during the period of mineralization but was interrupted several times by structural adjustments, and much of the ore is a breccia of older fillings in a matrix of younger cementing minerals. The deposition has clearly taken place in three well-defined stages, each with its own characteristic mineral assemblage.

During the first stage of mineralization barren quartz was the only mineral deposited, and it was deposited in small amounts in only a few of the numerous fissures and fracture zones. In some places the filling remained undisturbed, and no minerals belonging to younger generations were added, but most fillings were extensively brecciated, and relatively large amounts of younger minerals, especially the abundant and widely distributed second-stage quartz and its scant assemblage of sulfides, were added. The second-stage minerals cemented and in part replaced the early quartz breccia and apparently filled all available openings. Quartz was deposited first, but the sulfides made an appearance before the close of quartz deposition and continued to be deposited after quartz deposition ceased, the sulfide sequence as determined from minor structural relationships being pyrite, arsenopyrite, sphalerite, tetrahedrite, chalcopyrite, and galena.

Renewed fracturing later reopened the filled fissures and fracture zones and much of the first-stage and second-stage ore was reduced to a breccia. The reopened channels permitted the entrance of the third-stage solutions and the addition of much comb and drusy quartz and its accompanying assemblage of pyrite, gold, and stibnite. In some places the structural adjustments had little effect on the earlier fillings, and little of the third-stage quartz and associated metallic minerals was added. In many places entirely new fissures were formed independent of the earlier fissure and fracture zones and are now occupied solely by third-stage minerals. The fillings in the deposits are, therefore, notably heterogeneous and may be made up of minerals entirely or in part of any one or two of the three stages.

CHARACTERISTIC FEATURES OF THE ORE

In the gold deposits where mining has not extended below the oxidized zone the ore consists of iron-stained quartz seams, stringers, and lenses, which in places contain empty, or partly limonite-filled pores and larger cavities, formerly occupied by scattered sulfide grains. Small grains of free gold may be present in the limonitic material, visible generally after crushing and panning. The gold appears to be much more abundant in the cubic limonite pseudomorphs after pyrite in comb quartz than in the oxidized products of other sulfides, or even in the iron-stained quartz itself. In some of the lodes the quartz seams are so thin that the ore appears to consist merely of iron-stained fractures in the quartz monzonite and aplite. Scant sulfides appear in most of the deposits below the oxidized zone, either as scattered grains of pyrite, arsenopyrite, sphalerite, and galena in the second-stage quartz, or as even more widely scattered pyrite and stibnite crystals in the third-stage quartz. In none of the gold deposits do the early sulfides exceed 5 percent of the filling, and in most of them they amount to less than 2 percent.

Quartz of the first and second stage predominates in only a few deposits and is invariably associated with some of the young comb and drusy quartz. The third-stage quartz is the only quartz present in some of the gash fissures and lodes in sheeted rock. The ore shows some changes with depth. Comb and drusy quartz becomes less conspicuous in the lower workings than on or near the surface, and the gold content shows a corresponding decline.

In the base-metal deposits the ore is dominantly quartzose but contains as much as 10 percent of sulfides as scattered granules and small bunches composed of variable amounts each of sphalerite, tetrahedrite, and galena. Pyrite and chalcopyrite are very scant and ordinarily are not visible except in polished sections. The low iron content of the ore is reflected not alone in the scarcity of pyrite and chalcopyrite but also in the prevailingly light green, yellow, and orange color of the sphalerite. Most of the quartz in the deposits is the younger third-stage variety and consists of rather coarsely crystalline aggregates surrounding and penetrating the shattered and somewhat separated fragments of the sulfides and associated second-stage quartz. Gold apparently was not introduced with the young quartz, and the precious-metal content of the ore is confined entirely to the silver in the tetrahedrite and galena, neither of which, however, is particularly argentiferous.

The ore in the antimony deposit is confined to a single vein of massive coarsely crystalline stibnite between walls of comb quartz in which a few crystals of auriferous pyrite are widely scattered.

DISTRIBUTION OF THE ORE

The ore in the early Tertiary (?) deposits is not uniformly distributed but occurs in small shoots or pockets. Few of the shoots in the fissure veins have stope lengths of more than 30 to 40 feet. In most places the veins have not been explored for more than 100 feet below the outcrop, the commercial ore apparently having been exhausted within that depth, but the Washington gold-quartz vein was mined to a depth of 400 feet, the vein decreasing in size and the ore in tenor on the lower levels.

The ore is also spotty in lodes characterized by quartz lenses and bordering quartz seams and stringers. In some of the lodes the seams and stringers rather than the lenses contain the greater proportion of gold. These seams and stringers are composed of the third-stage minerals, whereas the lenses contain minerals of the first and second stages. The structural adjustments concurrent with mineral deposition fractured the rock alongside the lenses rather than the lenses themselves prior to the introduction of the gold-quartz solutions. Neither are the lodes along broad zones in fractured and sheeted granitic and aplitic rock more uniformly mineralized than the veins and smaller lodes. The richer ore in general is confined to comparatively small, narrow shoots, commonly less than 2 feet thick and exceptionally as long as 400 feet. The remainder of the lode is generally of low grade, containing less than 0.1 ounce of gold per ton. Most of the past production has been from the richer ore shoots, particularly in the weathered outcrops where the gold was largely recovered by sluicing. As in the veins, the underground work has been shallow, generally within 100 feet of the surface, and has scarcely reached the bottom of the oxidized zone.

STRUCTURAL CONTROL OF ORE SHOOTS

The distribution of the ore accords wholly with the presence and distribution of the third-stage quartz and its associated free gold and auriferous pyrite, and is, therefore, largely independent of earlier quartz and sulfide fillings, unless concurrent structural adjustments reopened the earlier fillings at the proper time to admit the gold-bearing solutions. The ore shoots thus comprise the younger quartz seams, stringers, and lenses, which penetrate the earlier fillings or occupy entirely new fractures or zones of fractures. The size of the ore bodies depends entirely on the size of the younger quartz lenses and the abundance and spacing of the accompanying seams and stringers. The extent of some ore bodies has been determined solely by the number and spacing of the thin quartz seams in the sheeted and fractured rock, and that of others by the thickness and length of lenses of the third-stage quartz. Some mistakes were made in the past in prospecting veins and lodes composed largely of early quartz and sulfides and apparently not recognizing the association of gold with the younger quartz, but fortunately the structural conditions that controlled deposition of the older quartz and sulfides also controlled the deposition of third-stage quartz, and hence the occurrence of sulfides commonly defines the shoots of commercial ore. The reopening of lode fissures has been an important factor in the localization of commercial ore.

Structural control has also operated in another way to delineate the limits of commercial ore, as much of the ore is found along the more gently dipping parts of the veins and lodes and pinches as the dip steepens. The less steeply dipping parts of the fissures and fracture zones apparently contained the most permeable openings, which, as deduced from striations, grooves, and plucked hollows, were produced by reverse movement along the guiding fault planes, the hanging wall having moved upward with respect to the footwall. The walls bounding the gently dipping parts of the fissures or fractures were thus readily separated by the reverse movement, and the ore-bearing solutions were easily admitted after each slight structural adjustment. In the steeper parts between the "flats" the walls were held tightly together during the faulting movements, and no openings structurally favorable for ore deposition were produced.

TENOR OF THE ORE

Little could be learned concerning the richness of the ore mined in the early days. Some of the ore was comparatively rich, as considerable gold was recovered in stamps from small amounts of ore. Some lots were reported to stamp more than 1½ ounces to the ton and some more than 5 ounces. Gold is visible in much of the higher-grade ore, and in places much "specimen" ore has been reported.

WALL-ROCK ALTERATION

The granitic and aplitic rock bordering the veins and lodes is remarkably fresh in appearance and characteristically shows little evidence of alteration. Much of the rock adjacent to the ore looks little different from rock many feet away, and wall-rock alteration cannot serve as a guide to the occurrence and distribution of ore. In places the biotite in the granitic rock has been somewhat bleached and changed, or partly changed, to chlorite or muscovite, but in other places the biotite shows essentially no evidence of alteration. Some quartz has been added to the rock, much of it in the form of seams and stringers, but some of it has permeated and party replaced the rock. The feldspar crystals contain scattered, microscopic patches and grains of sericite, but hardly enough to dull the vitreous luster of the crystals. Some small widely scattered crystals of pyrite have been observed in the country rock of some of the veins and lodes.

The deposition of ore, therefore, has been accompanied by only slight silicification, sericitization, chloritization, and pyritization. This feeble alteration is one of the most distinctive characteristics of the early Tertiary (?) ore deposits.

GENESIS OF THE DEPOSITS

Although the early Tertiary (?) deposits are contained in the late Jurassic or Cretaceous rocks of the Idaho batholith, their association with fractures of early Tertiary (?) or Laramide (?) age excludes any likelihood of a genetic relationship with the batholith. Likewise their lack of association with fractures and porphyritic dikes of Miocene age, which are younger and cut the veins and lodes, excludes them from a middle Tertiary age and leaves as the only likely source the deep-seated magmas of early Tertiary (?) age. The source of the ore-forming solution must have been deep-seated, for the deposits are not grouped about recognizable intrusive centers nor are they associated with intrusive dikes other than lamprophyric varieties. Instead the deposits are contained in fractures of considerable magnitude along which the metalizing solutions were apparently carried some distance or nearly to the surface before ore of commercial grade was deposited. Deposition at comparatively shallow depths is indicated by the complex and abundant fracturing and relatively abundant comb and drusy quartz, both of which are commonly regarded as shallow phenomena.

The deposits are very much like the gold-quartz deposits classed by Ferguson [47] and Nolan [48] as epithermal (formed at shallow depth and relatively low temperature)[49] in which the ore is composed almost entirely of comby quartz, pyrite, and free gold in wall rock commonly unaltered, except for a few inches or, at the most, a few feet on either side of the vein. Although in Boise Basin the temperature of the mineralizing solutions may have been moderately high during the earlier stages of deposition, as may be inferred from the more massive character of the quartz and the presence of arsenopyrite, the relative abundance of comb and drusy quartz, the presence of stibnite, and the very feeble wall-rock alteration suggest that during the late, metalizing stage the conditions of deposition were typically epithermal. The notable decline in gold content in a narrow vertical range suggests that the ore was deposited rather abruptly, perhaps because of general rapid cooling as the solutions spread from the heated channels into the numerous fractures of the extensively shattered and cooler rocks near the surface. As so much more gold has been recovered from the placers than from the veins and lodes and as the ore has been exhausted at such shallow depth, it would appear that only the roots of these shallow epithermal deposits have escaped erosion.

These early Tertiary (?) deposits are similar to the deposits in the Rocky Bar district, Idaho,[50] and apparently belong to the same epoch of metalization as the silver-gold deposits in the Atlanta district.[51] Both the Rocky Bar and Atlanta deposits show the same structural, textural, and mineralogical relationships as the early Tertiary (?) deposits in Boise Basin, differing only in that the Atlanta ore contains a preponderance of silver, and, in addition to the third-stage gold and comb quartz, has considerable polybasite, stephanite, pyrargyrite, proustite, and other complex silver sulfosalts. The deposits at Atlanta are correlated with early Tertiary (?) shearing and are ascribed an epithermal origin, the ore occurring in the upper parts of the fracture zones after ascending from a deep-seated source.

[47] Ferguson, H. G., The mining districts of Nevada: Econ. Geology, vol. 24, p. 137, 1929.

[48] Nolan, T. B., Epithermal precious metal deposits, in Ore deposits of the Western States (Lindgren volume), pp. 627–628, Am. Inst. Min. Met. Eng., 1933.

[49] Lindgren, Waldemar, Mineral deposits, 4th ed., pp. 444–452, New York, McGraw-Hill Book Co., 1933.

[50] Anderson, A. L., Geology of the gold-bearing lodes of the Rocky Bar district, Elmore County, Idaho: Idaho Bur. Mines and Geol. Pamph. 65, 1943.

[51] Anderson, A. L., The geology and ore deposits of the Atlanta district, Elmore County, Idaho: Idaho Bur. Mines and Geology Pamph. 49, 1939.

MIOCENE DEPOSITS

CHARACTER

The Miocene deposits are primarily gold deposits, or contain gold as the most valuable metal. They are structurally much more complicated than the early Tertiary (?) deposits and are characterized by much more variation in the kinds and amounts of minerals present. Some of them have no metals of consequence, except gold, whereas others contain noteworthy amounts of base metals and have been mined for lead, zinc, and copper, as well as for the precious metals. In several silver is the most valuable metal. According to substance, the deposits may be conveniently classed as gold deposits, base-metal deposits (in most of which gold and silver are important byproducts), and silver deposits. The gold deposits may be further subdivided on the basis of associated minerals into groups of gold-bismuth, gold-pyrite, and silver-gold deposits. There are, however, gradations from gold to base-metal, base-metal to silver, and gold to silver, as well as from gold-bismuth to gold-pyrite deposits.

The Miocene deposits occur as lodes and are either fillings or replacement bodies along fissures and fissure zones, between the fissure zones, or in zones of closely spaced sets of oblique fractures within shear zones. A few possess in part a veinlike habit, but lenses in fissures are invariably accompanied by ore seams and stringers in the rock alongside or pass into zones of stringers. The deposits, therefore, are described as lodes rather than as veins.

DISTRIBUTION

The Miocene deposits are confined to the Miocene "porphyry belts," and most of them are concentrated in and along the "porphyry belt" extending through Quartzburg and Grimes Pass, particularly in and near Quartzburg and Grimes Pass. A few of the Miocene deposits are also found along the "porphyry belt" south and southwest of Idaho City, in part near the early Tertiary (?) veins and lodes. In most places the deposits are in Miocene intrusives. Only a few are entirely in the fractured rock of the batholith.

A distribution of deposits according to composition is expressed along the "porphyry belt" that passes through Quartzburg and Grimes Pass. The gold-bismuth association is restricted to the Quartzburg area, whereas the base-metal deposits are more typical of the Grimes Pass region. The silver-gold and the silver deposits appear to favor the marginal areas of the "porphyry belts" and are not found within the main centers of base-metal mineralization.

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STRUCTURAL RELATIONS

Many of the structural relationships of the lodes have been treated in the discussion of the lode pattern (pp. 166–167), particularly the close correspondence between lodes and dikes in distribution and trend and the tendency of both to occupy fractures somewhat oblique to the long direction of the "porphyry belt" with the largest and most persistent of the lodes striking N. 70° E., less commonly N. 10°–20° E., and N. 35° E., and the smaller and less persistent ones ordinarily N. 30°–60° E. Although there is in general close agreement in lode and dike trends, the lodes nevertheless rarely are parallel to the dikes in their own vicinity but approach or extend obliquely across the dikes. The guiding fissure and fracture zones commonly have steep dips, or, if gently dipping near the surface, steepen with depth. Many of them dip in a direction opposite to the dip of the dikes and so pass through the dikes with depth and also cut across them on the strike. As pointed out on p. 166, the prominent N. 70° E. lodes generally dip south at a moderate angle, although northerly dips are not unknown, but the lodes of more northerly trend dip steeply to either northwest or southeast and may reverse their direction with depth.

The fissure lodes are in general exceedingly irregular and show local marked variations in both dip and strike. The Mountain Chief-Belshazzar lode, for example, changes its strike from N. 35° E. to N. 80° E. as it passes from the Mountain Chief property to the Belshazzar and on the Belshazzar ground changes its dip from about 30° S. near the surface to 70° S. with depth. Others show less marked changes, but their guiding fissures are more or less irregularly warped and are nowhere without undulations for more than a few feet. The Mayflower lode exemplifies these minor changes to a considerable degree and shows not only abrupt variations along the strike but repeated alternations in dip from steeply northwest to vertical. The Golden Age lode at Grimes Pass is one that reverses its dip from northwest to southeast with depth.

The several sets of fissures that guided the ore-bearing solutions are not equally prominent nor uniformly distributed along the "porphyry belt." The N. 70° E. set is found in all parts of the district and is everywhere prominent, but the N. 35° E. set is also prominent in the Quartzburg area and the N. 10°–20° E. and the N. 30°–60° E. sets in the Grimes Pass region. The N. 70° E. fissures are generally the longest and are commonly filled with ore for a greater distance than the others, but exceptions are known. The Gold Hill lode, which occupies a fissure of about N. 70° E. trend, has been stoped for a maximum distance of nearly 3,500 feet on one of the upper levels. The guiding fissure at the Mountain Chief and Belshazzar mines is also long but has not been as persistently mineralized throughout as the Gold Hill. Some of the lodes in the Grimes Pass area are also long though not uniformly filled with ore. The subordinate sets of fissures are generally no more than a few hundred feet long and have ore in only certain parts. The thickness of the fissure and fissure zones is also variable. Along some of the minor fissures the disturbed zone is only a few inches thick, whereas some of the main fissures are set in and along zones of fractured and altered rock as much as 40 feet across. Where the fissure zones are rather closely spaced the band of fractured rock may be several hundred feet wide.

The fissures and fissure zones are generally not simple fractures filled with ore but are commonly defined by numerous fractures, the most prominent of which parallel the fissure or fissure zone. Some comprise several prominent closely spaced fractures separated by intricately broken rock, and others contain sets of fractures oblique to the general trend of the fissure or fissure zone so spaced as to reflect tensional components of shearing along the main fissure. Many of the fractures are sharp and clearly defined; others are mere slips but have been important in guiding the mineralizing solutions and in localizing ore deposition. The main fissures are ordinarily marked by conspicuous bands of gouge and represent the planes along which most of the movement has taken place. In general the rock in and along the fissure has been so extensively crushed and fractured that much of the ore is in seams and stringers rather than in simple lenticular veins such as characterize some of the early Tertiary (?) deposits. The fractures, however, are not uniformly prominent along all parts of the fissure, but zones of slightly disturbed rock commonly alternate with zones in which the rock has been extensively crushed. The fissures are commonly best defined in the granitic rock of the batholith, but they generally splinter into a broader zone of fractures on entering the porphyritic dike rocks. On passing through the dikes the fractures commonly reunite in the granitic rock to form a single prominent fissure.

Most of the fissures show evidence of but minor displacement, and, although the rock may appear extensively fractured, the pieces have not been widely separated nor have dikes been offset for more than a few inches to a few feet, largely in a horizontal direction. As pointed out on page 166, striations on gouge and slickensides dip 25° to 35° SW. and indicate that the hanging wall has in general moved obliquely upward. The zones of most extensively fractured rock apparently occur where there are slight changes in the dip and strike of the fissure and the lateral movement has tended to spread the walls apart. Movement along the fissure and fissure zones was recurrent rather than continuous and took place during ore deposition as well as before and after. Such repeated movement concurrent with mineral deposition has probably been the main cause of the extensive fracturing and brecciation found along each of the lodes.

Although most of the lodes have been controlled in one way or another by fissures and fissure zones, some exceptions occur at the Gold Hill mine, where shearing has produced fracture zones in which the fractures overlap and are oblique to the direction of shearing. These sets of more or less closely spaced oblique fractures are tension fractures, and the ore in them has made some of the most productive lodes in Boise Basin. The fractures are short, discontinuous, and the individual fracture zone is rarely more than 10 feet wide but may have a stope length of 50 to 300 feet and height of 100 to 800 feet. This type of structure is confined to bodies of rhyolite porphyry and disappears in the granitic rock of the batholith where the zones of overlapping oblique fractures give way to simple fissures parallel to the direction of shearing.

MINERALOGY

The Miocene deposits have a much more varied mineral content than the early Tertiary (?) deposits and in consequence their mineralogic features are more interesting and noteworthy. The mineralogic differences are in general so marked that the Miocene deposits may be readily distinguished from the older group on the basis of mineral content and mineral relationships alone. Among the differences is the subordinate role assumed by quartz and the prominent part taken by the rather conspicuous and relatively abundant metallic minerals. The Miocene deposits also record two rather than three stages of mineral deposition, but the presence of only two stages of metalization serves in no way to simplify the mineral composition, as each stage is represented by variable and in general highly complex mineral assemblages. The structural break separating the two stages appears exceptionally pronounced and the intervening structural adjustment particularly severe. An abundant intermineralization gouge in which a considerable part of the first filling is incorporated typifies most of the deposits.

The mineral assemblages of each of the two stages are notably dissimilar and are easily distinguished. The first assemblage contains a preponderance of base-metal sulfides, and the stage of deposition may be conveniently designated as the base-metal stage. The gold and much of the silver are contained in the second assemblage, and its stage of deposition may as conveniently be referred to as the precious-metal stage. Each stage records some differences in kinds and proportions of minerals in the different deposits, but variations are marked and significant only in the assemblages of the precious-metal stage.

A third mineral assemblage may be added but comprises only minor amounts of minerals of supergene origin produced by the action of ground water on the primary minerals. These secondary minerals as well as the minerals of each of the two primary stages are accorded separate treatment.

MINERALS OF THE BASE-METAL STAGE

DISTRIBUTION AND CHARACTER

The minerals of the base-metal stage include much pyrite, locally considerable sphalerite, galena, tetrahedrite, and chalcopyrite, scant amounts of quartz and siderite, and in places a little pyrrhotite and enargite. The proportions of these minerals vary in the different deposits, and the assemblage itself may vary in importance in different lodes. The base-metal assemblage predominates in some deposits; in others its role is subordinate.

The pyrite is the most widely distributed of all minerals and is in most assemblages the most abundant mineral. Many deposits contain little except pyrite, present either as irregular seams and veinlets in the fractured rock or as irregular massive replacements of the rock itself. The pyrite appears to be earlier than all other minerals of the assemblage and appears to be separated from them by a break of considerable magnitude, for in many of the deposits seams and massive bodies of it are cut by seams and pods of sphalerite and galena. The structure break is so marked that the question arises as to whether the pyrite should not be accorded a separate stage of deposition equivalent in prominence to the main-base-metal stage. Apparently only where the pyrite was fractured were the other base-metal sulfides added.

Of the other sulfides of the base-metal stage, dark-colored sphalerite is in general the most widely distributed as well as the most abundant. It is commonly accompanied by galena, and in the Grimes Pass area the two are so abundant that both lead and zinc have been recovered from the ore. The sphalerite is found in every deposit in the district, in some deposits only as small granules or widely scattered pods in seams cutting the earlier pyrite or in wider bands associated with the other base metals. It is generally loaded with microscopic blebs of chalcopyrite alined with crystallographic partings (pl. 29, *A*) and is commonly rather extensively fractured, the fractures being filled with thin seams of chalcopyrite or tetrahedrite, or both, or the shattered grains being cemented together with dolomitic or ferriferous carbonates (see pls. 37, *A*, 38 *A*). The chalcopyrite also occurs as larger grains in some of the base-metal ore but is notably conspicuous only in the Grimes Pass area, where one of the lodes on the Coon Dog claims has as much chalcopyrite as the other sulfides combined and several cars of ore were shipped as copper ore. The tetrahedrite is likewise abundant in the Grimes Pass region and in the Silver Gem lode forms about one-fourth of the base-metal filling. It is easily recognized in most of the ore in the region and is nearly as abundant in some of the lodes on the Coon Dog claims as at the Silver Gem mine. It is present in the Quartzburg area but in only small amounts, generally in very widely scattered bunches. The tetrahedrite is notably argentiferous, and its presence is regarded with favor.

The other minerals belonging to the base-metal stage are scant but mineralogically interesting. The pyrrhotite was observed only in the Belshazzar lode, but is reported in the Mountain Chief.[52] It is apparently confined to a few small nests, widely scattered and forming only a very insignificant part of the filling. It is in part replaced by sphalerite and galena, but much of it has been changed to marcasite, apparently when it was fractured after the close of the base-metal stage of deposition and invaded by the younger precious-metal ore. The enargite ($Cu_2S.4CuS.As_2S_3$) was observed only at the Belshazzar mine, intimately associated with the tetrahedrite and contained in it in such a way as to suggest about contemporaneous formation. Siderite occurs at both the Mountain Chief and Belshazzar mines and at the Mayflower, but the quantity is small. It appears in small nests and pockets of base-metal ore as a scant cement of some of the brecciated sulfides. In other deposits the carbonate is apparently represented by ferriferous dolomites, which cannot be safely distinguished from carbonates of the precious-metal stage. Locally on the Homeward Bound claim of the Mayflower group, near Quartzburg, the carbonate is rhodochrosite.

PARAGENESIS

Slight movements concurrent with the sulfide deposition, which fractured earlier sulfides and permitted their cementation or replacement by younger minerals, have made the mineral sequence fairly easy to establish. The complete mineral succession from earliest to latest has been scant quartz, pyrite, pyrrhotite, sphalerite, tetrahedrite and enargite, chalcopyrite, galena, and carbonates. Marcasite, though associated with the pyrrhotite, did not form until the base-metal filling had been fractured and penetrated by the younger ore-forming solutions and, therefore, may be regarded as a product of the younger stage of deposition. The pyrite was extensively replaced by the younger sulfides and is commonly contained in them

[52] Ross, C. P., Some lode deposits in the northwestern part of the Boise Basin, Idaho: U. S. Geol. Survey Bull. 846–D, p. 268, 1933.

as more or less irregular or rounded residual grains. The sphalerite was extensively shattered, probably because of its excellent cleavage, which permitted easy separation, and was rather extensively penetrated and veined by tetrahedrite and chalcopyrite. In some places larger grains of tetrahedrite were minutely veined by chalcopyrite, indicating locally at least that slight structural adjustments occurred during or shortly after tetrahedrite deposition (pl. 29, *B*). Enargite likewise shows microscopic veining by chalcopyrite. As seams of galena penetrate the sphalerite and also hold remnant inclusions of sphalerite, tetrahedrite, and chalcopyrite, it was the last sulfide deposited. In the Washington mine it intricately penetrated and replaced the tetrahedrite in such a way as to produce peculiar intergrowths simulating the eutectic pattern.

MINERALS OF THE PRECIOUS-METAL STAGE

DISTRIBUTION AND CHARACTER

The solutions of the precious-metal stage, which were introduced after the fissures had been reopened by severe structural adjustments and after the earlier base-metal fillings had been extensively fractured, brecciated, and even crushed, varied considerably in composition from place to place but contributed either gold, or silver, or both, and small but variable amounts of other elements. The complete list of minerals deposited includes the nonmetals quartz, barite, dolomite, tremolite, and calcite; the metals gold, electrum, and native bismuth; the simple sulfides pyrite, arsenopyrite, sphalerite, and marcasite (as a replacement of pyrrhotite in the base-metal ore); the complex sulfobismuth salts matildite, galenobismutite, bismuthinite, and tetradymite; and the complex sulfantimonites of lead and silver boulangerite, miargyrite, pyrargyrite, and perhaps andorite. Quartz, and, to lesser extent, pyrite, arsenopyrite, and carbonates are distributed through all the deposits, but the barite and the bismuth and silver minerals are confined to a few. None of the metallic minerals other than arsenopyrite and pyrite are abundant, and the assemblage, therefore, is primarily a precious-metal assemblage. The variations in composition are primarily from gold to silver. Each metal has its rather peculiar mineral association, the gold preferring an association with bismuth or with quartz, arsenopyrite, and pyrite, the silver an association with complex antimonial salts and arsenopyrite.

The quartz is perhaps the most characteristic and generally the most abundant and widespread of all the minerals of the precious-metal stage. It is commonly the leading mineral in the gold-bismuth, the silver-gold, and the silver deposits but is not generally as abundant as the sulfides in the base-metal deposits. In some of the gold deposits it forms seams and lenses a few inches thick and contains scattered inclusions of the older base-metal filling, but in most deposits it occurs as narrow seams and stringers penetrating here and there through the lode. The quartz shows considerable variation in habit and grain size, not only from deposit to deposit but even within the same deposit. Much of it has a comb habit, some is drusy, and some is chalcedonic. In the larger seams and lenses of some of the gold-bismuth deposits it is rather coarsely crystalline and occurs as complexly interlocked crystals as much as half an inch long, commonly with small intervening open spaces into which needles and blades of the bismuth minerals project. Its grain size is more variable in the silver-gold and silver deposits and ranges from very fine-grained, or chalcedonic, to coarse, the chalcedonic variety predominating. The same deposits also contain comb quartz, particularly about inclusions of the brecciated wall rock, or older filling, and coarse and fine druses in open clefts. The quartz is generally fine-grained where it occurs as seams in the base-metal ores, but some of it also has a comb habit, and some occurs as fine to coarse druses in clefts, some crystals being exceptionally as much as an inch long. Much of the quartz of the precious-metal stage has the characteristic fine grain and comb habit commonly found in epithermal deposits.

Of the other nonmetallic gangue minerals, dolomitic carbonates are the most abundant and were added to some of the base-metal deposits in larger quantity than the quartz. The dolomitic carbonates are also far more widely distributed than the barite and tremolite and are generally found wherever there are appreciable quantities of base-metal ores. Some of the dolomite is ferriferous and perhaps might be designated as ankerite, but some of it is manganiferous and slightly pinkish. In places it forms crusts on the quartz and may show fine drusy surfaces in open spaces. It also occurs as a granular cement in the shattered base-metal sulfide masses.

The barite was found in only a few deposits, as sporadic small masses and seams in the base-metal ore in the Silver Gem lode and in sparse amounts at the Mountain Chief mine. It occurs, however, in considerable abundance at the Crown Point prospect, near the Mountain Chief mine, where locally it forms a lenticular vein as much as 12 inches thick between walls of comb quartz. Much of the barite in the several deposits forms coarse grains and coarse granular aggregates, but some at the Mountain Chief mine occurs as crystals in open cracks in the quartz. At the Silver Gem mine the crystalline masses occur as a filling within bands of the dolomitic carbonate, but seams also cut the carbonate and the quartz.

Tremolite ($H_2O.2CaO.5MgO.8SiO_2$) was found only at the Hartford property, about 2 miles northeast of Quartzburg, and occurs in the form of rosettes of slender white to gray needles in seams in the altered country rock and as crusts on comb quartz and pyrite.

Calcite is present in most deposits but only in small quantities mainly in thin seams in rather widely spaced fractures, which cut through both the base-metal and precious-metal fillings. In places it forms a thin coating on quartz and dolomite crystals or occurs as small obtuse rhombohedrons in clefts. The calcite is apparently younger than all other minerals and was apparently deposited at the close of the precious-metal stage after a somewhat minor structural reopening.

Pyrite is the most widely distributed of the second-stage sulfides, but, except in a few deposits, it occurs only as widely scattered crystals in and on the comb quartz and as crysals embedded in the intermineralization gouge. It is fairly abundant in the Mayflower lode, however, as crystals set in the gouge and as a filling of fracture in and across the gouge and earlier pyritic filling. The pyrite crystals are somewhat larger than the pyrite crystals of the base-metal stage but are otherwise not easy to distinguish from the older pyrite, except by its occurrence in crosscutting seams. In some deposits it is heavily impregnated with gold and at the Mayflower mine also with bismuth minerals.

Arsenopyrite has a much more restricted distribution than pyrite. It is found in the silver-gold ore at the Comeback mine, in the silver ore at the Washington and Edna mines, in the gold ore of the Mountain Chief, Belshazzar, and Mayflower mines near Quartzburg, and in the base-metal lodes at the Missouri mine, as well as in some of the lodes midway between Quartzburg and Grimes Pass. It is notably abundant in some of the ore at the Comeback mine, where it occurs as small rhombic crystals disseminated through some of the finer-grained quartz. Its associations in the silver lodes are similar, and its presence generally means that some of the silver sulfantimonites are also contained in the ore. The crystals are fairly coarse in the Mountain Chief-Belshazzar lode and are scattered more or less abundantly through the quartz, in places projecting outward into open clefts. Some of the richest gold ore mined at the Belshazzar mine contained the gold in and on arsenopyrite crystals. Arsenopyrite is found in just a few places along the Mayflower lode, largely in microscopic grains. The mineral is notably abundant at the Missouri mine and is impregnated more or less widely through the base-metal filling, in part as a replacement of the early pyrite.

The sphalerite deposited during the precious-metal stage has been noted only in lodes on the Mayflower property, where it occurs sparingly as small light-colored grains associated with comb quartz and pyrite in stringers cutting the earlier fillings.

The marcasite in the Belshazzar ore replaces pyrrhotite along the borders of quartz seams. It has a concentric shell-like structure and in part occurs as semispherical masses in a layer bordering the quartz, the size of the layer being proportional to the size of the quartz seam.

The bismuth minerals associated with the gold ores in the Quartzburg area are appreciably abundant in the Mountain Chief, Belshazzar, Mayflower, and Gold Hill mines. The minerals have also been found at the Mineral Hill and Buckskin properties, about midway between Quartzburg and Grimes Pass. In the Gold Hill and the Belshazzar and Mountain Chief lodes the bismuth minerals occur with the second-stage quartz, commonly as needles or tufts of needles between quartz crystals, or as grayish smudges in the granular quartz, but in the Mayflower ore the bismuth minerals occur in and between the crystals of the second-generation pyrite. The minerals are nowhere abundant but are generally visible in small amounts throughout much of the better ore. The proportions and kinds of bismuth minerals differ in the several deposits. Galenobismutite, bismuthinite, and tetradymite appear to be most widely distributed and are found in variable amounts in nearly every deposit, but matildite was not observed in any lode except the Mayflower, and the native bismuth only in ore from the deeper levels of the Gold Hill mine.

The galenobismutite ($PbS.Bi_2S_3$) was first identified in the Belshazzar ore [53] and is the most abundant bismuth mineral there as well as at the Gold Hill mine. It is also relatively abundant locally at the Mountain Chief and Mayflower mines, in each place more or less intimately associated with bismuthinite (see pls. 35, 36). It comprises most of the thin needles and spindles between the young quartz crystals and also the turfs extending into and across open vugs in the Belshazzar and Mountain Chief ore, but at the Gold Hill mine it occurs with other bismuth minerals in scattered small patches and small crystal aggregates in the quartz seams and as needle-shaped and lath-shaped crystals in other sulfides. It also penetrates and replaces some of the older galena and tetrahedrite, and locally some of the nearly contemporaneous boulangerite in the Mountain Chief-Belshazzar ore.

The bismuthinite (Bi_2S_3) is almost as abundant as the galenobismutite, but neither can be distinguished from the other, except by etch reactions and microchemical tests. Like the galenobismutite it occurs as needles and tufts of needles between quartz crystals. It appears to be more abundant than galenobismutite in the ore examined in polished sections at the Mountain Chief mine and more abundant

[53] Shannon, E. V., On galenobismutite from a gold quartz vein in Boise County, Idaho: Washington Acad. Sci. Jour., vol. 11, pp. 298–300, 1921.

than the galenobismutite on some but not all levels of the Gold Hill mine. In some places the bismuthinite laths extend into and replace such minerals as galena, pyrite, boulangerite, and galenobismutite, and perhaps some of the carbonates. It commonly occurs as mantling grains on the galenobismutite crystals.

The tetradymite ($Bi_2(Te, S)_3$) is also widely distributed and occurs invariably as minute microscopic grains in and on the bismuthinite (pl. 30, *A*). It appears to be relatively more abundant at the Gold Hill mine than elsewhere. Its association with bismuthinite rather than with other bismuth minerals is of interest, and its general occurrence on the borders of the bismuthinite suggests replacement relationships.

The native bismuth forms minute light-coppery-pink grains in the galenobismutite and bismuthinite in ore from the 1,100 level of the Gold Hill mine (pl. 30, *B*). Its occurrence at such great depth and not at higher levels excludes any possibility of a supergene origin.

The matildite, found only at the Mayflower mine, occurs separately in and as a replacement of pyrite. It is in part associated with galena (see pl. 31, *A*). Its identity was established by Ramdohr.[54] It shows a prominent lattice structure on etching with HCl or $FeCl_3$ (see pl. 31, *B*). The matildite is apparently one of the earliest of the bismuth minerals at the Mayflower mine, for its grains are penetrated and in part replaced by both galenobismutite and bismuthinite (see pl. 32, *A*).

Except for boulangerite and andorite (?) the sulfantimonites are found only in the silver-gold and silver deposits. Boulangerite ($5PbS.2Sb_2S_3$) was identified as a very minor accessory mineral in the Belshazzar and Mountain Chief ores, where it occurs largely in the form of bent and shreddy laths and fibrous crystals in the dolomitic carbonate and locally in grains of galena (pl. 32, *B*) and enargite (pl. 33, *A*). The andorite (?) occurs as laths pentrating matildite at the Mayflower mine and as grains projecting into and through some of the galenobismutite crystals in the Belshazzar ore (see pl. 33, *B*.). The andorite (?) is also associated with silver minerals at the Washington (pl. 34, *A*) and Edna mines. The mineral is nowhere abundant and is only recognized microscopically, its identity being based on etch reactions and microchemical tests for silver, lead, antimony, and sulfur, using the methods outlined by Short.[55] The composition is given as $Ag_2S.2PbS.3Sb_2S_3$. It has a grayish color and is somewhat harder

[54] Ramdohr Paul, Ueber Schapbachit, Matildit, und den Silber- und Wismutgehalt mancher Bleiglanze: Preuss. Akad. Wiss., Sitzungsber 3–6, pp. 89–91, 1938.

[55] Short, M. N., Microscopic determination of the ore minerals: U. S. Geol. Survey Bull. 825, pp. 78, 94, 180, 1931.

than the bismuth minerals and the silver minerals with which it is in contact.

The chief silver minerals in the silver deposits are miargyrite ($Ag_2S.Sb_2S_3$) and pyrargyrite ($3AG_2S.Sb_2S_3$), the miargyrite apparently being the more abundant of the two. Both were rather scantily represented in the ores available for study. They are commonly associated with arsenopyrite in the fine-grained quartz but also penetrate and surround remnants of the early base-metal fillings. They show particular tendency to enter and replace tetrahedrite and galena, commonly producing graphiclike intergrowths (see pl. 34, *B*). Some of the pyrargyrite in the Comeback lode also occurs in small bunches along fractures that cut through the earlier fillings. Much of the miargyrite and pyrargyrite appears as microscopic grains, commonly together but also in separate grains. Where they occur together the pyrargyrite invariably borders and sends irregular lobes into the miargyrite.

The native gold is one of the most widely distributed minerals in the Miocene deposits and occurs in appreciable amounts in all deposits, though very subordinate to the silver in the silver deposits. It appears to be most abundant where it occurs in association with the bismuth minerals, but it is also an important metal in many of the base-metal deposits. The gold is for the most part somewhat paler in color than the gold in the early Tertiary (?) deposits and commonly contains as much as 20 percent of silver, and locally at the Oro mine may be alloyed with sufficient silver to be classed as electrum. Much of the gold is contained in the young quartz, either as a filling between the quartz crystals or as a filling of fractures in the quartz, but some also occurs in the dolomitic carbonate, and considerable amounts in some deposits are intimately associated with pyrite, arsenopyrite, and the bismuth minerals (see pls. 35, 36). It very commonly lies in and along the bismuth minerals and in some places extends through the bismuth grains. In the Mayflower ore much of the gold has entered the second-stage pyrite (pl. 37, *B*) and has in large part replaced the pyrite along the borders of the bismuth grains as well as in fractures. Much of the gold is microscopic but locally may be coarse enough to be seen without a lens. Some of the gold mined at the Belshazzar mine was exceptionally coarse and locally formed wires and small slabs and sheets as well as minute grains. Some of the richest ore occurred with coarse arsenopyrite crystals that projected into open cavities, the arsenopyrite crystals partly being covered with gold and intricately penetrated by gold. The relations between the gold and the pyrite, arsenopyrite, and the bismuth minerals are in general so intimate as to suggest that all had formed under essentially similar conditions and almost simultaneously. In the base-metal deposits much of the gold is contained in the quartz seams and the carbonates, but some was deposited along the contacts of the fractured sulfides penetrated by the quartz or carbonate (see pl. 38, *A*). In general the gold content of the ore is highest where the quart seams are most numerous, particularly where the quartz seams contain a little of the second-stage pyrite. The sulfides of the base-metal stage appear to be notably auriferous only where they have been invaded and "salted" by the younger metalizing fluids.

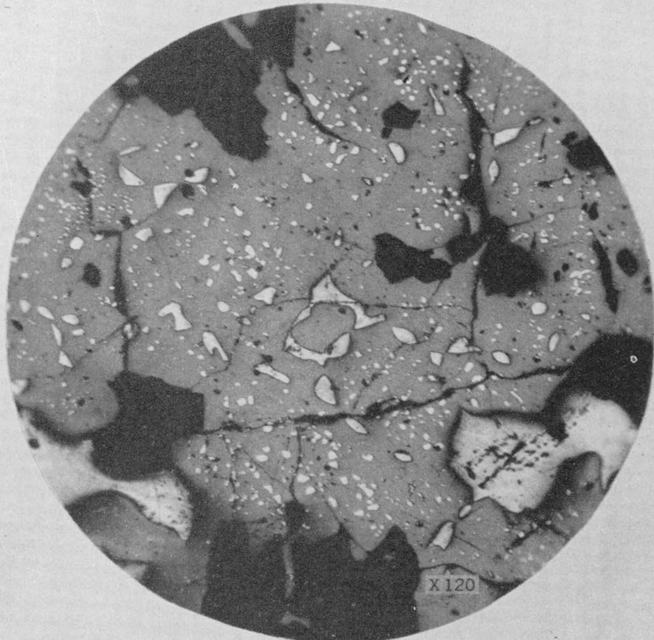
Electrum is the chief ore mineral at the Comeback mine. It is pale yellow and is perceptibly lighter colored than the gold in the other Miocene deposits. Bullion made of it contains nearly equal amounts of silver and gold by weight. Much of it in the ore appears to form small grains and seams between quartz crystals (pl. 38, *B*) and thin sheets in fractures in the very fine-grain quartz. In places it forms very rich pockets. It is apparently the youngest metallic mineral in the deposit, for minute veinlets of it were observed extending through and replacing the pyrargyrite.

PARAGENESIS

Because of the varied composition of the precious-metal ores it is not possible to list a paragenetic sequence that would apply to all deposits. Where the simpler assemblages have been added to some of the base-metal ores, scattered crystals of pyrite occur between and on the crystals of comb quartz and where gold is also visible the gold lies between the quartz crystals, or fills fractures in the quartz, or occurs in the pyrite as irregular grains in part directed along fractures in such a way that its relation can be explained only by replacement. Sphalerite where present rests on quartz crystals and fills the area between them. The order of deposition, therefore, has obviously been quartz, pyrite, sphalerite, and gold. Where arsenopyrite is also present its crystals embay the pyrite crystals or contain irregular residual grains of pyrite as inclusions. The gold has the same relation to the arsenopyrite as to the pyrite, and the mineral succession, therefore, is quartz, pyrite, arsenopyrite, and gold. At the Hartford mine, where tremolite rosettes occur as a layer on quartz combs and druses partly crusted with pyrite, the order is quartz, pyrite, and tremolite, but the position of the gold with respect to the tremolite has not been determined. Where the dolomitic carbonates are present they either crust the quartz crystals or fill fractures in the quartz, and, as gold may be contained in either or both, the succession is obviously quartz, pyrite, dolomite, and gold. Where barite is also present it lies centrally within carbonate seams, or occupies fractures in the carbonates, or fills openings between walls of comb quartz, or fills fractures in the quartz. At the Crown Point prospect, therefore, the mineral sequence is quartz, pyrite, arsenopyrite, and barite, whereas at the Silver Gem mine, it is quartz, carbonate, and barite.

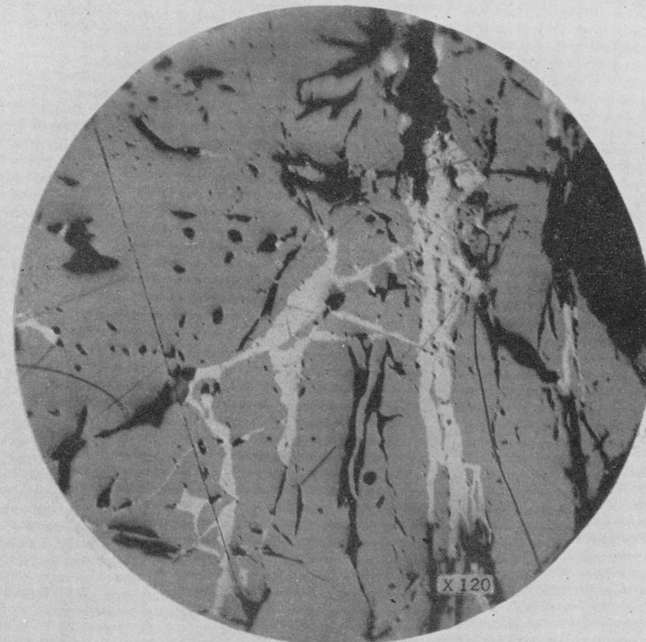
The mineral succession in the gold-bismuth deposits is somewhat more complicated. The relations of the quartz, pyrite, and arsenopyrite are the same as in the base-metal deposits. The gold and bismuth minerals have been deposited in and on these sulfides or have penetrated irregularly into them along fractures and are, therefore, somewhat younger. As the boulangerite has only been found as curved, feathery laths in the dolomitic carbonate and in grains of galena, its position in the sequence can be fixed only indirectly; but, as its laths are cut and some of them are contained as residual inclusions in the bismuth minerals (see pl. 33 *A*), it is consequently older than the bismuth sequence. As the matildite has been penetrated by laths of galenobismutite (pl. 32, *A*) and the galenobismutite in turn is bordered and cut by bismuthinite (pl. 35, *A*) and the bismuthinite has been partly replaced by tetradymite (pl. 30, *A*) and then by native bismuth (pl. 30, *B*), the bismuth-mineral succession is well established, though the associations are so intimate as to suggest almost contemporaneous, or perhaps overlapping, deposition. Apparently the gold was deposited somewhat later than the bismuth minerals, for in the Mayflower ore its grains have in part extended into and replaced some of the bismuth minerals as well as the second-stage pyrite. Similar relations were also observed at the Gold Hill and Belshazzar mines, but in general the association is so intimate as to suggest no great difference in age (see pls. 35, 36). The position of the andorite (?) is not certain. Its laths and grains appear to cut through at least the earlier of the bismuth minerals (pl. 33, *B*), but again there can be little age difference between the andorite (?), the bismuth minerals, and the gold. The complete mineral succession is probably quartz, pyrite, arsenopyrite, dolomite, boulangerite, matildite, galenobismutite, bismuthinite, tetradymite, native bismuth, and gold. Because of the lack of decisive relations between the gold and andorite (?) the andorite (?) is omitted from the succession, though its place probably lies between the bismuth minerals and the gold.

In the silver-gold deposits the sequence is considerably more complicated than elsewhere, largely because of more severe and more numerous structural disturbances and brecciation during the precious-metal stage of deposition. The early quartz of the precious-metal stage is, for the most part, coarse to relatively fine-grained and is commonly drusy, but in places it has been brecciated and cemented by a dolomitic carbonate and a finely crystalline or chalcedonic quartz. Some sphal-



A. SPHALERITE.

Shows characteristic inclusions of minute chalcopyrite blebs and somewhat large blebs of galena. Black mineral is carbonate. Hartford mine, near Quartzburg.

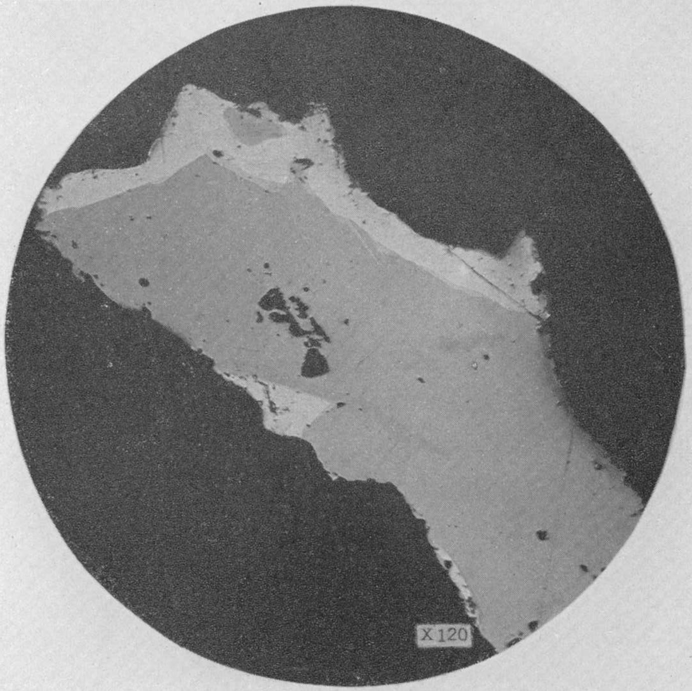


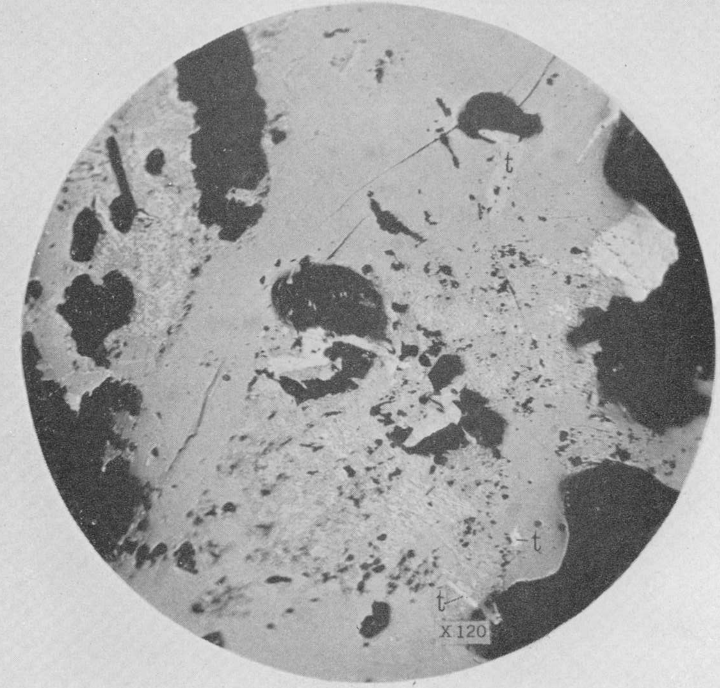
B. TETRAHEDRITE REPLACED BY CHALCOPYRITE.

Shows tetrahedrite (gray) cut and replaced by veinlets of chalcopyrite (white) after the tetrahedrite had become fractured by probable minor structural adjustments concurrent with mineral deposition. Carbonate and holes in section appear black. Golden Age mine, Grimes Pass.

PHOTOMICROGRAPHS OF POLISHED SECTIONS OF MIOCENE ORES.

Show structural and textural relationships of minerals in base-metal sequence.





A. TETRADYMITE (WHITE) AS A PARTIAL RIM ON BISMUTHINITE (GRAY) BETWEEN QUARTZ CRYSTALS (BLACK).

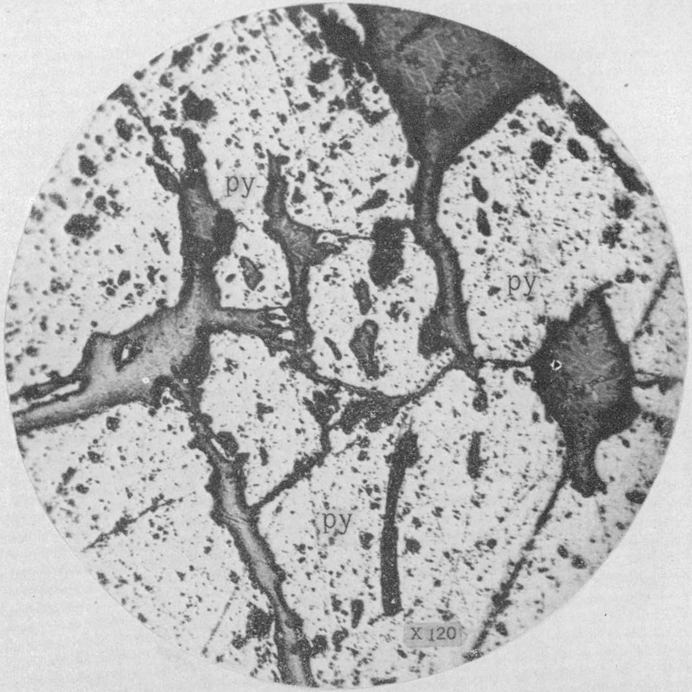
Gold Hill mine, Quartzburg.

B. INTIMATE ASSOCIATION OF GOLD (WHITE), BISMUTHINITE (GRAY), NATIVE BISMUTH (ROUGH MOTTLED AREAS IN BISMUTHINITE), TETRADYMITE (t), AND QUARTZ (BLACK).

Gold Hill mine, Quartzburg.

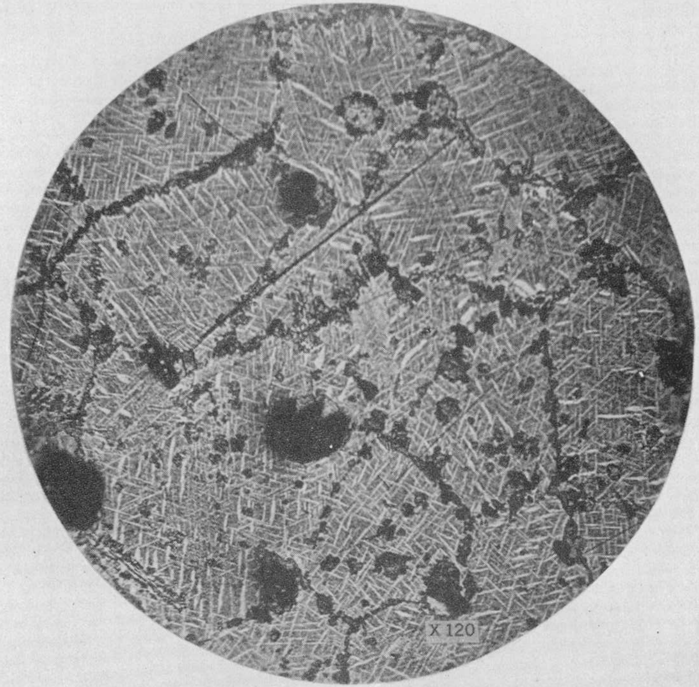
PHOTOMICROGRAPHS OF POLISHED SECTIONS OF MIOCENE ORES.

Show structural and textural relationships of minerals in precious-metal sequence.



A. FRACTURED SECOND-STAGE PYRITE (py) CEMENTED AND IN PART REPLACED BY VEINLETS OF SCHAPBACHITE IN WHICH ARE RETAINED SOME SMALL RESIDUAL GRAINS OF GALENA.

Mayflower mine.

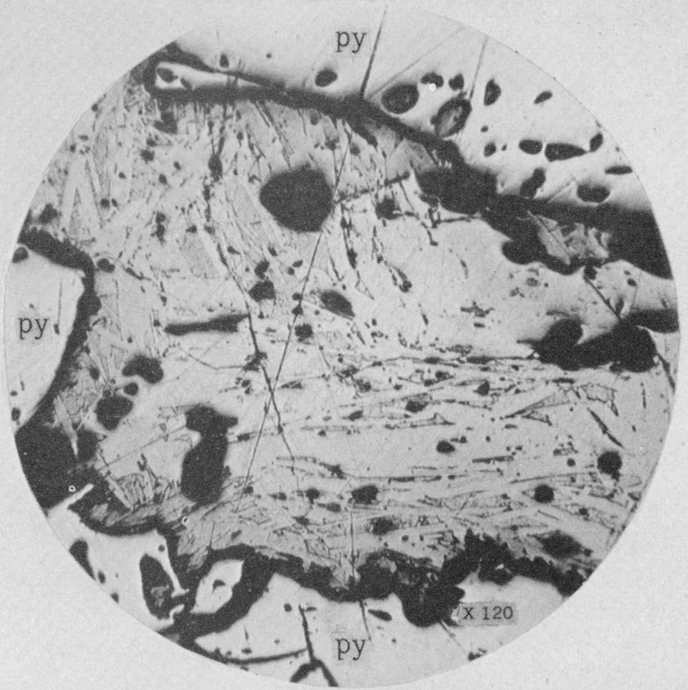


B. SCHAPBACHITE GRAINS DISTINGUISHED BY A PROMINENT LATTICE STRUCTURE AND CONTAINING SOME IRREGULAR REMNANTS OF GALENA IN AND BETWEEN THE SCHAPBACHITE GRAINS.

The galena net apparently is the result of centrifugal replacement. Mayflower mine.

PHOTOMICROGRAPHS OF POLISHED SECTIONS OF MIOCENE ORES.

Show relationships of some of the bismuth minerals.



A. SCHAPBACHITE (GRAYISH ETCH) PENETRATED AND IN LARGE PART REPLACED BY LATHS OF GALENOBISMUTITE.

Both are fitting in between crystals of second-stage pyrite (py). Mayflower mine.

B. LATHS OF BOULANGERITE (LIGHT GRAY) PENETRATING AND REPLACING GALENA (MEDIUM GRAY) IN ORE FROM THE BELSHAZZAR LODE.

The boulangerite is accompanied by dolomitic carbonate (black).

PHOTOMICROGRAPHS OF POLISHED SECTIONS OF MIOCENE ORES.

Show relationships of bismuth minerals and of boulangerite.

erite and galena are contained in the coarsely crystalline variety, but whether the two base-metal minerals are incorporated from the earlier base-metal filling or in part belong to the same stage of deposition as the quartz is not entirely clear. Some pyrite and considerable arsenopyrite are, however, associated with the early quartz, but the scant amounts of miargyrite and pyrargyrite and the electrum appear to have accompanied the younger chalcedonic quartz and also to have spread into the earlier quartz and sulfides. The pyrargyrite replaces the miargyrite (pl. 34, *B*), and the electrum the pyrargyrite as well as other minerals. The complete precious-metal sequence is quartz, pyrite, arsenopyrite, dolomite, quartz, miargyrite, pyrargyrite, and electrum.

The mineral relations in the silver deposits are not much different from those in the silver-gold deposits, and the sequence is quartz, pyrite, arsenopyrite, dolomite, quartz, miargyrite, and andorite. The silver minerals, therefore, like the gold belong to the closing stages of deposition.

Although the gold, wherever its relations could be observed, was the last metallic mineral deposited, it was not the final mineral of the succession, for in most deposits a minor amount of movement took place at the close of the precious-metal stage, and small but variable amounts of calcite were added in widely spaced fractures.

SUPERGENE MINERALS

Supergene minerals are not appreciably abundant in any of the deposits, for in general the oxidized zone is shallow and the primary sulfides not uncommonly appear in the outcrop. In most places the outcrops are more or less stained by brownish iron oxides, and some have been darkened somewhat by the admixture of variable amounts of black oxides of manganese, liberated by the oxidation of the manganiferous carbonates. Some of the outcrops also show greenish stains of scorodite, derived from the alteration of arsenopyrite, also greenish and bluish patches of malachite and azurite from the weathering of original chalcopyrite and tetrahedrite. Supergene sulfides are scantily represented and include small amounts of covellite, which have replaced galena, and some chalcocite, which has replaced chalcopyrite. Anglesite occurs scantily in the partly altered galena, but neither angelsite nor the other supergene minerals mentioned above have added materially to the tenor of the ore.

Supergene silver minerals, however, have increased the tenor of the ore in the silver-gold and silver deposits. Both argentite and native silver occur as secondary minerals, but of the two the native silver appears to be much more abundant and much more widely distributed.

Much of the argentite occurs as microscopic grains and veinlets that have replaced galena, but some larger grains are visible in fractures in the ore at the Washington mine. The native silver commonly occurs as coarse scales and wires in the partly oxidized and leached ore at the Comeback and Washington mines and as scattered foils and wires in fractures and small vugs in the primary ore at greater depth. Much of the ore mined at the Comeback mine in 1934 contained considerable native silver.

STRUCTURAL CHARACTERISTICS OF THE ORE

The different kinds of deposits are very much alike in their characteristic structural features as fracture filling rather than replacement has dominated their mode of formation. The general relationships of the fracturing have been described in some detail on pages 192–194, where it was pointed out that deposition occurred either along complex fissures and fissure zones along which the bordering rock had been extensively fractured or along zones of oblique fractures, minor components of a more extensive and complicated zone of shearing. For the most part the ore deposits vary in their structural details to the same degree as the controlling fractures, and the differences in deposits are largely compositional rather than structural.

In some of the fissures and fissure zones the ore is localized along the main fracture plane, and the filling, therefore, is more or less tabular and veinlike, but as many of the subsidiary fractures also contain ore, or the ore lenses alternate with zones of seams and stringers, the deposit as a whole has a lodelike rather than veinlike character, with the lenses comprising the main ore shoots. The lenses may range from an inch to 24 inches in thickness, but the thickness of the lode may be increased to several feet by the seams and stringers alongside. The broad fracture zones, which are as much as 40 feet across, contain some ore seams throughout, but most of the seams are concentrated near the main fracture plane, and the minable part of the lode is, therefore, restricted to a zone commonly less than 6 feet wide. The main ore shoot generally lies near or along the footwall, and most of the stringers extend into the hanging wall, where, in places, they may join another seam parallel to the footwall shoot. Some of the base-metal lodes near Grimes Pass are of this character and consist of fairly compact ore lenses 6 to 12 inches thick, locally as much as 24 inches thick, and as much as 40 feet long, bordered by numerous subsidiary seams and stringers, which commonly connect with a narrow hanging-wall seam a few inches thick. Along the strike the more massive bands commonly alternate with zones of less closely spaced seams and stringers of about equal length. The Belshazzar and Mountain Chief lodes are somewhat similar and have ore lenses a few inches to a foot or more thick with subordinate seams and stringers through a zone more than 20 feet wide. Some of the pyritic lodes, however, are more uniformly mineralized, because the pyrite has entered into and replaced the wall, and the original guiding fractures have been largely obliterated through the filling of fractures and the replacement of rock alongside. Other lodes are composed almost entirely of rather closely spaced seams and stringers or of seams and stringers with scattered small lenses, nests, or pockets of ore in gouge. Other deposits are made up of a series of lenses and affiliated stringers, separated one from another by equal spacings of essentially barren fissure material. Still other lodes are extraordinarily composite and are made up in large part of narrow seams and stringers, which may lie in and parallel to the plane of fissuring and in directions oblique thereto. Coalescence of these seams and stringers may form small bodies of ore. In places the main ore seams are in subordinate fractures oblique to the general direction of shearing and are localized by undulations along the fissure zone. In a few places minor amounts of ore have been disseminated through the rock for several feet, locally as much as 20 feet on each side of the main ore body. Compact seams apparently favor fissures in the granite rock of the batholith, for as the fissures pass into the dike rocks they tend, as pointed out elsewhere, to splinter into zones of fractures along which the ore becomes dissipated in a widely spaced zone of stringers. In one deposit the ore occurs as a replacement mass along a crushed zone in quartz monzonite porphyry.

The structure of the lodes also reflects the movement and recurrent fracturing that took place during the general period of ore deposition. Because deposition was interrupted by structural adjustments, the ore lenses, seams, and stringers are not all the same age; lenses commonly cut through older seams and stringers, and younger seams and stringers also penetrate and cut earlier fracture fillings. Commonly the earlier fillings have been widely incorporated into the younger ore stringers and lenses, and, in part at least, the structure of the lodes is that of a breccia—a breccia of older filling and altered country rock in a matrix of younger ore. As many as four sets of crosscutting seams and stringers have been observed within a deposit; for example, seams and stringers of pyrite are cut by seams and stringers of sphalerite and galena, the two in turn being penetrated and cut by stringers and lenses of quartz and associated minerals of the precious-metal stage, and the three by a still younger and more widely spaced series of seams and nests of calcite. The structural relations are even more complex in detail, for the lodes have not been uniformly and constantly reopened by structural adjustments concurrent with mineral deposition, and crosscutting stringers are, therefore, not uniformly or evenly distributed.

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The pronounced intermineralization movement intervening between the base-metal and precious-metal stages has also added to the complexity of the structural relations of the ore. Considerable amounts of the early base metals and pyrite were ground up in the gouge or incorporated in the gouge in the form of rolled pebbles and boulders. The bands of gouge are commonly 6 to 8 inches thick and in most places are among the most conspicuous features of the lodes. Some of the lodes are defined by several bands of gouge, of which one on either wall is more prominent than the others. In some deposits the main band of gouge crosses from one side of the ore body to the other. In many the main base-metal seam has been largely incorporated in the gouge, and the lode is characteristically a thick band of black gouge with crushed sulfides bordered by more or less shattered ore seams and stringers. Many deposits have been so much disturbed by the intermineralization movement that the lode fillings consist largely of a soft gougy matrix containing crushed ore. Crushing has played such a prominent role in most deposits that perhaps the typical lode might be defined as one that has a prominent band of gouge along either the foot or hanging wall or both, bands and lenses of ore along the gouge bands, and seams and stringers of ore in the less-disturbed rock alongside. In nearly all deposits the gouge has so much ore in it that it is mined along with the lenses, seams, and stringers. The gouge has also had an influence on the distribution of the younger precious-metal ore. In some places it has served to dam the ore-forming solutions, and the gold has been deposited on the gouge, or has penetrated into the gouge along fractures, or has been diverted into the fractured rock alongside the bands of gouge. In some places the fissures were so completely filled with gouge that the second-stage solutions were unable to enter but had to permeate zones along which movement had tended to separate the walls. Apparently the adjustments following the precious-metal stage of deposition were slight and produced little or no additional gouge. Cross slips have nowhere offset the ore bodies more than a few inches or a foot or two and the young ore seams scarcely at all. The gouge in the lodes helps materially to intensify the contrast between lode filling and country rock.

The lodes that are localized along zones of overlapping oblique fractures, for example, the Pioneer ore bodies at the Gold Hill mine, are appreciably different from the fissure lodes. The ore in them is spread through the minor fractures in thin seams, generally short, discontinuous, and jagged in detail, and the seams are set at an oblique angle to the trend of the ore body. Some fractures parallel the ore body in the general direction of the shearing, but these are in general not so highly mineralized as the oblique fractures, apparently because they were filled with gouge produced by slippage of the walls in the direction of the shearing. The solutions diverted by the gouge, sought out the open tensional fractures and deposited much of the ore in them. The lode structure is not conspicuous, and assays are necessary to distinguish between ore and altered rock.

CHARACTERISTIC COMPOSITION OF THE ORE

The principal differences in the deposits are in the relative proportions of the minerals deposited during the base-metal and precious-metal stages. On the basis of the most abundant and most valuable minerals it is possible to group the deposits into seven fairly distinctive, yet gradational types; namely, pyritic lodes, base-metal lodes, gold-base-metal lodes, gold-bismuth lodes, gold-quartz lodes, silver-gold lodes, and silver lodes. Some of these deposits are dominated by the minerals of the base-metal stage, others by minerals of the precious-metal stage, and some by the abundance of certain minerals belonging to each of the two stages.

PYRITIC LODES

The pyritic lodes are in general the least complex of the Miocene deposits, for most of them were not seriously disturbed by subsequent structural adjustments and therefore contain essentially nothing but pyrite and in places a little early quartz. In them the pyrite is for the most part much more abundant than in the other types of deposits, and the abundance appears to reflect a condition peculiar to the pyritic lodes in contrast to the other lodes. The typical deposit consists of a broad zone of highly pyritized rock containing bands, seams, and stringers of massive pyrite. In most deposits it is difficult to distinguish between the pyrite deposited in the fractures and the pyrite that impregnated the wall rock. Some broad zones are composed of practically nothing but massive pyrite, much of which perhaps was deposited by replacement of the country rock. In the less conspicuous pyritic lodes the pyrite is generally confined to seams and stringers.

Most of the pyritic lodes were disturbed to some extent by movement, though not in general to the same degree as other types of deposits, and some of them, therefore, contain small scattered bunches of base-metal sulfides, commonly sphalerite and galena, and locally also scattered seams and stringers of the second-stage quarts and pyrite. These lodes did not altogether escape the pronounced structural movement that intervened between the base-metal and precious-metal stages, and the bodies are commonly cut or bounded by bands of gouge as much as 8 inches or more thick. In general the scattered pods and nests of base metals lie in and along the bands of gouge or are incorporated in the gouge as crushed grains, or rolled pebbles, but in places widely scattered base-metal seams may be out in the walls and may cut across the pyritic seams and stringers. The small bunches and pockets of base metals, however, are far too widely scattered and form too small a proportion of the entire lode filling to add anything to the material value of the ore. As the proportion of base metals increases, however, the pyritic lodes pass over into the lodes of the base-metal groups.

In some of the pyritic lodes considerable quantities of pyrite were added after the period of intermineralization faulting, but the younger pyrite cannot be easily distinguished from the older pyrite unless the pattern of crosscutting seams is preserved, or the pyrite crystals are embedded in the gouge or lie in unbroken stringers in the gouge. Some of the pyritic lodes may have been considerably augmented by the addition of the younger pyrite. The Mayflower lode is a fine example of an earlier pyrite lode invaded by a relatively large proportion of younger pyrite, but as the young pyrite is associated with appreciable amounts of bismuth minerals and gold the lode is classed with the gold-bismuth lodes. The Homeward Bound lode on the same property and the Coin Bond lode several miles northeast of Quartzburg are also examples of pyritic lodes that have been reopened and have received appreciable amounts of gold. In some deposits considerable quartz has also been added and forms seams and stringers cutting the more or less massive pyrite. Both the J. S. and Missing Link lodes near Grimes Pass are highly pyritic and contain late quartz seams and stringers and probably have had pyrite added to them at the time the quartz was deposited. The significance of the reopening and the introduction of minerals belonging to the second cycle of deposition is clear, for the undisturbed or little disturbed pyritic lodes ordinarily contain less than 0.1 ounce of gold to the ton, whereas those that were invaded by younger ore-forming solutions not uncommonly assay from 0.25 to 0.75 ounce in gold per ton. Some have contained pockets of very rich ore.

BASE-METAL LODES

The base-metal lodes includes those in which the base metals and contained silver provide essentially the only source of value because of almost negligible amounts of gold. These lodes either escaped appreciable reopening after the base-metal stage, or the younger solutions contributed little except barren gangue minerals. This type of lode is represented by very few examples, as most of the base-metal deposits have an added gold content and belong to the gold-base-metal group. Only one lode was found in which the lack of gold might be ascribed to failure of intramineralization faulting to provide openings for the movement of the younger ore-bearing solutions. This lode, the Blackjack, on Grimes Creek above the power plant of the Mineral Mining Co., is structurally unlike the others and is a filling of sulfides, principally sphalerite and galena, in brecciated quartz monzonite porphyry. The ore cements and replaces the crackled porphyry and forms an ore body about 15 feet wide frozen tightly in the porphyry with no evidence of gouge either along the walls or within the body. Parts of the body evidently were slightly fractured, for some of the ore is cut by thin inconspicuous seams of quartz, but apparently little or no gold was added. The absence of conspicuous structural movements during the period of ore deposition sets this deposit apart from all others.

The other base-metal lodes exhibit the usual features of the Miocene deposits. Few of them contain a preponderance of pyrite but are characterized by a relative abundance of sphalerite and galena, locally tetrahedrite and chalcopyrite, accompanied by almost as much second-stage quartz or dolomitic carbonate and locally by minor amounts of barite.

In most deposits the base-metal sulfides are at least as abundant as the pyrite, and the typical deposit is made up of seams, lenses, nodules, and stringers of rather compact and intimately associated sulfides cutting the considerably pyritized rock in and along the fissure zone. In part the sulfides occur as bands and lenses along the plane of the fissures and in part as seams and stringers in the rock alongside. In places the seams and stringers connect with another band along the opposite wall. Some of the sulfide lenses are as much as 2 feet thick, and the presence of the seams and stringers alongside may increase the width of the lode to 4 or 5 feet. In some deposits the seams and lenses of base metals penetrate, or lie in or alongside, earlier seams and lenses of massive pyrite. The base-metal ore in general contains a relative abundance of pyrite inclusions. In some lodes the base metals have also entered into and replaced the altered wall rock and occur as disseminated crystals and granules several feet from the guiding fractures.

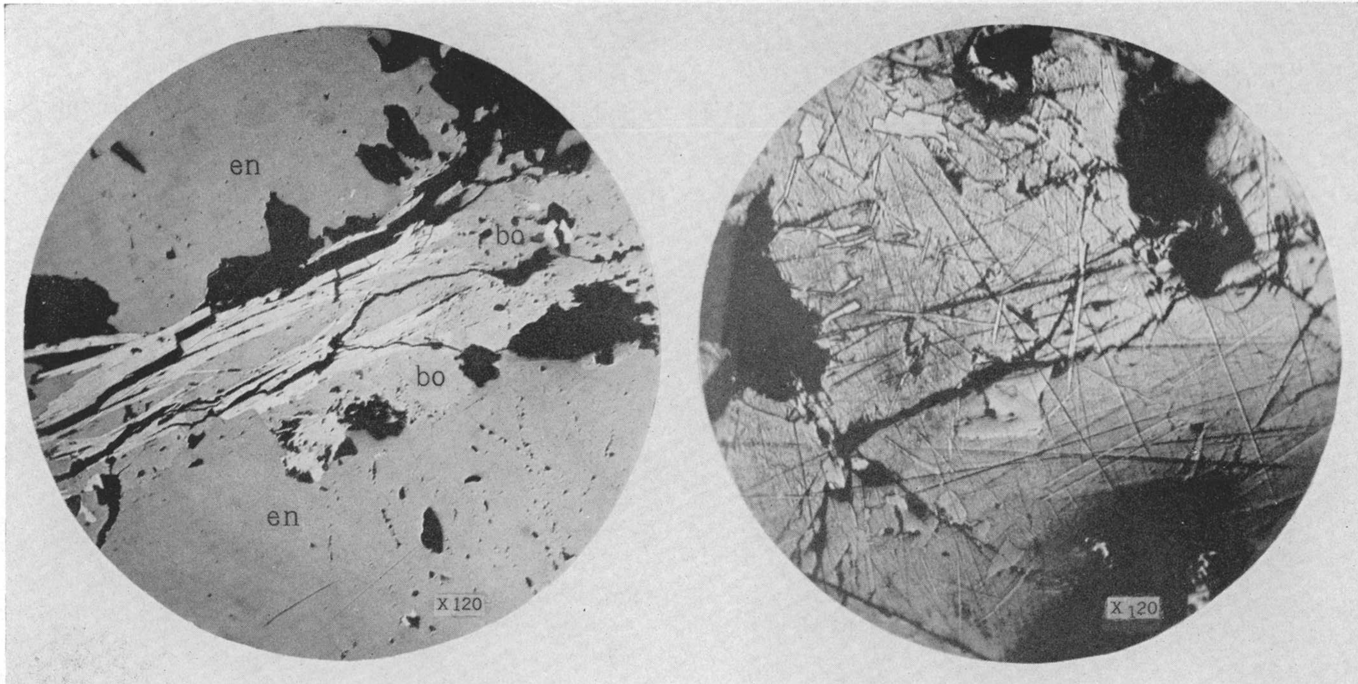
In most lodes the base-metal filling was more or less thoroughly shattered by the movements that intervened before the deposition of the second-stage minerals began, and the ore resembles a breccia of sulfide fragments in a scant to fairly abundant matrix of carbonate or quartz. The quantity of cementing matrix varies from lode to lode and even from place to place within the same lode. In some places the fractured sulfides have scarcely been separated; in other places the fragments have been torn apart and widely scattered through the matrix. In lodes not so thoroughly reopened, the added quartz, or carbonate, is in scattered seams and irregular bunches cutting the massive sulfides. Most of the base-metal deposits are also bordered and cut by broad bands of gouge in which considerable ore is also incorporated. Among the few examples of this group the Silver Gem is probably the most outstanding. Tetrahedrite is one of its most abundant minerals, and from shipments made the returns have been chiefly in silver, lead, copper, and zinc. The small amount of gold in the ore is of more than ordinary interest in view of the extensive fracturing of the base-metal filling and the presence of considerable carbonate and some young quartz and barite. The Smuggler lode in Charlot Gulch may also belong to this type of deposit, for most of its ore is apparently composed of galena. The Crown Point, with bunches of tetrahedrite invaded by a more abundant quartz-barite gangue, may also be included in the type.

GOLD AND BASE-METAL LODES

The gold and base-metal lodes are not appreciably different from the ordinary base-metal lodes, except that gold is an important byproduct, if not the most important product. In general the content of base-metals is somewhat lower than in the base-metal type but in most deposits is high enough to make recovery profitable. In most of them the ore perhaps could not be mined except for the combined value of gold and base metals. In many places, however, the base metals have been discarded in the tailings and the ore treated only for its gold.

The characteristic structural features of the gold-base-metal lodes are not materially unlike those of the base-metal lodes, unless the presence in some places of a relatively larger proportion of gouge may be considered a difference. The gold-bearing lodes have apparently been more severely disturbed by the intramineralization movements than the base-metal lodes, more of the base metals have been incorporated in the gouge, and more of the younger quartzose and carbonate seams, accompanied by a higher proportion of gold, have penetrated the lode filling. In some of the lodes the base metals are strewn along the gougy filling in scattered nests and pockets much as they appear in some of the pyritic lodes, but in others the sulfides form more continuous lenses and bands and occur also in the subsidiary seams and stringers. Some of the fillings have been only sporadically penetrated by second-stage quartz seams, but these seams have in a few cases carried high gold values. Because of the very irregular, generally spotty, distribution of the younger gold-bearing seams considerable risk is involved in mining the deposits for the gold alone, but chances for success are increased where the base metals are recovered as well.

The main lode on the Enterprise group in Charlot Gulch is fairly representative of the type and was first worked for its gold. Lead,



A. ENARGITE (en) BELONGING TO THE BASE-METAL STAGE OF DEPOSITION INVADED AND REPLACED BY YOUNGER BOULANGERITE (bo) AND BOTH OF THEM INVADED AND REPLACED BY LATHS OF BISMUTHINITE (WHITE).

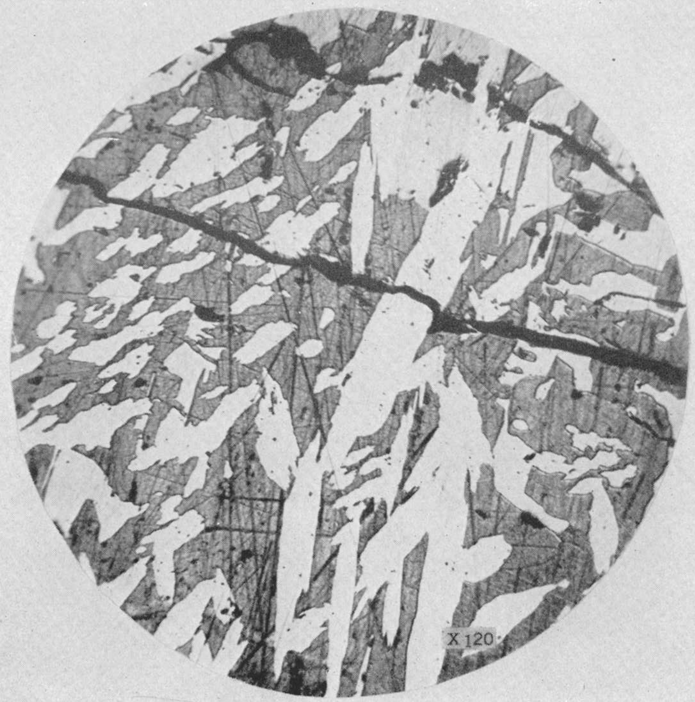
Belshazzar mine.

B. BISMUTHINITE (GRAY) PENETRATED BY BLADES AND LATHS OF ANDORITE (?) (WHITE) AND CUT BY SEAMS OF CALCITE (BLACK) IN FRACTURE.

Belshazzar mine.

PHOTOMICROGRAPHS OF POLISHED SECTIONS OF MIOCENE ORES.

Show relationships of the second-stage bismuth minerals and of the silver sulfosalts.



A. PYRARGYRITE (DARK-GRAY) PENETRATED BY GRAINS AND LATHS OF NEARLY WHITE ANDORITE (?).

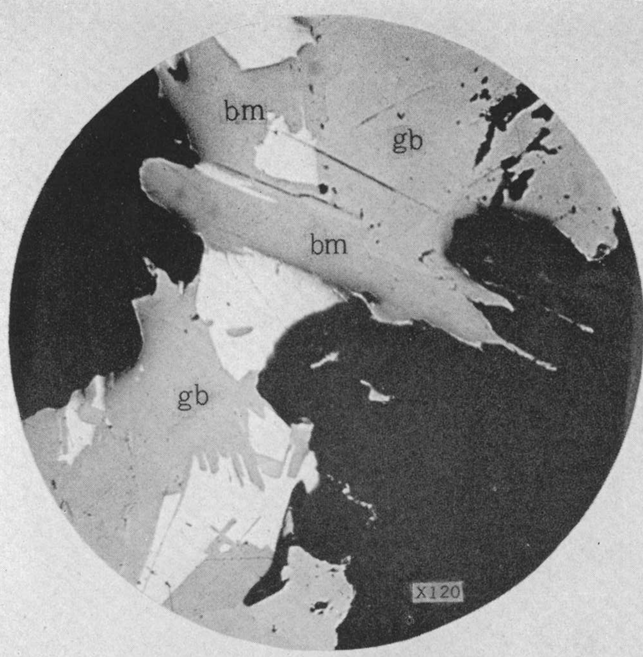
Silver lode at the Washington mine.

B. PSEUDOEUTECTIC INTERGROWTHS OF TETRAHEDRITE (DARK GRAY) AND MIARGYRITE (WHITE) AND OF MIARGYRITE AND PYRARGYRITE (MEDIUM GRAY) IN ORE FROM THE COMEBACK MINE.

The relations are interpreted as replacement of the tetrahedrite by miargyrite and of the miargyrite and tetrahedrite by pyrargyrite.

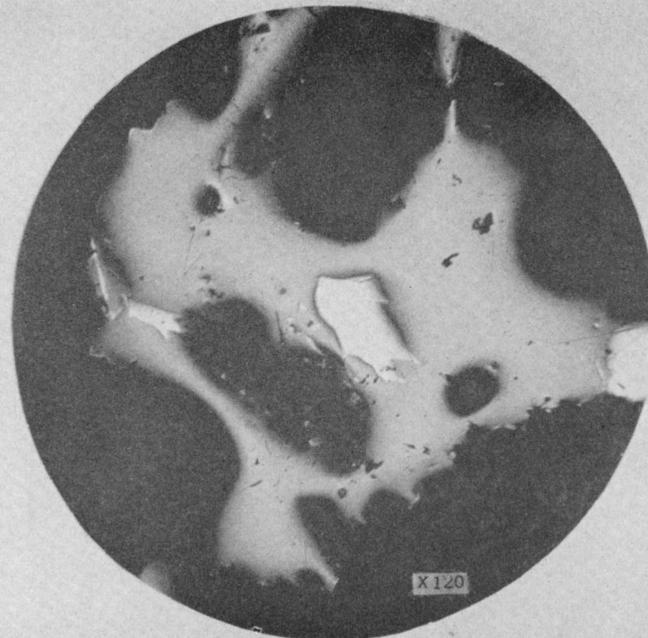
PHOTOMICROGRAPHS OF POLISHED SURFACES OF MIOCENE ORES.

Show relationships of the late silver sulfosalts.



A. INTIMATE ASSOCIATION OF GOLD (WHITE) WITH GRAINS AND CRYSTALS OF BISMUTHINITE (bm) AND GALENOBISMUTITE (gb) IN QUARTZ (BLACK).

Gold Hill mine.

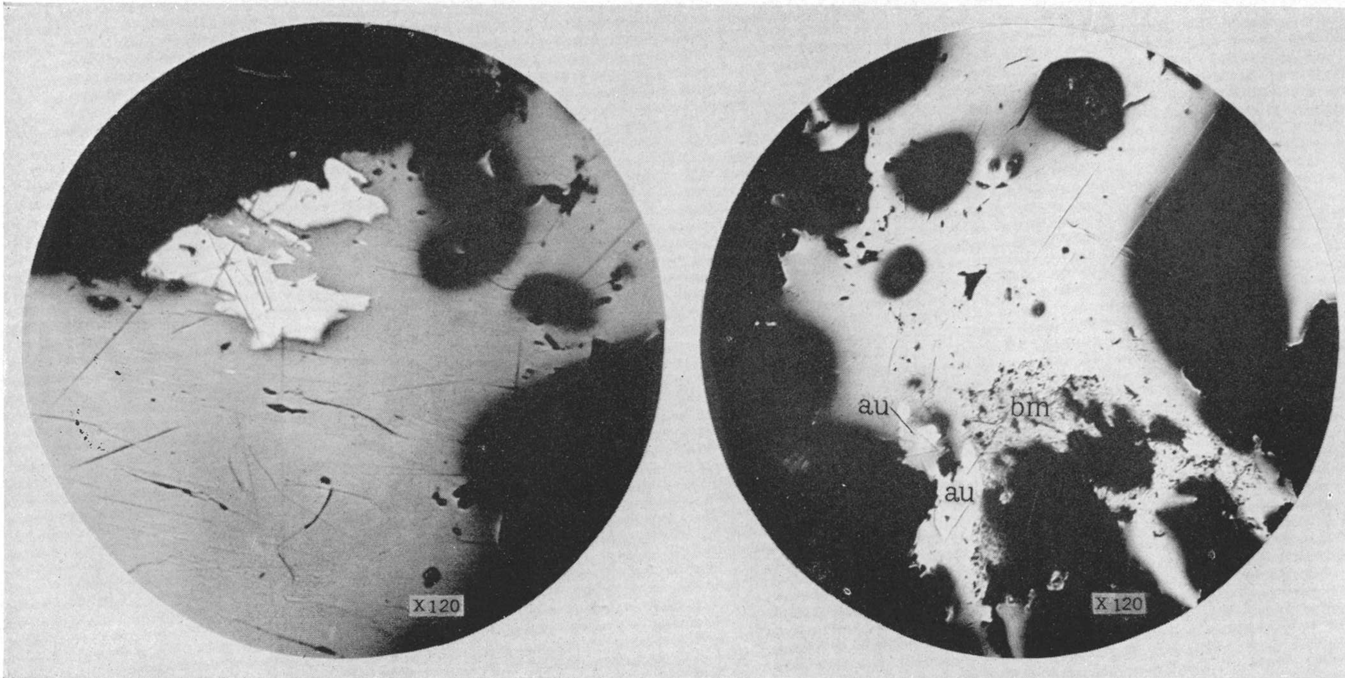


B. GOLD (WHITE) IN GALENOBISMUTITE (GRAY) AS A FILLING BETWEEN QUARTZ CRYSTALS (BLACK).

Gold Hill mine.

PHOTOMICROGRAPHS OF POLISHED SECTIONS OF MIOCENE ORES.

Show relations of gold to bismuth minerals in the gold-bismuth deposits.



A. ASSOCIATION OF GOLD (WHITE) WITH BISMUTHINITE (GRAY) AND QUARTZ (BLACK).
Gold Hill mine.

B. ASSOCIATION OF GOLD (au) WITH GALENOBISMUTITE (GRAY) NATIVE BISMUTH (ROUGH AREA MARKED bm ON THE GALENOBISMUTITE, AND QUARTZ (BLACK).
In ore from the 1,100-foot level of the Gold Hill mine.

PHOTOMICROGRAPHS OF POLISHED SECTIONS OF MIOCENE ORES.

Show relations of gold to bismuth minerals in the gold-bismuth deposits.

silver, and zinc were later recovered and added materially to the output. The Golden Age lode at Grimes Pass also contained appreciable amounts of galena, sphalerite, and tetrahedrite, but only the gold received attention. Attempt was made, however, to recover both base metals and gold at the Missouri mine. The ore at the Oro mine, which contained scattered bunches of tetrahedrite, was treated in a stamp mill to recover the gold, confined for the most part to thin quartz seams cutting the gougy matrix. Several cars of copper ore were shipped from the Coon Dog No. 1 in which both gold and silver figured prominently in the smelter returns. These examples perhaps suffice to show the importance and workability of the gold-base-metal type.

GOLD-BISMUTH LODES

The gold-bismuth lodes also have their own distinguishing features, and, except for the lodes on the Mayflower group, are different from the pyritic and base-metal deposits in that the fissure and fracture zones are filled largely with second-stage quartz, and the lodes, therefore, contain a preponderance of quartz. The structural history, however, has been no different from the others, and each of the lodes shows subordinate earlier pyritic and base-metal seams and stringers penetrated and parts of them broken and engulfed in the younger more abundant quartz. Both the Gold Hill and the Mountain Chief-Belshazzar lodes are alike in that much of the added quartz has occupied the main fissure and occurs in prominent veinlike lenses commonly more than a foot thick fringed by quartz seams and stringers in the walls alongside. These lenses have incorporated some pyrite and base metals but have left scattered pods and nests of base metals in or along the ever-present band of gouge, or in the more distant fractures in the walls. The sulphide seams and stringers, though invariably present through the lode and forming the chief filling in places, have less volume than the younger, superposed filling. The second-stage quartz in the Gold Hill lode had scattered grayish smudges of bismuth minerals, but the ore at the Belshazzar and Mountain Chief mines had a relatively high content of coarse pyrite and arsenopyrite crystals and scattered tufts and smears of bismuth minerals between and on quartz crystals.

The Pioneer lodes at the Gold Hill mine differ from the other gold-bismuth lodes only in structural details, as the ore is confined to the sets of oblique fractures and consists of thin quartz seams with gold and bismuth, which extend diagonally across the long dimension of the ore bodies. These short, jagged seams also cut widely scattered small seams and stringers of the earlier pyrite and sphalerite and to some extent even less abundant seams filled with galena and tetrahedrite.

The Mayflower lode is essentially a pyritic lode but contains some scattered bunches of base metals in the main gouge seams and to lesser extent in the fractures in the adjacent walls. As a gold-bismuth type it differs from the Gold Hill and Mountain Chief-Belshazzar lodes in almost a complete absence of quartz. Instead, the lode has been penetrated by rather abundant auriferous pyrite accompanied by bismuth minerals and free gold and in places scant amounts of arsenopyrite and quartz. The young pyrite has penetrated the lode much like the quartz seams and stringers in other deposits, but much of it appears to be concentrated near or along the prominent band of intramineralization gouge or locally in short diagonal seams which have filled fractures extending obliquely across from the footwall to the hanging wall of the lode.

The gold-bismuth lodes have been the largest and most consistent gold producers in Boise Basin. The gold-bismuth association appears to be a natural one and is not due to structural mishaps wherein gold might have been added to the bismuth deposits after a structural break. With depth, however, the gold and bismuth appear to part company, the gold dropping out but the quartz and bismuth ore continuing downward.

GOLD-QUARTZ LODES

The gold-quartz lodes differ from the others in the absence of the early pyritic and base-metal ores and are composed instead of quartz seams and stringers and a little associated pyrite and gold and locally tremolite, and generally minor amounts of late calcite. The seams and stringers are much like the late seams and stringers that penetrated the base-metal lodes and are apparently products of the precious-metals stage of deposition, but the solutions must have spread through new fractures created perhaps by the prominent intramineralization faulting in previously unfractured or little fractured rock. Small scattered inclusions of pyrite, sphalerite, and galena from an earlier very scant sulphide filling have been incorporated in the quartz seams and stringers in some lodes. The quartz is the usual comb and drusy variety associated with the younger stage of deposition, and some of it is also fine-grained. In general the seams are rather widely spaced, but in some places they are concentrated into relatively small shoots.

SILVER-GOLD LODES

The silver-gold lodes are confined to the ground of the Comeback mine and are typified by the locally famous Comeback lode. The structural features of the lode are much the same as for other lodes along the "porphyry belt." The fracture zone is about 40 feet wide and has prominent planes of fissuring along both the hanging wall and footwall, though much of the minable ore has been confined to the footwall fissure. Little attention has been given the widely scattered ore seams and stringers between the walls. This lode like the others is prominently outlined by bands of gouge, considerable amounts of pyrite and other sulfides being pulverized in the gouge, but the principal ore commonly forms thin lenses and stringers alongside or occurs in nests and bunches along the lodes. The ore is notably quartzose and, as pointed out in another part of the report, contains an abundance of chalcedonic quartz, which in places lies on or cuts a more coarsely crystalline in part comb and drusy quartz. Some of the coarser-grained quartz has engulfed fragments of pyrite, sphalerite, tetrahedrite, and galena, incorporated from a rather scant early base-metal filling, and is itself associated locally with considerable arsenopyrite and pyrite of about its own age. The electrum and silver sulfantimonites are apparently associated with the youngest seams, stringers, and lenses of the fine-grained, chalcedonic quartz. The rich ore is sporadically distributed and is found in scattered bunches or pockets. The lode is to be distinguished from the others, therefore, by the presence of two generations of the young-stage quartz and by the especial abundance of the fine-grained variety. Other distinctive features are the relatively high silver content of the ore and the overwhelming abundance of minerals belonging to the second cycle of metalization.

SILVER LODES

The silver lodes were not adequately exposed, and inferences made regarding them are based largely on ore examined on the dumps. The ore on the dump at the Washington mine suggests that the silver-rich second-stage ore-forming solutions penetrated a fractured but otherwise compact base-metal filling a few inches wide. The ore, though now rather quartzose, contains a fairly high proportion of base metals, particularly sphalerite and galena, and lesser pyrite, tetrahedrite, and chalcopyrite. The younger solutions contributed much rather fine-grained quartz, considerable arsenopyrite, and minor amounts of pyrite and the silver sulfantimonites, miargyrite, pyrargyrite, and andorite (?). The silver lode at the Edna mine apparently differs from the Washington lode in containing lesser amounts of the base-metal sulfides and proportionately larger quantities of the young, fine-grained, chalcedonic and also comb and drusy quartz. Numerous quartz seams and stringers were observed alongside the lode in the workings accessible underground, and the rather limited exposures suggest features somewhat like those of the Comeback lode but perhaps with a larger proportion of the silver sulfosalts.

DISTRIBUTION AND CONTROL OF ORE SHOOTS

As the ore was deposited for the most part as a filling of open spaces, the permeability of the fissure and fracture zones has obviously controlled the distribution of ore and the localization of the ore shoots, whereas the size and spacing of the openings has determined the size of the ore shoots. The problem of the distribution and control of ore shoots is, therefore, primarily a structural problem, and its solution depends on the analysis of the structural conditions that existed prior to and during the period of ore deposition.

In most of the fissure zones the distribution of the ore appears to accord more or less closely with perceptible changes in strike and dip, or with so-called undulations in the fissure walls, and some of the largest and richest ore shoots have been found where the dip is notably gentle or curvature along the strike conspicuously prominent. In part at least, steepening of the fissure has generally been accomplished by a decrease in the amount of ore, but the rule is not applicable to all deposits, and factors other than those of structure have also played a part in bringing about variations in the amount and tenor of the ore. As the distribution of the ore shows a marked relation to irregularities of the fissure walls, the original permeability may have been produced by the movement of one wall against the other so as to bring together into juxtaposition rock surfaces that do not fit together and, therefore, bound openings favorable to the movement of ore-forming solutions and the deposition of ore. Striations and grooves on gouge and slickensides along a number of the lodes show that one wall slipped past the other in a nearly horizontal but slightly inclined direction, the striations and grooves dipping 20° to 35° SW. This slightly inclined movement, therefore, has brought the walls into such positions that essentially any variation in strike or dip has localized zones of especial permeability separated by zones of barren fissure where the walls have rubbed tightly together. Most of the fissures are strikingly irregular, and zones of permeable openings alternate in rapid succession with zones of sealed fractures. The ore shoots in most deposits are prone to be rather small and have stope lengths of 30 to 40 feet separated by equal lengths of slightly mineralized or barren fissure, but the ore shoots are commonly repeated at intervals along the fissure zones, and in the larger mines the lenticular bodies may be spaced so closely as to provide an essentially continuous ore body several hundred feet long.

The distribution of the ore in the lodes of the Pioneer type (in zones of oblique fractures along broader zones of shearing) is also controlled by structural openings. In these the ore has spread through many small fractures opened by tensional stresses and alined obliquely to the general direction of shearing. These zones of tensional fractures were, therefore, especially permeable, as the opening did not produce any gouge to impede the circulation of the ore-bearing solutions.

Some of the oblique fractures along fissure zones, in the Mayflower lode, for example, were also similarly created by tensional stresses related to the shearing and therefore favored the localization of ore seams and stringers.

The problem of ore-shoot control involves not only the recognition of the mechanics of movement and the formation of permeable openings but also the time of reopening, for in most deposits the precious metals were added only after the earlier fillings had been fractured by further faulting movements. Most of the early openings were apparently filled with pyrite and base metals and the cycle of deposition brought to a close with the formation of pyritic and base-metal lodes, whereas the precious-metal ore shoots were deposited only in lodes reopened by renewed structural adjustments. Many lodes were only slightly reopened and hence had little chance to receive additions of gold ore, whereas other lodes were extensively reopened and literally flooded with mineral assemblages belonging to the precious-metal stage. Reopening, therefore, played an exceedingly important role in localizing ore shoots, and its place in ore-shoot control should not be underestimated. Fortunately, the structural adjustments continued in the same directions as the earlier movements, and the younger solutions for the most part invaded the zones that had originally been most permeable and that had been filled with the older base metals. The gold-bismuth ore in the Pioneer lodes, however, apparently took advantage of a set of fractures produced during the major intramineralization disturbance and so is largely independent of earlier fillings. Minor structural adjustments within the base-metal stage of deposition also acted to control the distribution of seams and bunches of sphalerite and galena and other associated sulfides with respect to the somewhat older pyrite.

The board bands of intramineralization gouge so conspicuous in most of the deposits has played a part in the distribution of the gold. In places the gouge has served to dam the solutions and force them out into minor fractures alongside; in other place the gouge has directed the gold-bearing solutions and caused the deposition of gold in bands along the gouge; and in still other places the gouge has sealed the fractures and kept the solutions entirely away.

The character of the country rock has also played an important role in the distribution of the ore shoots. In general the granitic rock of the batholith has been more favorable to the localization of ore bodies than the porphyry dikes because of the tendency of the granitic rock to produce open fissures and the tendency of the porphyry dikes to splinter into a broad zone of scattered smaller fractures. The Pioneer ore bodies, which are for the most part confined to dikes of rhyolite porphyry, appear to be the only exceptions. Elsewhere the dikes commonly contain broad zones of sulfide seams and stringers in relatively widely spaced fractures and show so little evidence of intramineralization disturbance as to have largely escaped more than minor additions of precious metals. Fissure and dike intersections have apparently had little affect on the localization of ore shoots, and most ore bodies are as large and rich many feet from a dike as against a dike.

Another factor of great importance also is involved in the distribution of the precious metals, but this factor appears to be largely independent of structural relationships. It involves the decline in the tenor of the ore with depth, irrespective of the fact that the favorable structural openings continue downward and may be fully as prominent at depth as at higher levels. In the Gold Hill lode the ore mined was bottomed on the 400-foot level, although the fissuring continued downward perhaps as prominently as above. The gold content of the Pioneer ore bodies decreased so materially just below the 1,100 level that minning had to cease, but again the associated quartz and bismuth minerals and earlier base metals were as plentiful there and on the 1,250 level as in the richest ore on higher levels. There was also a marked decline in the tenor of the ore at the Belshazzar mine below the 401 level, but the young quartz, arsenopyrite, and bismuth minerals were apparently as abundant as they were above that level. Much of the silver-gold ore at the Comeback mine was also found above the No. 4 level. Structural control can hardly explain this phenomenon, as the controlling structural features exhibit no material change. The distribution, on the other hand, may be related to changing physico-chemical conditions, particularly to falling temperatures as the ore-forming solutions approached the colder rocks nearer the surface. The limiting factor in the decrease in gold content with depth is probably the temperature, which was high enough to keep the gold in solution until the higher, cooler environments were reached. The same explanation may account for the distribution of the silver sulfosalts in the upper parts of the structural zones. Thermal zoning probably plays an exceedingly important role in the distribution of ore and ore shoots, particularly with reference to the precious metals.

TENOR OF THE ORE

Because of the irregular and sporadic distribution of the precious metals the tenor of the ore in any deposit is variable and dificult to evaluate. Most deposits have contained scattered bunches of very high-grade ore accompanied by much ore of lower grade, but, as accurate sampling in advance of mining and milling has been done at but few mines, the average tenor of the ore is known in only a few places. Systematic sampling was carried on in recent years at the Gold Hill mine, and the mill records show that the ore from the different ore bodies contained from less than 0.3 to as much as 0.5 ounce in gold and small amounts of silver to the ton. Some of the ore was sorted underground, but much of the material hoisted consisted of altered rock with thin ore seams, which individually were very rich but were mixed with sufficient broken rock to maintain a mill feed of fairly constant value. Much of the ore milled at the Mountain Chief mine apparently contained from 0.5 to 1.0 ounce of gold to the ton, but the actual tenor varied considerably and was probably in part considerably less. The Belshazzar ore was reported to average 0.5 ounce to the ton, but rich pockets in places increased the gold content to several ounces to the ton. Systematic sampling at the Mayflower mine during the early half of 1938 showed much ore with 0.5 to 1.0 ounce in gold to the ton and in places pockets with several ounces to the ton. Ore with as little as 0.15 ounce in gold to the ton was being milled. No sampling was done at the Comeback mine, but only the rich ore seams were selected, sorted, and shipped to the smelters. In general these shipments netted several hundred dollars to the ton in both gold and silver.

The tenor of the base-metal ore is also variable and depends not only on the abundance and distribution of the base-metal sulfides but also on the presence and sporadic distribution of the precious-metal seams. Smelter returns on three cars of ore from the Silver Gem lode in 1919 were reported by the operator to have contained 0.2 ounce of gold and 80 ounces of silver to the ton, 6 percent of copper, 3.5 percent of lead, and 6 percent of zinc. Two carload lots from the Coon Dog No. 1 claim in 1916 contained according to Jones [56] 0.12 ounce of gold and 14 ounces of silver to the ton, 5.2 percent of copper, and 7.1 percent of zinc, whereas sampling on another lode showed 0.1 ounce of gold and 11 ounces of silver to the ton and 12 percent of copper. Ballard also reports an assay of 0.1 ounce of gold and 19.5 ounces of silver to the ton, 16 percent of lead, 13.2 percent of zinc, and 10.8 percent of copper.[57] Smelter returns shown the writer on mill shipments made from the Enterprise group in 1930 showed a range of 1.4 to 3.13 ounces of gold and 10.0 to 15.6 ounces of

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[56] Jones, E. L., Jr., Lode mining in the Quartzburg and Grimes Pass porphyry belt, Boise Basin, Idaho: U. S. Geol. Survey, Bull. 640, p. 110, 1917.

[57] Ballard, S. M., Geology and gold resources of Boise Basin, Boise County, Idaho: Idaho Bur. Mines and Geology Bull. 9, p. 92, 1924.

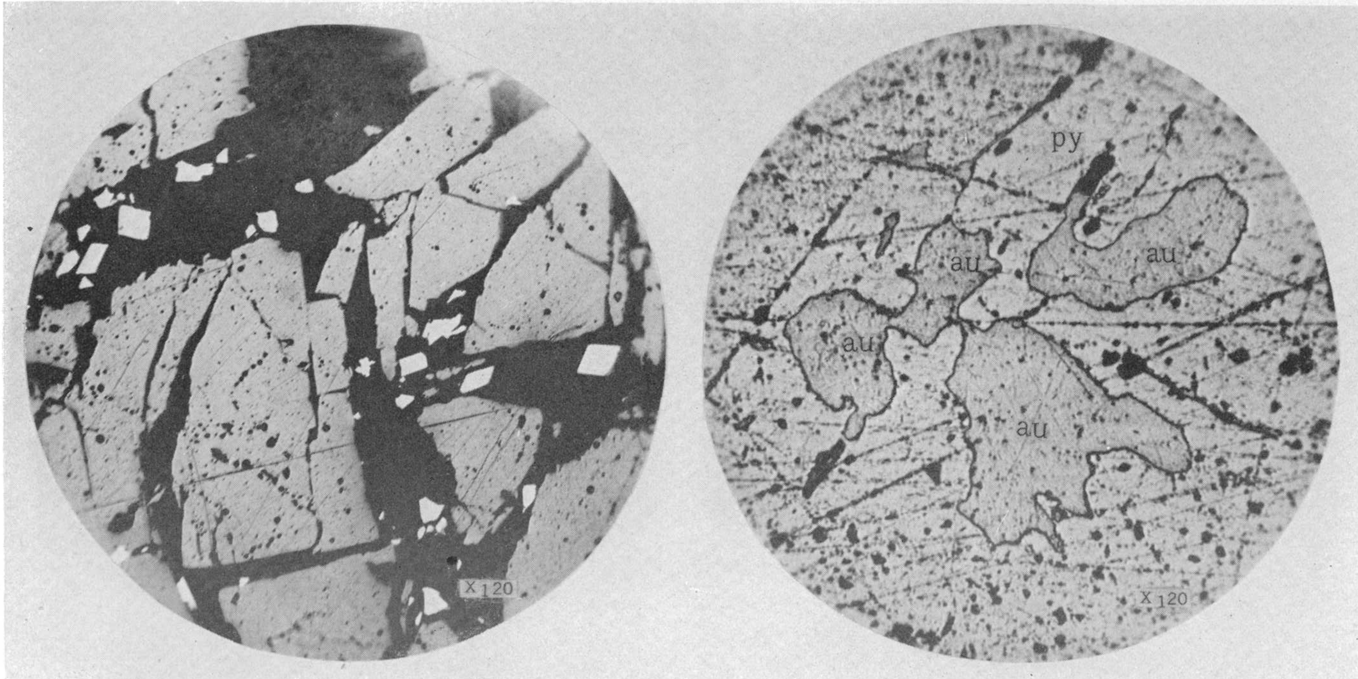
silver to the ton, 0.4 to 0.58 percent of copper, 12.3 to 25.26 percent of lead, and 5.2 to 7.35 percent of zinc.

Most of the pyritic lodes have probably contained less than 0.1 ounce of gold to the ton, but those that had been reopened and had received addition of the younger gold show as much as 0.5 ounce of gold to the ton and, as in other lodes, scattered bunches of very much richer ore.

WALL-ROCK ALTERATION

As already indicated, the deposition of the ore in the Miocene deposits was accompanied by very intensive and extensive wall-rock alteration. The country rock in and along the lodes has been extensively bleached, softened, and made somewhat earthy in appearance. Along many of the lodes the texture of the rock has been so modified that its original character cannot be directly inferred, and the rock must be examined at some distance from the lode before it can be certainly classified. The original dark minerals in the rock have in geneal entirely disappeared along the zone of alteration, and the feldspars have lost their vitreous luster and become chalky. Where the alteration has been especially intense the feldspars have lost their original outlines, and the primary granitic or porphyritic textures of the rock have been obliterated. Further changes in appearance have also been induced by the widespread distribution of disseminated crystals of pyrite throughout much of the bleached, altered rock. The striking changes in the wall rock contrast vividly with the inconspicuous changes in the wall rock of the early Tertiary (?) deposits and are probably the most distinctive features by which one may distinguish between the Miocene and the early Tertiary (?) deposits.

All the rock minerals, except such minor accessory minerals as apatite and zircon, appear to have been attacked and altered by the ore-forming solutions. Throughout the more intensely altered zones the hornblende and biotite have been bleached and changed to coarse grains of white mica, or to white mica and calcium carbonate. The plagioclase feldspar has invariably been greatly altered, and where the alteration has been most intense the crystals have been changed to aggregates of coarse sericitic grains, which commonly are arranged in divergent, sheaflike groups (pls. 39, *A*, *B*, 40, *B*). All traces of original microscopic multiple twinning in such altered crystals have been completely destroyed (pl. 39, *A*, *B*), but in the less intensely altered rock remnants of the twinning may be visible through somewhat finer-grained sericitic aggregates. The feldspar phenocrysts in the porphyritic rocks are generally altered to coarser sericitic aggregates than the feldspars in the groundmasses (pl. 40, *B*). In general the sericitic alteration has been confined to the feldspars and

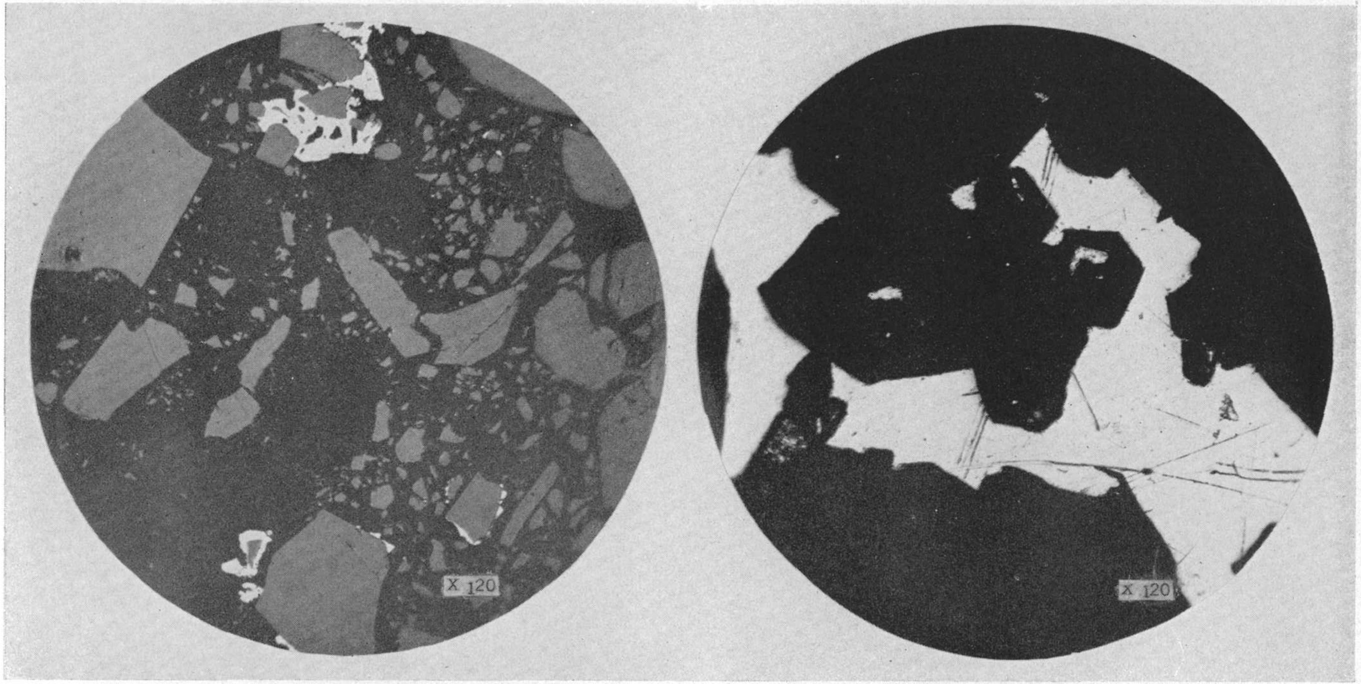


A. FIRST-STAGE SPHALERITE (GRAY) SHATTERED BY INTERMINERALIZATION MOVEMENT AND CEMENTED BY SECOND-STAGE QUARTZ (BLACK) AND ARSENOPYRITE (WHITE RHOMBIC CRYSTALS).

B. GOLD (au) IN AND REPLACING THE SECOND-GENERATION PYRITE (py) IN ORE FROM THE MAYFLOWER LODE.

PHOTOMICROGRAPHS OF POLISHED SECTIONS OF MIOCENE ORES.

Show relations of arsenopyrite and gold to sphalerite and pyrite.



A. SHATTERED FIRST-STAGE SPHALERITE (GRAY) CEMENTED BY SECOND-STAGE CARBONATE (BLACK) AND IN PART CEMENTED AND CRUSTED BY GOLD (WHITE).

Missouri mine.

B. ELECTRUM (WHITE) FILLING IN BETWEEN CRYSTALS OF DRUSY QUARTZ.

Comeback mine.

PHOTOMICROGRAPHS OF POLISHED SECTIONS OF MIOCENE ORES.

Show relations of gold to sphalerite and electrum to quartz.

the original dark minerals, but in some of the more intensely altered rock even the quartz has been partly sericitized. In many places the rhyolite and quartz monzonite porphyries may be recognized by the presence of the clear quartz phenocrysts and patches of coarse sericite after feldspar and ferromagnesiam phenocrysts in matrices of small quartz grains and fine sericite (pl. 40, *B*), whereas the granitic rock may be identified by irregular quartz grains in a sericitic matrix (pl. 39, *A*). In places the bleached and altered rock has been somewhat silicified, but the effects of silicification are not widespread and are generally confined to the more highly sericitized rock. Secondary carbonates are also confined to widely scattered patches and small veinlets of calcite. Aside from the widespread sericitization the most conspicuous process of alteration has been the abundant formation of pyrite, in large part by replacement of the already sericitized rock (pls. 39, *B*, 40, *A*).

In general the order of alteration has been sericitization, scant silicification, and pyritization. Some carbonate may have been produced during the stage of sericite formation, but much of it appears to be somewhat younger, perhaps in large part younger than the pyrite, in fact the carbonatization may have been associated with the closing stages of mineral deposition, as so much of it is in patches and seams cutting the altered rock and in places the ore itself. The wall-rock alteration has in general weakened and softened the rock and made it especially susceptible to mashing and the formation of gouge. Much of the faulting has actually been in the altered rock alongside the main base-metal seams, and much of the gouge is made up of sericitic material and the crushed ore minerals incorporated from ore seams and stringers.

The rock alteration appears to have been an integral part of the mineralization processes and to have been associated with each surge of the ore-bearing solutions, though the most widespread and most conspicuous effects appear to have just preceded or accompanied the base-metal stage of deposition. In general the ore shoots are confined to the zones that show the most intense sericitization. Increase in the intensity of alteration has been found by experience to denote an approach to an ore body. No one rock appears to be more susceptible to alteration by the ore-forming solutions than any other, although the rhyolite porphry, which had already been considerably sericitized by its own end-stage emanations and was later attacked by ore-forming solutions, is the most thoroughly altered. Even the lamprophyric dikes that were intruded into and across the lodes show some effects of hydrothermal alteration, probably because they were intruded so shortly after ore deposition as to have come under the influence of the solutions associated with the closing stages of the metalization.

GENESIS OF THE DEPOSITS

The intimate association of the lodes with the dikes and stocks of the "porphyry belts" and the close correspondence between lodes and dikes in structural details imply that the ore-forming solutions had their source in the same deep-seated magma as the injected intrusives themselves and were expelled from the parent magma near the close of the general period of igneous activity, shortly after the injection and consolidation of the rhyolite porphyry dikes. The association of the lodes with the rhyolite porphyry dikes is particularly marked and is shown not only by the fact that all lodes are in or near bodies of rhyolite porphyry or are along parts of the "porphyry belts" where rhyolite porphyry dikes are especially numerous but also by the fact that the end-stage emanations associated with the consolidation of the rhyolite porphyry dike produced hydrothermal effects identical with those produced by the somewhat younger ore-bearing solutions. The phenomena are so closely allied as to indicate that both rock alteration and ore deposition have been affected by hydrothermal emanations following closely upon and directly connected with the intrusion and consolidation of the rhyolite porphyry.

The source of the ore-forming solutions was, therefore, probably deep-seated, but the evidence seems clear that the ore was not deposited until moderately shallow depths had been reached and the temperature of the solutions had declined considerably. The porphyritic dikes and stocks with which the lodes are associated are typical hypabyssal intrusives and were evidently injected into the zone of abundant fractures such as characterizes the higher levels of the earth's crust; and their texture indicates that they cooled at a fairly rapid rate. The precise depth at which ore deposition took place cannot be accurately determined because of the absence of dependable markers, although erosion has been sufficient to strip off most of the lake beds and volcanic rocks that probably blanketed the region at the time of dike intrusion; but erosion has probably not extended much below the general base of those strata and has not removed the infaulted blocks. As the strata in the infaulted block at Idaho City probably exceed 800 feet in thickness, erosion has probably extended to depths of at least 1,000 feet since ore deposition, but how much more cannot be measured. That ore deposition took place at fairly shallow depths is also suggested in the abundant fracturing in and along the lodes prior to and during ore deposition, in the presence of comb and drusy quartz, and in the general extensive brecciation of the ore, features not generally associated with ore deposits formed at moderate or considerable depths.

In general the structural, textural, and mineralogical features of these deposits associate them with the epithermal precious-metal and epithermal base-metal deposits[58] or with those that Graton classes as leptothermal.[59] The epithermal deposits have been defined as those that have been deposited at comparatively shallow depths and, commonly, but not always, at relatively low temperatures, generally in or near volcanic rocks, and have distinctive features of structure and texture as well as mineralogic composition that set them apart from the deposits formed at greater depth. Most of the Miocene deposits in Boise Basin are very much like the characteristic epithermal base-metal deposits described by Burbank,[60] but some resemble the epithermal silver gold deposits described by Nolan.[61] During the base-metal stage of ore deposition the temperatures were apparently moderate and perhaps little different from those commonly associated with the deposition of ores in mesothermal deposits (formed at moderate depths and at moderate temperatures), but the presence of scant amounts of pyrrhotite in the Belshazzar and Mountain Chief ore suggests that locally temperatures were in part at least moderately high. The precious-metal assemblage as a whole, however, is a typical epithermal assemblage, although the presence of arsenopyrite and bismuth minerals implies fairly high temperatures during the early stages of deposition, whereas the younger silver sulfantimonites and native gold and electrum indicate that the temperatures declined very materially before deposition was complete.

The distribution of the precious metals appears to be restricted to a comparatively limited vertical range along the upper parts of the lodes and suggests a rather well-defined thermal stratification largely independent of the controlling structural features. The intimate association of some of the gold with the arsenopyrite and bismuth minerals suggests a steepened thermal gradient and an overlap in the deposition of the precious metals on the minerals of higher-temperature origin, amounting to a telescoping of the deposits and an appreciable dumping of the valuable metals at the higher levels when declining temperatures favored precious-metal deposition.

It is of interest to note that the composition of the ore-forming solutions changed greatly during the general period of ore deposition, particularly after the fissures and other fractures had been filled with

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[58] Lindgren, Waldemar, Mineral deposits, 4th ed., pp. 498–510, New York, 1933. Burbank, W. S., Ore deposits of the Western States (Lindgren volume), pp. 641–645, Am. Inst. Min. Met. Eng., 1933.

[59] Graton, L. C., Ore deposits of the Western States (Lindgren volume), pp. 187–189, Am. Inst. Min. Met. Eng., 1933.

[60] Burbank, W. S., op. cit., pp. 641–645.

[61] Nolan, T. B., Ore deposits of the western States (Lindgren volume), pp. 625–626, Am. Inst. Min. Met. Eng., 1933.

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pyrite and base-metal ores. When ore deposition was resumed after the lodes had been reopened, precious metals rather than base metals were deposited. This material change obviously took place in the solutions at depth, and there is probably a close relation between the precious-metal solution and the severe adjustments that tapped the solutions at their source and provided for their movement into the reopened lodes some distance above. The reopening appears to have been accompanied by an appreciable increase in the temperature of the upsurging solutions, which kept the precious metals in solution until the higher parts of the lodes were reached.

OXIDATION AND ENRICHMENT

Oxidation of the ores of both the early Tertiary (?) and Miocene deposits throughout the region has reached only shallow depths. In most places residual sulfides persist in the present outcrops and are everywhere exposed in the shallow workings immediately below. Incipient oxidation may continue to somewhat greater depth, in especially favored localities to as much as 200 feet below the surface, but its expression is commonly feeble. Some oxidation was noted at the Mayflower mine at depths of 150 feet, but the oxidation was confined to the pyrite in the altered wall rock, not to the ore protected from the surface waters by an impervious casing of the intermineralization gouge. Opportunity was not afforded elsewhere to obtain data on the lowest limits of oxidation, but the available openings in general, many of them less than 100 feet below the surface, showed no traces of oxidation. The early lode miners concentrated their efforts on the oxidized ore because it was accessible and easily treated by crude methods, but everywhere the oxidized ore was bottomed within a comparatively few feet of the surface and the workings commonly abandoned.

The general lack of oxidization in the present lode ore is in accord with the geomorphic history of the region. It is true, as pointed out by Ross,[62] that the region was comparatively low and was undergoing little active erosion, while the ore deposits were being deeply weathered and the gold was being freed from the enclosing gangue and country rock and made ready for easy concentration in placers. However, crustal movements late in Pliocene and through Quaternary time accelerated erosion, locally favoring the rapid removal of the deeply weathered rock and the concentration of the gold on the slopes and in the lower parts of Boise Basin and exposing fresh rock and ore on the surface. Since then erosion has so largely dominated over weathering that little opportunity has been afforded for oxidation.

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[62] Ross, C. P., op. cit. (Bull. 846–D), pp. 244–245.

Evidence of supergene enrichment is also meager, and secondary ore minerals are not appreciably abundant, except in some of the silver lodes. Considerable native silver and some argentite were mined along with the primary electrum at the Comeback mine in workings less than 100 feet below the surface, but little of the enriched ore extended to the mill-tunnel level, and much of it was within 50 feet of the outcrop. Considerable cerargyrite (AgCl) was reported in the upper workings of the Edna mine in an early report of the State mine inspector, and a mill was erected to treat the secondary ore, but the amount of ore could not have been much, as the mill operated only a very short time. Some wire silver and minor amounts of argentite were observed in the small pile of ore on the dump at the portal of the long crosscut at the Washington mine, but as the mine could not be entered the amount and distribution of the secondary ore could not be learned. It is presumed that the ore must have come from the lower workings tapped by the crosscut about 400 feet below the collar of the shaft, but the silver may have been deposited after the shaft had been sunk and had facilitated the downward movement of the ground water, although, because of considerable local relief and consequently deeper and more vigorous underground water circulation, oxidation and enrichment may have extended to greater depths locally than in other parts of the region. Scant amounts of secondary sulfides have been observed in the partly oxidized ore in some of the base-metal deposits, but the secondary minerals have contributed little toward increasing the tenor of the ore.

Gold enrichment, except for mechanical concentration on the surface by the removal of weathered products, has apparently been negligible. The solution of gold and its transportation are facilitated by the presence of manganese, but the manganese as manganiferous carbonate is present in only small amounts and even absent from most deposits; where present it is insufficient in quantity to assist appreciably in the solution of the gold, particularly as the carbonate has been as little oxidized as the associated metallic sulfides. Rich ore has been mined in the shallow oxidized zone, but ore equally rich has been found far below any observable limits of oxidation or possible enrichment, and, except for the residual surface concentration, the gold content is no higher in the ore near the surface than in the unaltered sulfides below, although it is more easily recovered. Clearly the gold in such lodes as the Belshazzar, Mountain Chief, Gold Hill, Mayflower, Comeback, Golden Age, and others was formed at about the same time and by the same processes as the associated sulfides. Some of the richest ore uncovered in the Pioneer workings of the Gold Hill mine was on the 1,100-foot level, and the exceptionally coarse gold in the high-grade pockets at the Belshazzar mine occured below the limits of any visible signs of oxidation. The rich pockets at the Comeback mine are likewise primary, for electrum is never a supergene mineral, as gold and silver alloyed as electrum always part company in the oxidized zone. Weathering of the lodes and removal of the disintegrated rock and gangue minerals have produced rich outcrops and have probably been the source of much of the gold sluiced from the outcrops in the early days, but the accumulation was residual and not the result of downward supergene enrichment.

OUTLOOK

Mining in Boise Basin has not always been looked upon with favor, in part at least, because of misconceptions concerning the origin of the deposits. The view has generally been held that the deposits were genetically related to the Idaho batholith and, therefore, were simply the roots of veins and lodes largely removed by erosion. As these deposits are now known to have no genetic relationships with the Idaho batholith but to be related instead to early Tertiary (?) and to early Miocene magmas, the prejudice that may have existed against them insofar as their origin is concerned can, in part at least, be set aside. The prejudice, nevertheless, is not without some basis of fact, for in general the ore in most of the deposits has not been found to extend for more than a short distance beneath the surface, and it appears to possess features commonly found in ore deposited at fairly shallow depths and through a comparatively shallow vertical range.

The early Tertiary (?) deposits have yielded several million dollars worth of ore directly to the mills and have contributed indirectly to the larger part of the placer production. Most of the lode production has come from workings within 100 feet of the surface, and whatever may have been the cause of the shallow development the appearance of sulfides was probably not one of them, inasmuch as the sulfide content of the ore is very low and most of the gold is associated with the comb quartz and pyrite and is easily amenable to the older methods of stamp milling and amalgamation. The shallow development apparently reflects a limited downward continuation of ore of commercial grade and does not reflect metallurgical difficulties encountered on passing below a zone of oxidation. Failure of the ore to persist with increasing depth appears to be a consequence of its origin.

The early Tertiary (?) deposits are classed as epithermal and show the characteristic features of the gold-silver group, which has nowhere been noted for a large lode production.[63] Such deposits have been

[63] Nolan, T. B., op. cit., p. 627.

formed at no great depth below the surface, and the ore in them is characteristically restricted in depth. The lodes in Boise Basin have been considerably eroded, and the remaining ore in the known deposits has in most places been exhausted within a relatively few feet of the present surface.

The outlook for deep development of the early Tertiary (?) deposits is not encouraging. More attention, however, could well be directed to search for additional ore bodies along the extensions of known veins and lodes and to the discovery of new deposits. The recent activity and production at the Golden Cycle mine show that the possibilities of veins and lodes of this kind have not been exhausted and that additional discoveries may be made. One should bear in mind, however, that the ore is likely to be pockety and confined to small shoots and bunches along the more gently dipping parts of the fissures and fractures zones. The bunches of ore may be individually rich, but no great persistence in depth should be expected. Special attention should be given to the veins and lodes filled with the third-stage comb and drusy quartz rather than to those with a preponderance of quartz belonging to earlier stages of deposition. To assure successful operations, mining costs and overhead expense must in general be kept at a minimum. Exploitation of the deposits involves considerable risk because of the relatively small size and uncertain distribution of most of the ore shoots.

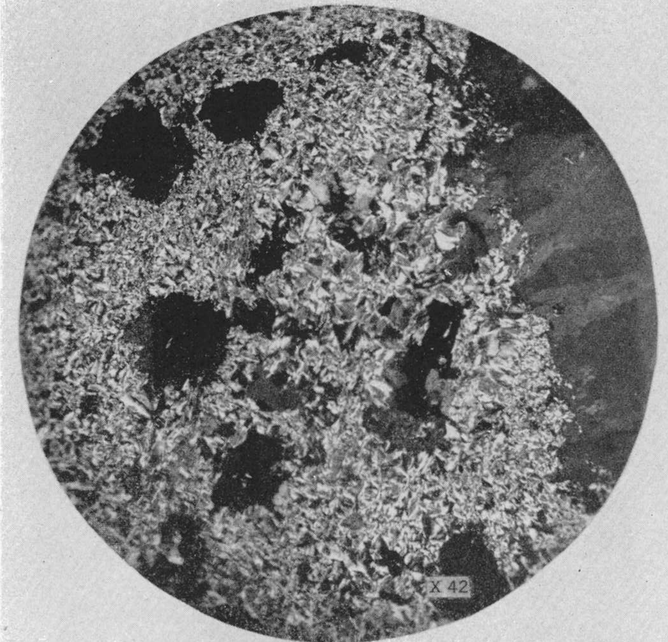
The Miocene lodes are also classed as epithermal and were probably formed at as shallow depths as the early Tertiary (?) deposits, but they have not been as deeply eroded as the older deposits and have consequently furnished a much smaller proportion of gold to the placers. Some of the ore bodies, as at the Comeback and Gold Hill (Pioneer lodes) mines, probably did not reach much above the present surface. The distribution of the gold appears to have been controlled by a relatively steep thermal gradient, and the gold apparently does not extend down the lodes as deeply as the base metals or other associated minerals. The vertical distribution of the gold in the ore shoots apparently ranged through an interval of 500 to 1,000 feet, but in most places erosion may have left little more than the lower halves of the ore shoots.

The Miocene lodes have appeared to be more responsive to deep development than the early Tertiary (?) lodes. Most of the deposits are of moderate size, but they are not uniformly mineralized and the ore shoots are discontinuous, spotty, and localized by special structural conditions dependent on openings provided by marked lateral but at the same time upward movement along curved and prominently irregular fault planes. The precious metals, however, were introduced into the lodes only after a pronounced structural reopening had taken place at the end of the base-metal stage of deposition and were deposited only in the reopened parts of the lodes. Rich pockets and small rich shoots apparently formed wherever structural and thermal conditions were especially favorable. Some deposits were little affected by the structural adjustments concurrent with mineral deposition and had little gold added to them. Whether the fissure and fracture zones were thoroughly reopened after the base-metal stage, or fractured only here and there, must be considered in any program of development. Study of the paragenesis of a deposit may well serve as a basis for estimating potential economic possibilities ahead of an extensive development. Increasing intensity of wall-rock alteration may be regarded as a guide to ore channels and favorable structural zones. Reopening during the period of ore deposition and local changes of dip and strike also appear to be the guides to ore shoots. As supergene enrichment has been negligible, except perhaps in the silver deposits, ore shoots and pockets as rich as those in or just below the oxidized zone may be expected and do occur at appreciably greater depth.

The outlook for sustained production along the "porphyry belt" in the Quartzburg-Grimes Pass area appears somewhat brighter than for the early Tertiary (?) deposits, but again the more active exploration should be confined to the search for additional ore bodies along the extension of known lodes and to the discovery of new lodes. Outcrops are generally inconspicuous, and additional deposits might well be discovered. The lodes with precious metals furnish, as in the past, the best prospect for commercial development, but the base-metal deposits, though small, may afford some production under favorable prices for metals, if intelligently and economically exploited. Further search might be made for fracture zones of the Pioneer type, which appear to offer better possibilities in deeper development than the fissure lodes. Exploitation of the Miocene deposits also involve considerable risk because of the relatively small size and irregular distribution of most of the ore shoots, but ore can in general be expected to continue to somewhat greater depths in them than in the early Tertiary (?) deposits.

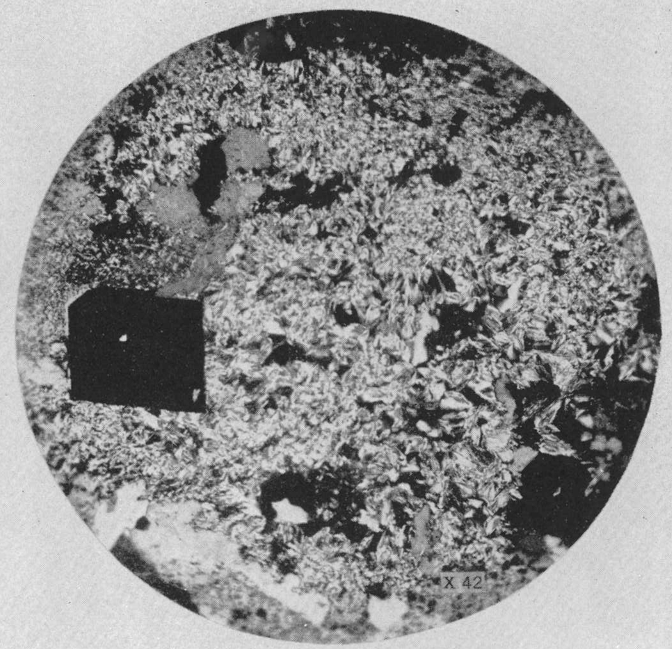
MINES AND PROSPECTS

In describing the individual mines and prospects, the writer has segregated the properties into two groups, based on geologic age, early Tertiary (?) and Miocene. In keeping with earlier procedure, the mines and prospects opened on the early Tertiary (?) veins and lodes are described first.



A. INTENSELY SERICITIZED AND IN PART SILICIFIED QUARTZ MONZONITE (MESOZOIC) IN AND ALONG THE LODES AT THE HARTFORD PROPERTY NEAR QUARTZBURG.

The sericite grains are particularly coarse and the original texture of the granitic rock has been entirely obliterated. Crossed nicols.

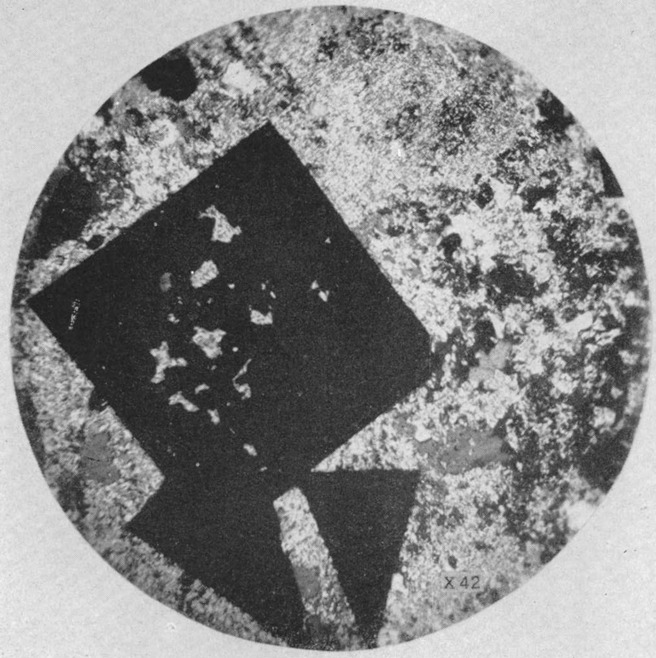


B. THOROUGHLY SERICITIZED QUARTZ-HORNBLENDE-BIOTITE MONZONITE PORPHYRY CUT BY THE BELSHAZZAR LODE.

The sericitized rock is also replaced by pyrite (black crystal showing square cross section). The original texture of the porphyry locally has been completely destroyed. Crossed nicols.

PHOTOMICROGRAPHS OF THIN SECTIONS.

Show intense wall-rock alteration associated with the Miocene mineralization.



A. SERICITIZED, SILICIFIED, AND PYRITIZED QUARTZ-HORNBLENDE-BIOTITE MONZONITE PORPHYRY AT THE MOUNTAIN CHIEF MINE.

The large pyrite crystals (square and triangular outlines) in part retain unreplaced inclusions of sericite. Crossed nicols.

B. MODERATELY SERICITIZED RHYOLITE PORPHYRY AT THE COMEBACK MINE.

The large plagioclase phenocryst has been completely converted to a sericitic aggregate and the biotite to coarse foils of sericite or muscovite, but some of the original quartz and orthoclase of the groundmass remain. Crossed nicols.

PHOTOMICROGRAPHS OF THIN SECTIONS.

Show intense wall-rock alteration associated with the Miocene mineralization.

EARLY TERTIARY (?) DEPOSITS

ILLINOIS MINE

The Illinois mine is near the center of the Gambrinus district, about 4 miles in an air line northeast of Idaho City, at the head of Illinois Gulch. It was discovered soon after placer operations were begun in Boise Basin, and much gold was recovered by sluicing the outcrop. The gulch below the mine is reported to have been extraordinarily rich in placer gold, and it is further reported that the Illinois lode, one of the largest in the district, probably furnished a large part of the gold in the gravels along Moore Creek. The mine was first worked by shallow tunnels. Later a 200-foot shaft was sunk in the hanging wall about 50 yards from the outcrop. A crosscut was driven from the bottom of the shaft to the lode, but according to reports no drifting was done. Some work contined until the nineties, but the mine then remained idle until 1933, when a new tunnel was started in unexplored ground east of the old workings. By 1938 the new work totaled 340 feet of crosscuts and drifts. The production from the Illinois mine is reported to have been $225,000, mainly from small shoots of very rich ore.[64]

The Illinois lode occupies a prominent fracture zone 30 to 40 feet wide, which strikes about N. 70° W. and dips about 40° SW. This zone consists of sheeted and intricately fractured quartz monzonite and aplite, with the more prominent fractures about parallel to the zone and dipping about 60° to 65° SW. Others strike N. 45° E. and dip 65° SE. Both sets of fractures are in places offset by slips of more northerly trend, and that whole lode has in one place been displaced 150 feet horizontally by a fault that strikes N. 20° E. All the old work was done on the segment of the lode west of the fault and the recent work on the east segment 150 feet farther up the gulch.

Throughout the fracture zone are numerous small seams and ramifying veinlets of rather coarsely crystalline quartz, most of it of the comb variety. In places the quartz forms small lenses. The main ore shoot is reported to have been about 400 feet long and to have contained a streak 2 feet thick that was exceptionally rich.[65] The segment of lode on the east side of the fault also has small quartz stringers in fractures. Some of these stringers and bunches of quartz formed a small ore shoot and provide a stope 18 feet long and 15 feet high from which ore was milled. The east segment of the lode appears to have been more greatly disturbed by postmineral movement than the west segment and shows much more gouge.

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[64] Lindgren, Waldemar, The mining districts of the Idaho Basin and the Boise Ridge, Idaho: U. S. Geol. Survey, 18th Ann. Rept., pt. 3, p. 685, 1898.

[65] Lindgren, Waldemar, op. cit., p. 685.

The quartz throughout appears to be the young rather coarsely crystalline variety with a marked tendency to show comb structures and open druses. In places the quartz has scattered limonitic pseudomorphs after pyrite. The gold appears to be associated with the quartz, but it also occurs in fractures in the country rock. The quartz monzonite and aplite, although extensively penetrated by the quartz seams, show little conspicuous evidence of alteration by the gold-bearing solutions.

LUCKY BOY MINE

The Lucky Boy mine adjoins the Illinois on the east and is said to be on a continuation of the same lode. Some prospecting was done in the early days, but most of the active development has been since 1900, particularly in 1915 and 1916, when some ore was milled. The mine, however, closed down after 2 years' work and was later taken over by the Lucky Boy Mining Association which still retains ownership. In 1933 the mine was leased to a new operator, and work was started to reopen the 600-foot crosscut, but the project was abandoned in less than a year. The underground workings were inaccessible when visited in 1933 but are reported by the management to consist of the 600-foot crosscut, drifts, and stopes, and a shaft from which mining has extended from the 200-foot level to the surface. The property was equipped with a 10-stamp mill, but the camp was destroyed by forest fire in 1934. Records of production were not obtained.

Of the several fracture zones known to cross the property, only the Illinois has been extensively developed. The others are parallel, and one is reported to lie 30 feet south and another 200 feet north of the Illinois. The main lode strikes about N. 80° W. and dips about 50° SW. As on the Illinois ground, it consists of a wide zone of sheeted and fractured granitic and aplitic rock with thin quartz seams and stringers, small quartz lenses, and iron-stained fractures. The lode is reported to be as much as 30 feet across and to contain an ore body as wide and 360 feet long. The quartz is the usual auriferous coarsely crystalline comb variety, although in some fractures the quartz filling is virtually paper thin.

MASCOT MINE

The Mascot mine is about centrally located in the Gambrinus district and lies but a short distance east of the Illinois and Lucky Boy. Data bearing on the early discovery and activity were not obtained. When the Fryett Mining Co. started development in 1930, there was already a tunnel 330 feet long. During the next year two other tunnels were driven, one 160 feet long and the other 290 feet long, and by the end of 1934 the total development consisted of 1,485 feet of workings.[66] The upper tunnel is just under the outcrop and not more than 50 feet above the No. 2. The lower tunnel (No. 3) is in the bottom of the gulch about 60 feet vertically below the No. 2. These workings were mapped in 1933 and, because they were more extensive than any others accessible in the Gambrinus district, are reproduced in plate 41. This figure shows the complicated system of fracturing typical of the early Tertiary (?) lodes. The mine was subsequently leased and the underground development considerably extended. The property was acquired by the Mascot Mines, Inc., in 1935. Development was extended about 190 feet, and a 25-ton mill was erected. Some ore has been milled, but the amount was not learned.

The general trend of the lode apparently corresponds with the trend of the nearby west-northwesterly lodes, but the fracture zone is so broad and the individual fractures have such diverse strikes that relations are difficult to decipher, particularly because the fracture zone has apparently been further broken by younger northeasterly faults and invaded by porphyritic dikes. The more prominent fractures appear to strike N. 60° E. and dip steeply southeast, but others locally as conspicuous strike N. 40°–45° E., and a few strike due north. One of the northward-striking faults has apparently offset the main fracture zone about 50 feet measured in a horizontal direction and has guided the intrusion of a dark-colored dike, which resembles the Miocene dacite porphyry. Many of the fractures contain thick seams of gouge; others are identified as sharp breaks. In places the country rock (quartz monzonite and aplite) has been complexly shattered, but the broken fragments are little separated. Dark-colored dikes of lamprophyric character are also conspicuous underground and occupy, or have been guided by, different sets of fractures.

On the intermediate (No. 2) level the tunnel was driven along a minor zone of fractures of east-southeast trend, for part of the distance along a lamprophyric dike. A prominent fissure striking N. 60° E. and dipping 45° SE. was encountered a short distance from the portal in which appeared an ore shoot about 3 feet thick and 60 feet long. This shoot furnished ore for milling. It ended along the strike where the fairly well-defined fissure changed into a broad fracture zone, composed of many individual more widely spaced slips. Toward the surface the ore shoot was dissipated as widely scattered stringers. Below the level the fissure steepened, and the ore shoot pinched out.

On the lower level the tunnel was swung to the south in order to intersect the ore shoot exposed on the level above. Because of a

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[66] Simons, W. H., Thirty-sixth Ann. Rept. of the mining industry of Idaho for the year 1934, p. 104, 1935.

marked steepening in dip between the two levels, the fissure was cut much sooner than expected but was mistaken for some other minor fissure not exposed above and the crosscut continued on into the little-disturbed country rock far beyond the point where the shoot had been projected with the gentle dip as found on the No. 2 level. The fissuring is very weak on the lower (No. 3) level, and the narrow fracture zone appears to be without ore. Further exploration to the east disclosed the dark-colored porphyritic dike alined along a northward-trending fault. The dike was drifted on for a considerable distance. Crosscuts to the east of the dike exposed only fresh, unfractured, granitic rock, but those to the west disclosed broad zones of mineralized fractures. In places these fractures have been offset by minor faults parallel to the one that guided the porphyritic dike. Development had not, in 1933, revealed the extent of the offset of the main fracture zone.

Considerable amounts of comb quartz were mined from the main ore shoot on the intermediate level, but little quartz was observed in the fractures in the lower workings. Many of the iron-stained fractures panned gold.

GAMBRINUS MINE

The Gambrinus mine is another mine centered in the Gambrinus district about 5½ miles northeast of Idaho City on the low ridge between the valleys of Moore and Elk Creeks. It lies near the base of the steep 500-foot scarp that crosses the Gambrinus district in a northwesterly direction. The lode was discovered in 1864, and the principal work was done then and in the year that followed. It was opened by short tunnels and shallow shafts, none of them extending more than 100 feet below the surface. Apparently little or no work has been done since 1906, and all workings were inaccessible in 1932. The total production is estimated at $263,000.[67] This amount apparently does not include the gold sluiced from the outcrops.

The lode consists of a zone of sheeted and fractured granitic and aplitic rock as much as 40 feet across, and like the Illinois, is one of the most prominent mineralized fracture zones in the district. The lode strikes about N. 60° W. and dips about 45° SW. The filling consists of a net of thin quartz seams in fractures. The sheeted zone had two closely spaced ore shoots, which, although comparatively small, were very rich.[68] These pitched to the east, steeply at first and then at a more moderate angle.

At the surface the lode is highly weathered but consists otherwise of little altered rock with auriferous quartz seams. At depth, the quartz,

[67] Lindgren, Waldemar, op. cit. (18th Ann. Rept., p. 687.

[68] Lindgren, Waldemar, op. cit., p. 687.

which apparently is largely the coarsely crystalline, white, comb and drusy kind, associated with the third cycle of metalization, is accompanied by scant stibnite, scattered grains of pyrite, and free gold.

ACCIDENT PROSPECT

The Accident lode, discovered in 1932, lies between the Illinois and Gambrinus lodes. It has been prospected by several cuts and a short tunnel. This work exposed a zone of fractured granitic rock trending N. 85° W. and dipping steeply southwest, which contained two small ore shoots composed of thin quartz seams and veinlets and iron-stained streaks from which gold could be panned. These shoots were beneath a narrow weathered lamprophyric dike exposed in the hanging wall. Not enough work had been done to reveal the full size of the fractured zone, which is not less than 8 feet wide in the cuts. The quartz in the seams and veinlets is the milky coarsely crystalline variety showing comb and drusy structures.

ORPHAN PROSPECT

The Orphan lode, another late location in the Gambrinus district, lies near the Mascot and in 1933 had been prospected by a 70-foot crosscut. This crosscut exposed a conspicuous zone of fractured granitic and aplitic rock about 14 feet wide, bounded by a firm granitic hanging wall. This lode, like others nearby, trends N. 85° W. and dips about 60° SW. Beneath the hanging wall is 18 to 24 inches of greatly mashed, soft, iron-stained rock and then about 12 feet of less highly fractured aplitic rock, the lower part of which has seams that panned gold. In the top of the crush zone are quartz seams several inches thick, but in the less highly but intricately fractured rock below the seams are thin and occur as ramifying networks. The quartz in the thin seams is the comb variety and contains scattered crystals of cubic pseudomorphic limonite.

EUREKA MINE

The Eureka mine is in the Gambrinus district alined along the Illinois zone of shearing and is said to be on the east end of the Illinois lode. The mine apparently has not been worked since the early eighties, and the old tunnel and 60-foot shaft are no longer accessible. Ore worth about $30,000 is reported to have been milled besides what was taken by surface sluicing.[69]

The lode consists of a wide zone of sheeted and fractured granitic rock with numerous stringers and thin seams of quartz. Small pockets of rich ore were reported, but the ore in much of the lode was regarded as of low grade.

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[69] Lindgren, Waldemar, op. cit. (18th Ann. Rept.), p. 684.

BLAINE MINE

The Blaine mine is in Illinois Gulch, about half a mile south of the Illinois mine. It is one of the oldest mines in the Gambrinus district but has not been worked for many years. The workings are no longer accessible but are reported to have consisted of a tunnel about 400 feet long, which is probably everywhere within 30 feet of the surface, and crosscuts from the tunnel level. Some ore was milled, but records of production were not available.

The fracture zone, which is reported to be 30 feet wide, strikes west-northwest and dips southwest and, therefore, is like others in the Gambrinus district. It contains the usual quartz seams and stringers.

CLOVERLEAF MINE

The Cloverleaf mine, formerly the MacCarthy, is in the Gambrinus district, near the head of Eldorado Gulch, in sec. 6, T. 6 N., R. 6 E. It is reached by road by way of Elk Creek and Lager Beer and Eldorado Gulches. The property is an old one and after a long period of inactivity was reopened by the Cloverleaf Metals Co. in 1935. Some of the older workings were rehabilitated and additional openings made. In 1937 a 25-ton mill was completed and a small amount of ore treated. Because of failure to find additional ore bodies, work was suspended in 1938. The property comprises one patented and several unpatented claims and one patented mill site. The development consists of about 1,260 feet of underground workings, principally on two tunnels and a shaft, shown in longitudial section in plate 42.

The deposit is like most of the others in the Gambrinus district and occupies a fracture zone that trends about N. 65° W. and dips 65° to 70° SW., the dip steepening with depth. The ore shoots terminated as the dip steepened and the walls came together. Slickensides along the fracture zone show that the movement was vertical and that the hanging wall moved upward with respect to the footwall. The ore shoots are small. The larger of the two had an average length of about 40 feet, with a maximum stope length of 90 feet. The shoot pitched to the southwest and was mined to a depth of 170 feet below the surface.

The ore is highly quartzose and contains but very little sulfide. Some of the quartz is the early rather coarsely crystalline white to glassy variety, barren of sulfide; some is the fine-grained, almost chalcedonic quartz with finely disseminated arsenopyrite and pyrite, or slightly coarser-grained quartz with small grains and granules of arsenopyrite, sphalerite, and galena, which fill fractures in the early barren quartz; and some is the young coarsely crystalline, in part massive, in part drusy and comby, quartz with small scattered crystals of auriferous pyrite. The young-stage quartz occurs largely with a breccia of the earlier quartz. Some of the richest ore was reported mined where the second-stage quartz had been fractured and cemented by the third-stage quartz, the sulfides having been effective precipitants of the gold carried in by the youngest ore solutions. The country rock is but slightly sericitized along the lode but in places is slightly impregnated with a little disseminated pyrite.

CLEVELAND MINE

The Cleveland mine is in upper Eldorado Gulch, across the gulch from the Cloverleaf mine (formerly MacCarthy), in sec. 6, T. 6 N., R. 6 E. It is one of the oldest mines in the Gambrinus district but, like so many of the old properties, had remained idle from the nineties until taken over by the Cloverleaf Metals Co. in 1937. Most of the older workings in the upper tunnel level were rehabilitated, disclosing two winzes below the tunnel level. Much new work was done from a long crosscut some distance below. As ore of commercial grade was not uncovered at the deeper level, the work was abandoned early in August 1938. An ore shoot about 100 feet long, from which considerable gold was milled in the early days, is reported. A plan of the old and recent workings is shown in plate 43.

The Cleveland fissure strikes about N. 65° W. and dips 60° to 65° SW., the dip increasing with depth. It contains a vein 1 to 2 feet thick, exceptionally as much as 4 feet thick. In places additional quartz seams occur alongside. The fissure shows a marked reverse movement, with prominent vertical striations and grooves on slickensided surfaces. The vein is thicker and the subsidiary seams more numerous where the dip is not so steep. The fissure zone contains much gouge, especially on the footwall.

The lode has been considerably disturbed by Miocene shearing and has been cut by several faults and many minor slips. These faults strike N. 20°–30° E. and dip about 65° SE. One has offset the lode 40 feet horizontally, and grooves and striations on the slickensided plane show that the movement has been northeastward at a low angle. These striations dip southwest at an angle of 20°. The lode has also been cut by a Miocene dacite porphyry dike 15 to 20 feet wide, exposed, however, only in the lower workings (pl. 43).

The ore is like that in the Cloverleaf and consists of the early barren and younger auriferous quartz, as well as minor amounts of the second-stage quartz, with scant amounts of galena, sphalerite, and minute crystals of arsenopyrite. The sulfides are so meagerly represented as to escape detection except in the mill concentrate. The ore deposition, as elsewhere, has been attended with but slight alteration of the fractured wall rock.

TEXIDA MINE

The Texida mine is in the Gambrinus district near the Cleveland, in secs. 6 and 7, T. 6 N., R. 6 E., on the low, hilly summit between Elk and Moore Creeks. The development comprises an open cut about 100 feet long, a shallow shaft on one of the lodes, and a 690-foot crosscut about 245 feet below the surface workings. The crosscut was driven from Eldorado Gulch but was not driven far enough to intersect the lodes exposed on the surface. The property consists of four claims.

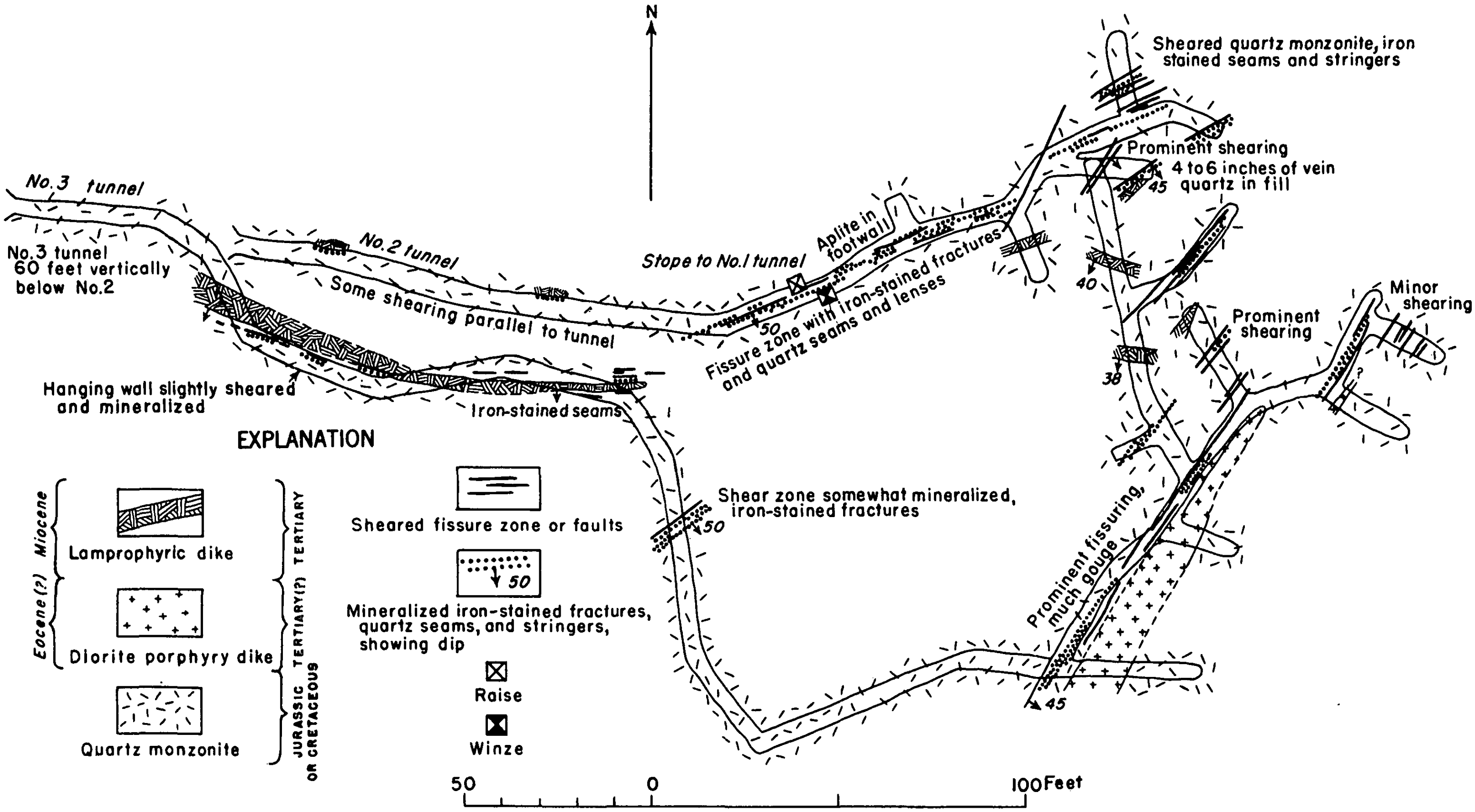
Several lodes crop out on the surface, but only one has been prospected. It occupies a well-defined fissure zone with prominent walls about 8 feet apart and strikes N. 60° W. and dips about 65° SW. The lode has some quartz lenses 6 to 10 inches thick, locally 24 inches thick. Some of the quartz is the fine-grained grayish variety, but most of it is the younger more coarsely crystalline quartz of comb and drusy habit. Some of the younger quartz pans gold.

BOULDER MINE

The Boulder mine is in sec. 30, T. 7 N., R. 6 E., on Elk Creek about 6½ miles north-northeast of Idaho City. The mine was located in the early days, and in the eighties preparations were made to exploit the lode on a large scale. The 30-stamp mill installed at that time was operated but a short time, however, either because the ore was of too low grade to be handled profitably or because insufficient reserves had been blocked out to keep the mill running.[70] Some rich ore was mined in 1896, but little work was done from then until 1906, when development was resumed on a larger scale and the mill repaired and reduced to 20 stamps. The mill was operated during the summer months for several years. Then there was little work until 1929, when the property was acquired by the Gold Eagle Mining Co. The mine was later leased, and some work was done each of the next 3 years by the June Mining Corp. The underground development has been fairly extensive, mainly in three tunnels, but only part of one tunnel was accessible when the property was visted in 1932. In 1934 the mine plant was destroyed by a forest fire. Records of past production were not obtained.

Three mineralized fracture zones are reported to cross the property, but only one has been extensively prospected and developed. These fracture zones trend about N. 70° W. and dip 50° to 60° SW. and are partly in granitic rock and partly in aplite. The main lode consists of as much as 60 feet of sheeted and otherwise extensively fractured rock in which are scattered small quartz seams and, in the more prominent fractures, small lenticular veins, some of which have contained very

[70] Lindgren, Waldemar, op. cit. (18th Ann. Rept.). p. 684.



SKETCH MAP OF THE NO. 2 AND NO. 3 TUNNELS AT THE MASCOT MINE (JULY 1933) rich ore. The lode has been disturbed considerably by postmineral faults, and segments have in many places been sharply displaced, particularly to the north. The very extensive premineral and postmineral fracturing has made it very difficult to maintain the underground workings.

Most of the quartz observed on the ground was the earlier fairly coarse-grained variety in which occurred scattered grains of pyrite arsenopyrite, and sphalerite.

ELKHORN MINE

The Elkhorn mine is in sec. 16, T. 7 N., R. 6 E., on upper Elk Creek in the old Elkhorn district. It was famous in the early days but has not been worked for many years. The mine was particularly active in 1867 and 1868, but no record could be found as to when and by whom the last work was done. The mining was carried on from a 1,400-foot tunnel with stopes to the surface.[71] Its production apparently exceeded that of any mine in the Gambrinus district and is given as $800,000.[72] All the production came from a single vein, the Elkhorn.

The fissure occupied by the Elkhorn vein has the west-northwest trend of the early Tertiary (?) lodes and presumably dips southwest. According to Lindgren,[73] the vein was particularly well-defined and comprised quartz lenses as much as 18 inches thick. It had a large shoot of high-grade ore, which contained as much as 2 ounces of gold per ton. Near the surface the vein is said to have split into quartz stringers and at a depth of 100 feet to have been cut off by a fault.

FOREST KING MINE

The Forest King mine is about 8 miles northeast of Idaho City and is above the steep scarp that extends across the northern part of the Gambrinus district. The mine was located in 1875 and a 10-stamp mill erected on the ground in 1884.[74] It apparently has not been worked much since, and the 900-foot tunnel that was driven in the early days was not open in 1932.

According to Lindgren, the deposit occupied a fracture zone striking N. 56° W. and dipping 60° SW. Massive quartz appeared in the outcrop in hard unweathered quartz monzonite, but below the surface the deposit was composed of smaller quartz seams in a fracture zone several feet thick in which the rock was considerably crushed. Some small but rich ore shoots 6 to 12 inches thick were uncovered.

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[71] Lindgren, Waldemar, op. cit., p. 689.

[72] Jones, E. L., Jr., Lode mining in the Quartzburg and Grimes Pass porphyry belt. Boise Basin, Idaho; U. S. Geol. Survey Bull. 640, p. 95, 1917.

[73] Lindgren, Waldemar, op. cit., p. 689.

[74] Lindgren, Waldemar, op. cit., p. 687.

SUBROSA MINE

The Subrosa mine is reported to be on a continuation of the Forest King lode and is on the high steep slope facing Moore Creek and the central part of Boise Basin. It was located and worked during the early days and was then idle until 1896, when work was resumed with the intention of finding the downward continuation of the ore shoot from a lower level.[75] In 1921 the Subrosa was acquired by the Monetary Metals Co. (later the Consolidated Mines Syndicate), but the workings were not reopened and the development remains the same as in the late nineties. According to unconfirmed reports, considerable ore was mined in the early days, mainly from comparatively small but rich shoots. The ledge strikes in the same direction as the Forest King, about N. 56° W., and dips southwest. Lindgren reports that the lode is several feet thick and is composed in large part of crushed granitic rock with quartz seams in fractures. In places the lode is said to be displaced by faults and cut by dark-colored dikes.

WASHINGTON MINE

The Washington mine is in sec. 33, T. 7 N., R. 6 E., near the east margin of the Gambrinus district and near the head of the east fork of Gambrinus Gulch, about 7 miles northeast of Idaho City. It is within a short distance of the Lowman highway and is reached by a branch road about 2 miles long. The mine was located in the early days of quartz mining and when examined by Lindgren in 1896 had been opened by a 290-foot tunnel and a 316-foot shaft, which was sunk near the portal of the tunnel. Four hundred feet of drifts had been driven from the shaft on the first level, 250 feet on the second, and 170 feet on the third.[76] Work continued for a number of years after Lindgren's visit, and the tunnel was lengthened to 960 feet, the shaft deepened to 414 feet, and another drift driven on the 400-foot level. Later a winze was sunk from the 400 level, about 180 feet east of the shaft, to a depth of 165 feet, and short drifts were run out on the 500- and 565-foot levels. In 1921 the mine, together with the Subrosa, was acquired by the Monetary Metals Co., and development work was resumed. During the next several years an extensive crosscut 3,735 feet long was driven from the lower gulch and in 1924 tapped the bottom of the vertical shaft just below the 400-foot level. The crosscut was extended about 125 feet beyond the shaft, and drifts were run along several minor fracture zones, but no workable ore was found, except in the vicinity of the old workings.[77] The company constructed a com-

[75] Lindgren, Waldemar, op. cit., p. 688.

[76] Lindgren, Waldemar, op. cit., p. 688.

[77] Ballard, S. M., Geology and gold resources of Boise Basin, Boise County, Idaho: Idaho Bur. Mines and Geology Bull. 9, p. 97, 1924.

plete camp, including a new mill, and the development continued until October 1926. In 1927 the Monetary Mining Co. was merged with the Consolidated Mines Syndicate, but no further work was done, and when the property was visited in 1932 and 1933 the long crosscut was blocked and the camp was in ruins. In August 1934 the surface plant was destroyed by forest fire. In 1937 strenuous effort was made to rebuild the camp and rehabilitate the mine. The road from the highway was rebuilt, camp buildings were constructed, and the long tunnel was reopened for a distance of about 800 feet.

The Consolidated Mines Syndicate holdings aggregate four patented and 11 unpatented claims with a total development of approximately 10,200 feet. No records of production were obtained, but Lindgren reports $90,000 milled from 4,300 tons of ore in the early days,[78] and Ballard reports a total of $92,000 above the 400-foot level[79] below which there was practically no stoping.

The property is unique among those in Boise Basin in that it has a silver as well as a gold vein and, therefore, has a deposit of probable lower Miocene age as well as one of early Tertiary (?) age. All the stoping has been confined to the gold vein. The silver vein, however, has been exposed on each of the levels underground. Some rhyolite porphyry dikes are exposed several miles to the northeast, but locally the only dikes are lamprophyric, and one, a biotite vogesite, is exposed in the workings underground aligned along a fault striking N. 40° E. and dipping 60° SE.

The gold vein occupies a well-defined fissure of general easterly trend, which dips vertically to steeply south. According to Lindgren,[80] the vein had an ore shoot 45 feet long and 1 to 6 feet thick, cut off at depth by the silver vein. The ore shoot apparently terminated not far below the 400-foot level and apparently had been mined out before the recent extensive prospecting by long crosscut had been started. The vein filling consisted largely of milky coarse-grained quartz with scattered pyrite crystals, the quartz apparently belonging to the third stage of deposition.

The silver vein is reported to strike about N. 70° W. and to dip 75° to 90° SW. It intersects the gold vein a few hundred feet east of the shaft as well as at depth. The vein is reported to range from 8 inches to 4 feet in thickness where exposed on the different levels underground, but its length has not been determined. Judging from the ore removed during development and piled on the dump, the vein filling must be composed largely of base metals, particularly sphalerite and

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[78] Lindgren, Waldemar, op. cit., p. 688.
[79] Ballard, S. M., op. cit., p. 96.
[80] Lindgren, Waldemar, op. cit., p. 688.

galena, in which may be found microscopic grains of chalcopyrite and tetrahedrite. Some of the filling, however, shows evidence of extensive brecciation and the introduction of a younger suite of minerals, including silver sulfosalts. The minerals introduced into the reopened parts of the filling include chiefly quartz, locally considerable arsenopyrite and some pyrite, and variable but generally scant amounts of miargyrite, pyrargyrite, and another mineral of doubtful composition, though tentatively identified as andorite. Fractures in the ore contain some scattered plates and wires of native silver, undoubtedly of supergene origin. Most of the quartz is fine-grained, but some is coarse and drusy and shows a marked comb structure. The associated iron and silver minerals are also fine-grained, and it is evident that the conditions attending the deposition of these younger minerals were distinctly epithermal.

HAYFORK MINE

The Hayfork mine is on Hayfork Creek, a tributary of Moore Creek, in sec. 36, T. 7 N., R. 6 E., about 10 miles northeast of Idaho City. It lies about a mile above the mouth of Hayfork Creek and the same distance from the Boise-Lowman highway on Moore Creek. The mine covers two groups of claims, the Gold Bug, on the creek, and the Black Eagle, on the top of the high ridge west of the Gold Bug. The mine has been known for a number of years and as early as 1906 had been prospected by a number of shallow cuts. Most of the development, however, has been carried on since 1923, when the property was acquired by the Jarvis brothers.

All recent work has been confined to the Black Eagle group. The Black Eagle lode has been opened by three tunnel drifts and explored by other workings. The highest tunnel is just beneath the crest of the ridge, and its 200-foot length takes it through the ridge from the Hayfork side to the Moore Creek slope. The No. 2 tunnel is about 70 feet below the No. 1. Its length is about 280 feet, which also carries it through to the opposite side of the ridge. The No. 3 tunnel, completed in 1937, is 120 feet below the No. 2, and it also has been driven through the ridge, its length being 700 feet. The No. 3 tunnel is connected with the No. 2 by a raise, but no stoping up to August 1, 1938, had been done between. Prospecting was also under way on the Moore Creek slope at two places below the No. 3 level. The workings on the Gold Bug include the original cuts and short tunnels driven about 1906 and some other crosscuts and drifts driven between 1923 and 1933. These workings trace the Switzerland lode on the Gold Bug group for about 2,000 feet. A 200-foot drift on the west end of the lode was open in 1932, but of the two more recent openings on the east end of the lode only the upper crosscut and drifts with some 300 feet of workings were accessible in 1933. The production up to 1932 from the Switzerland was reported to total $5,000 and from the Black Eagle about $10,000, but since then much more ore has been mined and treated in the mill on the creek below the Gold Bug.

The structural and mineralogical features of the mine are much like those in other parts of the Gambrinus district. Several prominent fissure zones that trend west-northwest and dip southwest cross the property and are in places displaced by northeast faults, some of which are occupied by dark-colored dikes. The Black Eagle fissure zone strikes N. 70° W. and dips about 45° SW., the dip steepening somewhat with depth. The fissure zone is as much as 9 feet across and is made up of intricately fractured rock and considerable gouge. The lode, however, occupies less than one-third of the disturbed zone and is but 2 to 3 feet wide. The ore shoot in the upper workings is about 150 feet long and is made up of small lenses and bunches of quartz and has accompanying thin seams in iron-stained fractures in the weathered but little hydrothermally altered granitic rock. Much of the richer ore was reported to occur along the footwall beneath a prominent postmineral gouge seam, but streaks of high-grade ore also appeared in the hanging wall. All the ore has been stoped above the No. 2 level.

Several fracture zones cross the Gold Bug group, but most of them contain little ore. They strike N. 60°–80° W. and dip steeply southwest, the Switzerland striking N. 70° W. and dipping 70° SW. The zone of fractured granitic rock containing the Switzerland is 4 to 9 feet across, but the lode is only half as wide and is defined by prominent bands of gouge on both the hanging and footwalls. The lode is exposed for only 55 feet in the upper tunnel. It appears to be made up of recurrent quartz seams and lenses a few inches thick in fractured rock bounded by bands of gouge 8 to 12 inches thick. The lode is cut off by a fault trending N. 20° E. at the east end of the drift, and the fault is occupied by a dark-colored dike. The drifting was deflected northeast along the dike for a short distance and then east-southeast along a poorly defined fissure zone, which may be the continuation of the Switzerland. Continued drifting and crosscutting has disclosed other fracture zones.

The ore is not much different from the ore in other parts of the Gambrinus district. It is composed of coarse-textured quartz in places accompanied by minor amounts of sulfides. In the Black Eagle lode most of the quartz is the rather coarsely crystalline young-stage variety, much of which tends to form interlocking combs, in part deposited around fragments of older less coarsely crystalline quartz in which are sporadically scattered fairly large crystals of arsenopyrite and pyrite and fewer grains of sphalerite and galena. These sulfides comprise less than one-tenth of the filling. Free gold is visible in places, in part replacing the sulfides, but more generally it occurs in the younger comb quartz in part associated with scattered pyrite cubes younger than those that accompany the older arsenopyrite. Scant amounts of stibnite are reported in some of the comb quartz. The young comb quartz is not nearly as abundant in the Switzerland lode as in the Black Eagle, and most of the quartz there is the older less coarsely crystalline variety accompanied by small crystals of pyrite and small but variable amounts of sphalerite, galena, and arsenopyrite.

TWIN SISTER MINE

The Twin Sister mine is in sec. 33, T. 7 N., R. 5 E., about a mile east of Old Centerville, near the head of Mill Creek. It was discovered and located during the early days of placer mining. Like so many of the old mines it was idle for many years, and work was not resumed until 1933, when the property was leased from the Mineral Mining Co. The mine was originally worked to a depth reported as 250 feet, but these old workings were entirely caved, and the mine was reopened by a 100-foot incline at the side of the earlier work. Drifts were run from the bottom of the level, and stoping was carried on below and to the side of the old stopes. The mine is credited with an early day production of $50,000. It is reported that 1,000 tons of ore were milled during 1934. Work was suspended shortly afterward, and the mine has since been idle.

The property is crossed by two lodes, but the work has been confined to a single one. This lode strikes about N. 70° W. and dips 45° SW. Its average thickness is about 3 feet, but in places the thickness increases to 7 feet. The lode is made up of quartz lenses, with quartz seams and stringers on either side. It is divided into two parts by a 10-inch band of gouge parallel to the walls of the fissure zone and produced by postmineral faulting. Massive quartz commonly lies below the gouge and seams and stringers above. Pockets of rich ore are reported to lie on either side of the gouge.

Much of the ore mined in 1934 consisted of reddish and brownish iron-stained quartz containing porous streaks and small cavities from which sulfides had been leached. A considerable part of the ore was also crusted with thin films of greenish scorodite. The unoxidized ore exposed at the bottom of the incline, however, showed scattered sulfide grains in the quartz, the sulfides being mostly fine-grained arsenopyrite and lesser amounts of pyrite, sphalerite, galena, and stibnite. The sulfides, except the stibnite and some of the pyrite, were associatel with a massive rather coarse-grained quartz, brecciated and cemented by a younger quartz of the comb variety, which held small scattered pyrite cubes, stibnite needles, and small grains of gold.

In general the two stages of quartz are not easy to differentiate, except where the older sulfide streaks have been broken and are scattered as inclusions through the younger quartz. The country rock shows little evidence of hydrothermal alteration and none more than a few inches from mineralized seams.

BIG BEN MINE

The Big Ben mine is in Lewis Gulch, in sec. 27, T. 7 N., R. 5 E., about 2½ miles east of Old Centerville. Some ore was milled in the late nineties, but nothing more was done until 1927. In 1932 the workings included a 255-foot crosscut with 130 feet of drifts at a depth of 155 feet measured on the dip of the vein and an intermediate level 50 feet below the outcrop with 100 feet of drifts, the two levels connected by a raise with the surface. Some ore was stoped and treated locally in a small stamp mill.

Although the fissure strikes about N. 70° E. and dips 45° to 50° SE., the dip increasing with depth, the deposit has all the other features characteristic of the early Tertiary (?) veins. The fissure zone, which is 3 to 6 feet across, is occupied almost entirely by a quartz vein 3 to 30 inches thick, associated with few stringers, except on the intermediate level. The country rock throughout the fissure zone has been considerably crushed, but the rock shows little evidence of alteration by the ore solutions, except for the presence of slight amounts of sericite and sparse disseminations of minute pyrite crystals. The fissure is prominently outlined by a footwall gouge, the product of postmineral movement. In places the vein lies along the hanging wall of the fissure, in other places along the footwall.

The ore consists almost wholly of massive white quartz with few sulfides, except in a small shoot exposed on the intermediate level. The sulfides include scattered crystals of pyrite and arsenopyrite in a coarse-grained quartz, which has in places been brecciated and cemented by younger quartz of the comb type. The younger quartz has some widely scattered cubes and grains of pyrite. Some of the early pyrite crystals are one-half inch square, but the arsenopyrite crystals are nearly microscopic.

CASH REGISTER MINE

The Cash Register mine is in Thompson Gulch, in sec. 22 or 27, T. 7 N., R. 5 E., about 2 miles east of Old Centerville. This property is another that was known in the early days and received considerable work but unlike most of the other old mines in the region has received no recent attention, the last work underground having been done prior to 1926. When visited in 1932 the workings were entirely inaccessible, and the only openings were surface cuts, by which it was possible to trace the main vein for about 800 feet. Some old workings on the west end of the vein had been abandoned, and the more recent work had been confined to tunneling on the east end beneath outcrops near the bottom of the gulch. The more recent work is reported to total more than 360 feet of crosscuts and drifts.

Some ore was mined a number of years ago, and according to unverified reports the stamp mill recovery on 35 tons of the better ore was approximately $30 per ton.

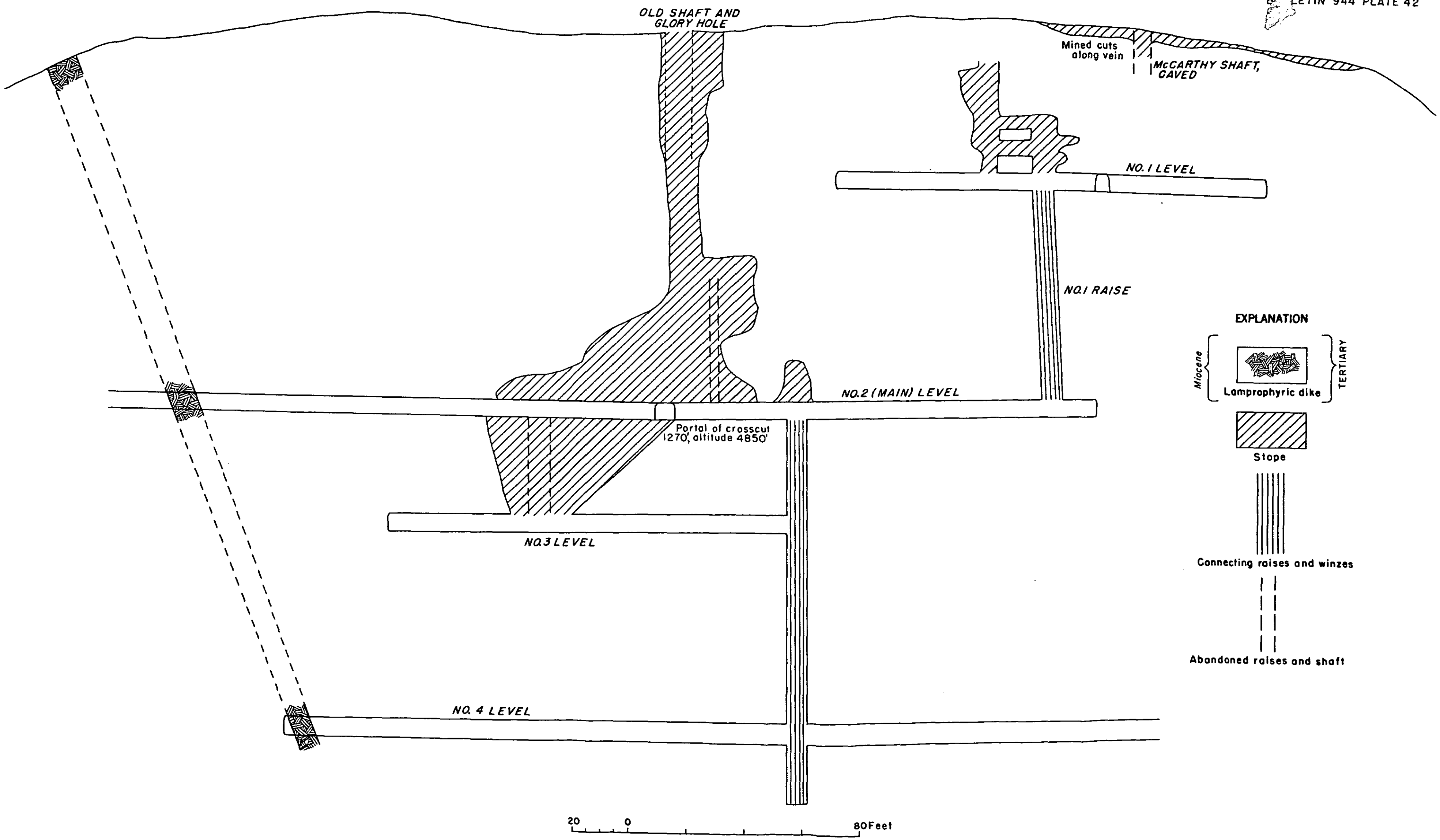
At least two veins are known to occur on the property, but the Cash Register is the only one that has received much attention. It occupies a prominent fissure zone trending N. 80° E. and dipping 40° SE. and is reported to range from 9 to 30 inches in thickness, much of it composed of low-grade ore but here and there with pockets of high-grade ore. At one place the vein is reported to be cut off by a dike along a fault striking N. 20° E. The other vein is reported to have been opened for 180 feet in the crosscut to the Cash Register vein and to range from 3 to 8 feet in thickness. It is composed of massive white quartz, part of which has a low gold content.

The ore is more or less typical of the early Tertiary (?) ore, and most of it is the early coarse-grained massive quartz with scattered grains of pyrite and arsenopyrite confined to small and widely spaced shoots. In places this filling has apparently been somewhat fractured and the fractures healed by the younger comb quartz. This younger quartz with its associated gold determines the position of the richer pockets.

MATTIE MINE

The Mattie mine, formerly the Lippencott and Warner, is at the head of Willow Creek, about 4 miles northwest of Idaho City. The mine was worked in the early days, but nothing was learned of its early history. It was reopened by the Engineer Mines Co. in 1923 after a long period of idleness. The new operation, however, was shortlived. Except for some surface work in 1932 and 1933, the mine has since been idle. The workings comprise a tunnel, two shafts, one of which is 60 feet deep, a winze on the lower level, and enough drifts with the tunnel to total 600 feet. These workings were not accessible in 1932.

Two lodes cross the property, but only the Mattie lode has received much atention. The Mattie strikes about N. 55° W. and dips 35° SW.; the other strikes N. 10° W. and dips 45 SW. Much of the Mattie lode is reported to consist of crushed and fractured aplite and quartz monzonite with scattered seams and stringers of quartz. It contained an ore shoot about 40 feet long, which was followed



LONGITUDINAL SECTION OF THE CLOVERLEAF MINE downward by the winze for 100 feet.[81] The quartz apparently belongs to the young stage of deposition and contains scattered cubes of limonite pseudomorphic after pyrite.

SUMMIT MINE

The Summit mine is on the long ridge between Elk Creek and Grimes Creek, about 2½ miles southeast of Old Centerville. It was discovered in the nineties by tracing the placer gold of Deer Creek to its source and was later prospected by shaft and drifts. The shaft was retimbered in 1933, but the absence of ladders made it impossible to go underground.

The lode, like most of those in the Gambrinus district, strikes west-northwest and dips about 45° SW. According to Lindgren the deposit is contained in a zone of sheared and crushed granitic rock as much as 18 feet across with an ore shoot 4 feet thick and 60 feet long containing thin seams of quartz rich in gold.[82]

MAMMOTH MINE

The Mammoth mine, apparently in sec. 25, T. 8 N., R. 6 E., is at the lower north end of Summit Flat at an altitude of about 8,000 feet. It is within 3 miles of the head of Grimes Creek at the margin of the broad, flat-bottomed valley occupied by the creek and less than half a mile west of the road built by the Civilian Conservation Corps from Pioneerville to Pilot Peak and the Lowman highway on the Moore Creek summit. The mine was discovered in 1863 by prospectors in search of placer gold and was worked extensively in the early days and off and on to the present. The underground workings are extensive and include a 1,500-foot crosscut to the 200-foot level, a shaft 350 feet deep to the 400-foot level, and drifts on the 100-, 200-, and 400-foot levels. Little work has been done, however, below the 200-foot level. The crosscut was open when the mine was examined in 1932, but most of the drifts were closed.

The total production prior to the middle twenties has been estimated at nearly $500,000.[83] About $60,000 was reported to have been recovered from quartz float, about $300,000 from the 100-foot level to the outcrop, and nearly $200,000 from the 200-foot level. A well-equipped stamp mill has been operated from time to time in recent years, but the production therefrom was not obtained. During 1937 and a part of 1938 the mill treated ore from the Golden Cycle mine.

One vein and two lodes occur at the property, the Mammoth vein and the Jackson and Jupiter lodes, but only the Mammoth vein has

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[81] Ballard, S. M., op. cit., pp. 98–99.
[82] Lindgren, Waldemar, op. cit. (18th Ann. Rept.), p. 689.
[83] Ballard, S. M., op. cit., p. 95.

been developed extensively. The Mammoth vein apparently belongs to the group of early Teritary (?) deposits, but the Jackson and Jupiter lodes may be of lower Miocene age. Many of the Miocene rhyolite and quartz monzonite prophyry dikes occur in the vicinity of the mine, and one rhyolite porphyry dike is known to cut the Mammoth vein. The Mammoth vein appears to be well within the zone subjected to lower Miocene shearing and igneous activity and has been materially affected by that disturbance.

The Mammoth vein occupies a fissure zone striking approximately N. 80° E. and dipping 45° SE. Above the 200-foot level the vein ranges from 2 to 3 feet in thickness, exceptionally 8 feet, and contains a series of ore shoots 40 to 60 feet long on the strike, separated by approximately equal spacings of barren or lower-grade ore. Most of the production came from ore shoots east of the shaft, and stopes are visible for a full 200 feet. A hundred feet beyond, however, the vein is offset by a fault, which is reported to strike N. 10° E. and to dip about 60° NW., and, although much crosscutting and drifting has been done, the displaced segment has not been found. If this fault is like other faults of lower Miocene age it should have a marked horizontal component of movement, inclined perhaps from 20° to 30° to the south. Another ore shoot lies west of the shaft, separated from the east ore shoot by 200 to 250 feet of barren ground. It is reported that the east ore shoot did not continue to the 400-foot level, although the one on the west side did. Most of the ore occurs in the form of quartz lenses, in places accompanied by subordinate seams and stringers. The quartz is massive, white, and coarse-grained, but much of it is somewhat drusy. It has evidently been deposited in two stages, and remnants of the early stage quartz commonly contain grains and crystals of pyrite, sphalerite, and galena. Some of the gold occurs as a replacement of the earlier sulfides, but much of it is free in the younger drusy quartz.

The Jackson and Jupiter lodes are about 600 feet apart and strike about N. 10° E. They dip toward each other, the Jackson about 70° NW. and the Jupiter about 70° SE. The Jackson is 3 to 4 feet thick and the Jupiter as much as 15 feet thick. Both lodes are enclosed by extensively sericitized rock. The Jackson lode has some quartz but not as much as the Mammoth vein, whereas the Jupiter lode has little quartz but some pyrite, sphalerite, and galena. Neither of the lodes contains as much gold as the Mammoth vein. The Jackson is reported to have produced about $35,000 in gold.

RED LODE MINE

The Red Lode mine is in the Summit Flat district, on the Elk Creek slope of Freeman Peak, 1½ miles from the Moore Creek-Grimes Creek saddle. It lies some distance down the slope and is reached by road from the head of Grimes Creek. The property was prospected more than 50 years ago but was generally inactive until taken over by the Red Lode Mining Co. sometime after 1930. The holdings consist of the Olympia group of 11 unpatented claims, a newly constructed mine camp, and a water-power driven 5-stamp mill. The road to the camp was built after the Red Lode Mining Co. had taken over the property. The underground workings are reported to total 4,000 feet of development distributed among three main tunnels, none of which was entered.

A number of small so-called gash veins are exposed on the surface above the lower tunnel level and are contained along parallel sheeted zones in the batholithic rock. These veins strike about N. 80° E. and dip about 40° S. and, therefore, conform with the general trend of the veins and lodes in the Summit Flat area. Most of the veins are less than 8 inches thick and only 20 to 30 feet long. They appear to be equally as nonpersistent on the dip as on the strike and are too widely spaced to be mined collectively. Their lack of size, however, is more than compensated by their number, for they crop out sporadically far up the slope. The filling is a white, milky quartz, largely of the coarse comb type in which a few small widely scattered pyrite crystals occur.

MADEMOISELLE MINE

The Mademoiselle mine is in sec. 12, T. 7 N., R. 6 E., on the divide that separates the head of Moore Creek from Grimes Creek in the saddle between Pilot and Freeman peaks. The workings consist of a series of cuts and an adit at shallow depth from which the ore has been stoped to the surface. The property is equipped with a small mill.

The deposit is the lode type and occupies a zone of shearing that strikes about N. 85° E. and dips 55° to 60° S. The ore consists of thin quartz seams in the fractured granitic rock and also quartz lenses 6 to 12 inches thick. The quartz is the comb variety affiliated with the closing stages of the early Tertiary (?) mineralization and has a few very widely scattered crystals of pyrite and some gold in visible grains. The ore has been stoped for a distance of 150 feet along the adit.

GOLDEN DIVIDEND MINE

The Golden Dividend mine is in sec. 11 or 12, T. 7 N., R. 6 E., on the northeast side of Freeman Peak, not far from the Mademoiselle. The property is apparently an old one, but it was reopened in 1932. The workings consist of shafts and cuts from which production amounting to $10,000 was reported for the early days. The fissured zone in the granitic rock trends about N. 85° E. and dips 60° S. It contains a lenticular quartz vein several inches thick composed of the young quartz of comb habit.

SUNSET PEAK PROPERTIES

Several small properties lie on the upper slope of Sunset Peak at the head of Hayfork Creek. They have been developed by shallow shafts and tunnels and open cuts. They are on well-defined fissure zones, which trend east and dip 60°–70° S., and contain small gash veins 1 to 8 inches thick made up chiefly of comb quartz, with here and there scattered crystals of pyrite and grains of gold. Small rich shoots have been found in some of them. Some of the veins have been displaced by faults of northerly trend.

GOLDEN CHARIOT MINE

The Golden Chariot mine is on Rock Creek, in sec. 19, T. 8 N., R. 7 E., and is reached by road from Summit Flat. The mine is an old one, but some work has continued off and on to and including 1938. The development has been fairly extensive, but the only open workings are those on some veins, or lodes below and north of the old mine. The old workings include a vertical shaft 165 feet deep and several hundred feet of crosscuts and drifts on different levels. Down the creek are three other tunnels, one with more than 700 feet of crosscuts and drifts and the other two with less. According to reports, the production from the shaft workings did not exceed $15,000 and from the lower tunnels not more than $10,000.

The mine is in an area of numerous rhyolite and quartz monzonite porphyry dikes, but from what could be seen from exposures and in the one open 700-foot tunnel the gold deposits are confined to the granitic rock of the Idaho batholith and are cut only by lamprophyric dikes. The main vein or lode exposed by the working from the shaft was not seen, but it is reported to strike east and dip about 45° S. The fracture zone is said to be about 30 feet wide and traceable for 4,500 feet. The ore shoots in it are said to be confined to lenticular veins 20 to 40 feet long, composed largely of quartz which assayed 1 to 1½ ounces of gold to the ton. Most of the quartz was near the shaft.

No well-defined veins or lodes were observed in the openings down the creek, but several fracture zones of west-northwest and east-northeast trend and southwest to southeast dip were exposed. The structural and mineralogical relations suggest the early Tertiary (?) type of mineralization. The workings from which ore was mined in the early days were not accessible.

GOLDEN CYCLE MINE

The Golden Cycle mine is in sec. 20, T. 8 N., R. 7 E., just below the sharp turn in Rock Creek about 1½ miles northeast of the lower end of Summit Flat. The mine is owned by Golden Cycle Mining Corp., and most of the development has been since 1936. When the mine was visited late in July 1938, the workings consisted of a tunnel about 400 feet long driven directly into the steep slope with the stopes near the portal reaching the surface. Considerable ore had been mined and until the middle of 1938 had been trucked to Summit Flat and treated in the Mammoth mill. In the latter half of the year arrangements were made to treat the ore at the Sloper mill. The total output of the mine was not learned, but the price paid for treating the ore at the Mammoth mill was reported as $1,700. During the time the mine has been in operation it has been rated among the larger producers, ranking next to the Mayflower, near Quartzburg, in production.

The deposit is the early Tertiary (?) gold-quartz type and has most of the structural and mineralogic characters credited to the early Tertiary (?) group of deposits. Lower Miocene rhyolite and quartz monzonite porphyry dikes are numerous in the vicinity of the mine, but none have been found in the underground workings where the rock is little-altered quartz monzonite. The deposits occupies a fracture zone of somewhat variable but general easterly trend which bears slightly south of east near the face and north of east near the portal. In places the dip is vertical, in other places steeply north. The fracture zone is 3 to 4 feet wide and is occupied by quartz seams and bands in fractures and locally has lenses of quartz a foot thick. The deposit is classed as a lode rather than as a fissure vein. It differs, however, from most of the other lodes of the district in that the quartz forms a proportionately larger part of the deposit and is more uniformly distributed along the strike of the fissure zone, thereby producing a continuous ore body of considerable length rather than a series of shorter ones. The ore had been stopped for 300 feet and the full length of the body had not been disclosed when the property was visited in 1938. Near the face the lode had been cut by a fault, but the displacement had not been sufficient to offset the lode for more than a few inches. This fault strikes N. 45° E. and dips 70° SE. and is apparently a product of the Miocene shearing. It shows diagonal striations dipping 55° SW. The ore body is also cut by a westward dipping low angle fault, which displaces the lode about 18 inches laterally. Near the portal the fault cuts the lode about 14 sets above the tunnel level, but the dip carries the fault to the drift level near the face. Ore occurs both below and above the fault.

Most of the ore is massive rather coarsely crystalline quartz, but there is also considerable drusy quartz in small clefts. In places the quartz, which is largely the quartz affiliated with the late stage of ore deposition, has scattered ill-defined fragments and grains of older quartz and sulfides, particularly sphalerite and galena and less conspicuously pyrite and arsenopyrite. Some of the sphalerite and galena grains are fairly coarse. Gold is also present, much of it free in the younger quartz but some is on and in sulfides. In places the gold is visible to the unaided eye, and the mine has attracted considerable attention because of the presence of "specimen" rock. None of the ore milled is reported to have carried less than 1 ounce of gold per ton.

SLOPERS MINE

A property known as Slopers is probably in unsurveyed sec. 13, T. 8 N., R 6 E., on the broad, notably flat summit between the headwaters of Grimes and Rock Creeks and the Payette Canyon, in the Summit Flat district. It is near Rock Creek at an altitude of about 7,000 feet, more than 2,000 feet above the Golden Chariot and Golden Cycle mines, and is reached from Summit Flat by road from a point near the Mammoth mine. The workings consisted of a 42-foot shaft with short drifts at the 30- and 40-foot levels. In 1938 work was started by lessees on a crosscut from the slope below. A small mill was also equipped at about the portal level.

The ore deposit is not well exposed on the surface and has not been adequately opened underground. It appears to be a lode of considerable size, occupying a fracture zone perhaps as much as 20 feet wide, which is not uniformly mineralized. The lode may strike about N. 55° E. and dip steeply southeast. Numerous quartz monzonite porphyry dikes (Miocene) crop out nearby, but none were seen in contact with the lode. The ore occurs as irregularly distributed seams, bands, and stringers in the fractured rock of the batholith and consists wholly of quartz, most of which is the third-stage comb or drusy variety. Native gold may be observed in the quartz, but its distribution is spotty.

GRANDVIEW MINE

The Grandview mine is in sec. 30, T. 8 N., R 5 E., in the Payette Canyon at the head of the East Fork of Horn Creek, about 3 miles west-southwest of Grimes Pass. It lies just below the crest of the divide separating the Payette River from the Grimes Creek drainage basin at an altitude of 5,200 feet and is reached by a steep road ascending from the bottom of the Payette Canyon. The property is an old one, but nothing was learned of its early history. It was at one time known as the Brunnel, and when the American Mines Development

Co. took over the property in 1928 it had about 410 feet of workings about equally divided between two tunnels. During 1928 and 1929 the American Mines Development Co. extended the lower tunnel to 450 feet, but no more work was done until the Buck Horn Mining Co. took over the property in 1936. The road from the river was then rebuilt and the camp largely reconstructed. The tunnels were rehabilitated, and during 1938 some ore was stoped and shipped and the development extended.

The holdings comprise the Grandview group of 12 unpatented claims, and the workings consist of the two tunnels, one about 60 feet vertically above the other, which total about 755 feet, all but 250 feet of which in July 1938 were in the lower tunnel.

The workings expose a single vein, which has the usual structural and mineralogical features of the early Tertiary (?) gold deposits. The strike of the vein varies from N. 50° W. to N. 65° W. and its dip from 40° to 60° SW., the dip increasing with depth. The vein has been exposed for about 250 feet in the upper tunnel and has been partly stoped to the surface. It is 3 to 6 feet thick and consists in places of massive vein quartz and in other places of quartz seams, lenses, and bunches in fractured but little-altered granitic rock. At its face it was 9 feet thick but consisted largely of fractured country rock with seams and bunches of quartz. The country rock, though little altered, is difficult to hold because of extensive fracturing; for that reason few of the stopes were open, and little could be learned of the amount of ore that had been mined. The lower tunnel was blocked just beyond the point where the crosscut intersected the vein about 230 feet from the portal. The visible parts of the vein ranged from less than 1 inch to 2 feet in thickness. A winze from the level above and a raise from the lower level indicate that the two tunnels are connected and that some stoping has been done between.

Most of the vein filling consists of coarsely crystalline, massive white and glassy quartz notably free of vugs and druses and containing in places some scant sulfides, principally pyrite and a very little sphalerite and galena. The ore shows little evidence of brecciation during the general period of ore deposition, but it is otherwise no different from the typical gold-quartz ore and vein filling in the Gambrinus district. The late comb and drusy quartz is not very evident along the exposed parts of the vein.

K. C. MINE

The K. C. mine is in sec. 1, T. 8 N., R. 5 E., in the lower part of the Payette Canyon on the south side of the river, about 2½ miles above the power plant. It received considerable attention in 1932 when ore shipments were made to smelters near Salt Iake, Utah. Soon afterward a 10-stamp mill was erected on the river below the mine.

In 1932 the development comprised a number of surface trenches, a 60-foot drift just below the surface, and about 425 feet of workings in a lower tunnel less than 100 feet below the outcrop. Several small shoots were mined from the lower drift, and a winze was sunk. The property was incorporated as the K. C. Mines,, Inc., on October 26, 1936, but the charter was forfeited on November 30, 1937. According to the State mine inspector the development in 1937[84] consisted of 6 tunnels, the principal ones being No. 1, 300 feet long; No. 2, 250 feet; No. 3, 150 feet; and No. 5, 150 feet long.

The mine lies at the north margin of the "porphyry belt" that extends through Quartzburg and Grimes Pass, but the deposit has all the structural and mineralogical features of the early Tertiary (?) deposits. The vein lies along a fissure zone that trends about N. 78° W. and dips about 65° SW. and consists of about 4 feet of fractured and crushed granitic rock containing recurrent quartz lenses with long barren spaces between. The largest quartz lens is about 150 feet long and ranges in thickness from 2 to 30 inches. It has at least one small ore shoot about 20 feet in length from which some ore has been mined and another about 20 feet long and 8 to 20 inches thick that has been opened by a winze. Two to 7 inches of post-ore gouge lies along the hanging wall. The fissure zone is also shared by a black dike, which lies in the footwall beneath the vein. In common with the deposits in the Gambrinus district, the adjacent country rock has been little altered, and the fractured rock between the quartz lenses is quite fresh.

Most of the ore consists of coarse-textured white quartz, which in places contains scattered sulfide grains, principally sphalerite, arsenopyrite, and galena, and lesser pyrite and stibnite. Two generations of quartz are present, the earlier a finer-grained massive quartz partly replaced by the arsenopyrite, pyrite, sphaleite, and galena, the younger a much coarser-grained, in part, somewhat drusy quartz, which cements broken fragments of the earlier quartz and sulfides and contains in itself scant amounts of stibnite between crystals and in fractures and here and there visible grains of gold.

BLUE ROCK MINE

The Blue Rock mine is located in sec. 32, T. 8 N., R. 4 E., on one of the two early Tertiary (?) base-metal deposits. It is in Confederate Gulch, nearly 2 miles northwest of Quartzburg. The deposit was probably discovered in the early days of lode mining and "rediscovered" about the time of the First World War. By 1919, the only

[84] Campbell, Arthur, Thirty-ninth Annual Report of the Mining Industry of Idaho for the year 1937, p. 179, 1938.

year when a published record could be found with mention of the property, the development consisted of several open cuts and a 100-foot crosscut, with drifts of 70 feet and 175 feet to each side. The tunnel was blocked when the property was visited in 1932, and study was confined to the outcrop and open cuts. Considerable ore was piled on the dump, but no shipments had been made nor had there been any attempts at milling. The property is now owned by the Blue Rock Mines Corp., incorporated September 21, 1935, and consists of 5 unpatented claims.[85]

The mine is nearly 2 miles from the margin of the main "porphyry belt" of the Quartzburg-Grimes Pass area. The ore has all the features of the early Tertiary (?) deposits, except that base metals are comparatively abundant and the late quartz is nonauriferous. The deposit, accompanied by a lamprophyric dike, occupies a prominent fracture zone as much as 10 feet wide, but the ore occurs in the form of quartz lenses 2 to 4 feet thick, and locally as much as 6 feet. The fracture zone strikes about N. 65° W. and dips about 75° SW., about parallel to the locally prominent jointing in the porphyritic quartz monzonite. The walls of the zone are well-defined and are separated from the quartz filling by narrow bands of gouge. The rock in and along the fracture zone shows little sign of hydrothermal alteration. An ore shoot in the west drift is reported to be 40 feet long.

The ore in the lenses consists of coarsely crystalline quartz and rather numerous granules of yellowish-green and orange sphalerite, coarse grains of cubical galena, and somewhat less abundant tetrahedrite, the sulfides comprising about one-fifth of the hand-sorted material piled on the dump. Pyrite and chalcopyrite appear only as microscopic grains in the other sulfides. Most of the quartz is younger than the sulfides and has been deposited in the fractures and openings in a sulfide breccia. Some of the quartz is the coarse drusy variety, but most of it has a decided comb habit. Little gold was deposited, as a selected sample of the typical ore assayed 0.04 ounce in gold and 19.1 ounces in silver.

SILVER HILL MINE

The Silver Hill mine is located on the other of the two early Tertiary (?) base-metal deposits and lies a short distance southeast of the Blue Rock mine on the ridge between Confederate Gulch and Granite Creek, about 1½ miles northwest of Quartzburg. The exploratory work consists of a 200-foot adit driven west-northwest along the crest of the ridge and several cuts on the outcrop. In 1932 the adit

[85] Campbell, Arthur, op. cit., p. 116.

was blocked a short distance from the portal. The property is held by the Consolidated Mines Syndicate.

The Silver Hill mine is probably on a continuation of the same fracture zone as the Blue Rock, or on one that is closely parallel. The structural and mineralogic relations are almost identical with the structural and mineralogic relations at the Blue Rock. The strike is the same, but the measured dip is 55° SW. instead of 75° SW., a variation in dip that is not uncommon along fracture and fissue zones. The adit cuts the fracture zone about 30 feet from the portal and, except for an offset of a few feet 90 feet from the portal, continues along the zone to the face. The ore is confined to quartz lenses, in part shattered and bordered with gouge, in partly silicified and scantily pyritized porphyitic quartz monzonite. These lenses are as much as several feet thick and are in places accompanied by smaller seams and stringers below in the footwall, all equally mineralized. In some places the granitic rock alongside is reported to contain ore.[86]

The ore is composed largely of coarsely granular quartz, in part as closely interlocking crystals with small open spaces between deposited around coarse granules and bunches of sulfides, mostly yellowish-green sphalerite, generally somewhat lesser amounts of tetrahedrite and galena, and scant amounts of pyrite and chalcopyrite. The sulfides appear to be associated with and replace an earlier quartz, but the younger quartz forms the main filling. In much of the ore the sulfides resemble irregular islands strewn through the rather coarsely crystalline quartz. Tetrahedrite is reported to be relatively abundant near the portal of the adit and again at the face. It accounts for most of the silver in the ore. The gold apparently does not exceed 0.1 ounce in the best of the picked ore. Ballard reports that a sample across 2½ feet of the vein at the face assayed 0.12 ounce in gold and 30 ounces in silver and earned 3 percent of copper.

ANTIMONY PROSPECT

The antimony prospect is in sec. 20, T. 6 N., R. 6 E., on lower Hoodoo Creek one-fourth of a mile above its junction with Moore Creek. It is about 3 miles from Idaho City and less than half a mile from the main highway to Lowman. The deposit is exposed along the creek, and the only work done on it prior to 1934 had been to blast a clean face on the outcrop at the base of the slope near the creek bed and to open some small cuts at several places along the ridge to the north.

The deposit occupies a prominent fracture zone about 10 feet wide made up of many parallel fractures with broken rock between. The ore, however, is confined to a vein 2 to 8 inches thick along the footwall. The strike of the vein and fracture zone is N. 65° W., and the dip is 60° SW., a direction that conforms with the vein and lode

[86] Ballard, S. M., op. cit., p. 74.

trends in the Gambrinus district. Most of the vein is composed of coarsely crystalline stibnite in the form of flattened blades as much as 2 inches long projecting inward from narrow walls of comb quartz. In the quartz are small widely scattered crystals of pyrite, largely altered to limonite. The deposit differs from the gold-quartz veins in the Gambrinus district only in the abundance of stibnite and the absence of earlier quartz and sulfides.

BERT DAY MINE

The Bert Day mine is in the Cold Springs district, about 5 miles southwest of Idaho City, at the head of Big Gulch 2 miles west of Moore Creek. The workings consist of surface cuts and two short tunnels, one of them 150 feet below the outcrop. Some ore was treated in an arrastre in the early days, and some was milled at the McKinley mine a few years ago. No record was obtained on the amount of ore produced.

The mine appears to be along an early Tertiary (?) lode, although the fracture zone strikes N. 60°–70° E. and dips 55° SE. and, therefore, does not accord with the more general west-northwest shearing of the early Tertiary (?) rocks. The lode lies along the contact of a rhyolite dike in fractures that are confined to the granitic rock of the batholith. The lode may be traced for 400 feet by surface cuts and appears to average about 18 inches, but is as much as 5 feet in the lower tunnel. Ore has been mined along the surface for 300 feet in shoots 10 to 36 inches wide. The ore has a tendency to occur in bunches and consists of seams and lenses of rather coarsely crystalline quartz of the comb type. Scattered crystals of pyrite and some grains of free gold were observed in the quartz.

BIG GULCH MINE

The Big Gulch mine is in the Cold Springs district, about a mile above the mouth of Big Gulch. The workings comprise surface cuts and several short tunnels. Some ore was mined in the early days and milled locally in an arrastre. The source of the ore was a mineralized zone 3 to 5 feet wide that contained fine-grained and coarse-grained quartz in thin seams and small bunches. The mineralized zone strikes about N. 70° E., dips steeply northwest, and appears to be confined wholly to the granitic rock of the batholith. It may be traced for a hundred feet or more.

K. M. MINE

The K. M. mine is in Big Gulch, about 5 miles southwest of Idaho City. The development comprises several shallow cuts and tunnels. One of the tunnels is about 95 feet long. Some ore was mined in the early days and treated locally in an arrastre.

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Several lodes have been exposed, two in the 95-foot tunnel and another in some fairly recent workings a short distance down the gulch. The two in the 95-foot tunnel strike N. 40° W. and dip 55° to 60° SW. These consist of wide zones of gouge and fractured granitic rock, the larger one being more than 25 feet across. The one down the gulch strikes N. 70° E. and dips 40° SE. There the zone of fracturing is not as broad as the others, and the amount of gouge is considerably less. The ore occurs in bunches, lenses, and scattered seams and stringers in the fractured rock and consists largely of comb quartz accompanied by few, scattered crystals of auriferous pyrite.

BOOMER PROSPECT

The Boomer prospect is in the Cold Springs district, about 4 miles southwest of Idaho City. The development consists of a tunnel about 225 feet long and several open cuts on the surface 200 feet above. So far as known there has been no production.

The general character of the ore suggests the early Tertiary (?) mineralization, but the geologic relations resemble the Miocene, particularly as there are numerous rhyolite dikes in the vicinity of the mine and the dikes and mineralzed fracture zones are alined east-northeast. It is possible, however, that the dikes are not Miocene but may be related to the body of early Tertiary (?) granodiorite that outcrops a short distance away.

Several fracture zones are exposed underground, each striking N. 60°–70° E. and dipping 50° to 60° NW. The largest fracture zone is about 12 feet thick and contains 2 feet of gouge. The others are about 2 feet thick and have bands of gouge 2 to 6 inches thick. Two of the lodes, including the largest, are disclosed in the surface cuts. Another with a quartz vein 4 feet thick is exposed across the gulch on the neighboring slope.

Most of the ore consists of scattered quartz seams and stringers 1 to 6 inches thick in the fractured granitic rock. Some of the quartz is fine-grained, but much of it is coarse and drusy and in places has a prominent comb structure. The quartz commonly contains scattered crystals of cubic pyrite, which on oxidation may show grains of rusty gold. Some grains of molybdenite also appear in the granitic rock distributed along fractures but not in association with the quartz seams. The molybdenite occurs in the less highly fractured rock alongside the main fracture zone and is in places cut by the quartz seams.

BLUE BIRD MINE

The Blue Bird mine is in the Cold Springs district on the ridge above the Boomer. The workings consist of shallow cuts and sluiced ground along a prominent fracture zone in the granitic rock of the batholith. In the fracture zone are thin quartz seams and stringers containing limonite-stained casts after pyrite. Much of the quartz is the drusy kind and forms seams and lenses 1 to 3 inches thick. The size of the lode could not be determined.

MIOCENE DEPOSITS

GOLD HILL MINE

LOCATION AND DEVELOPMENT

The old and famous Gold Hill mine is on Granite Creek, just below the town of Quartzburg, near the center of sec. 9, T. 7 N., R. 4 E. It is owned by the Talache Mines, Inc., which acquired the title from the Gold Hill and Iowa Mines Co. in 1931. The property includes 19 patented and 28 unpatented claims. It has been developed principally through a 1,246-foot, 3-compartment vertical shaft with 9 intermediate levels, containing in all more than 40,000 feet of workings. There are also other workings, including the old Gold Hill shaft, which have been abandoned, and workings of unknown number and extent on the old Iowa, Sunday, and Confederate lodes. The ore was treated in a 100-ton electrically driven fine-grinding amalgamation mill until the mine was shut down and the plant dismantled in 1938.

HISTORY

The Gold Hill mine, one of the oldest and the most productive gold mines in the State, was worked almost continuously from 1864 until 1938. Its development started only 2 years after the discovery of placer deposits in Boise Basin, and like so many other lode mines of the region it was uncovered by placer operations. Most of the early work was confined to the Gold Hill lode, first by tunnels driven into the ridge on the northeast side of Granite Creek and then, from 1875 until the early nineties, by the Gold Hill shaft, which was sunk to a depth of 400 feet below creek level. The ore shoots known at that time, however, were so nearly exhausted that work on the Gold Hill lode was abandoned prior to 1900.

Considerable early work was also done on the Iowa lode, a short distance northeast of the Gold Hill, but it, like the Gold Hill, was abandoned many years ago, and the only evidence of former work consists of old dumps and cuts. The Last Chance, about 250 feet north of the Gold Hill, is another lode that received early attention, but the workings along it, on the west side of Granite Creek bordering Confederate Gulch, are caved and have long been abandoned. Much work was also done on the Sunday lode, in Confederate Gulch a short distance west of the Gold Hill, just prior to 1906, but the operations were suspended when the work could not continue without draining the extensive Gold Hill and Iowa workings.

The Pioneer ore bodies, to which attention was directed as the ore reserves on the Gold Hill lode dwindled, were then exploited, and a shaft was sunk on the Pioneer claim, from which ore had been produced as early as 1884. The ore, however, was not as rich as the ore in the Gold Hill lode, and little work was done on the Pioneer claims until later. In the early nineties the Pioneer shaft was sunk to the same depth as the Gold Hill shaft. From 1900 to 1908 the mine was idle, and the shafts and underground workings were filled with water. In 1910 the workings were unwatered, the Pioneer shaft was sunk to the 500-foot level, and a connection was made with the 400-foot level of the Gold Hill. Some of this work was done by the Boston and Idaho Gold Dredging Co., but much of the subsequent development was carried on by the Gold Hill and Iowa Mines Co.

Operations were again suspended in the early twenties, and the mine was idle until March 1927, when the Talache Mines, Inc., took over the mine under lease and option. The workings, which had extended to the 600-foot level, were unwatered, the mill was reconstructed, and preliminary development work was carried on through the early part of 1929. Production was then maintained through early 1931, although operations were interrupted in August 1929 by a fire that destroyed most of Quartzburg. The shaft had in the meantime been sunk to greater depth, and in 1931 active development was under way on the 850 and higher levels, and the shaft was extended below the 850 level to the 1,100 level. Operations were halted temporarily in August 1931, when the entire surface plant was wiped out by the disastrous forest fire that swept through the Quartzburg-Grimes Pass region, but the pumps were soon repaired and the mine kept from flooding. Underground development was resumed, and in 1932 a crosscut was driven on the 1,100 level beneath the ore bodies exposed on the levels above. Development also continued on the 700 and 850 levels, and other bodies of ore were blocked out. A 30-ton mill was completed and in operation in late 1933. During the next year its capacity was increased to 100 tons per day by installing additional equipment.

In 1931 the Talache Mines, Inc. acquired full title to the mine from the Gold Hill and Iowa Mines Co. In 1934 a lease and option on the mine was given to the Harris Mining Corp. The lease expired on October 1, 1935, and the Talache Mines, Inc., continued operations. During 1936 and 1937 the shaft was sunk to the 1,250-foot level and a crosscut extended beneath the ore bodies of the upper levels, and much other development was carried on in the search of ore. Ore of commercial grade, however, was not found on the 1,250-foot level, and, as all other known ore bodies had been mined, the company ended operations in the late spring of 1938 and dismantled the entire plant.

PRODUCTION

The total mine production up to 1929 appears to have been fully $7,500,000.[87] According to Lindgren the production from the Gold Hill lode between 1886 and 1894 was estimated at $1,280,000 and that from the Pioneer lodes between 1884 and 1895 about $498,000, but as not all the production was recorded he believed the two produced at least $2,225,000.[88] Ballard states that the gross production of the Gold Hill prior to 1911 is supposed to have approximated $5,500,000 and between 1911 and 1923 slightly more than $1,949,300.[89] Figures on the production by the Talache Mines, Inc., for the years between 1929 and 1938 were not obtained but would probably bring the total production for the mine well above $8,000,000.

STRUCTURAL RELATIONS

The Gold Hill mine is in a part of the "porphyry belt" where dikes are relatively small, though numerous, and show a marked change in trend from west-northwest to east and east-northeast. The dikes of rhyolite porphyry are especially abundant and appear to be crowded more closely together at the mine than in places nearby. They are associated locally with a few dikes of dacite and quartz monzonite porphyry and lamprophyre. All except those of quartz monzonite porphyry are exposed in the underground workings (see pl. 44). The dikes in general have slightly divergent trends to the east and east-northeast. Those of rhyolite porphyry in part branch and intersect one another and also cut the dikes of dacite porphyry. Apparently the mine was the site of especially extensive and complicated shearing and fissuring during the general period of dike intrusion as well as during the time of ore deposition. Wherever the structural relations may be observed underground the dikes dip steeply north (see pl. 45). On the surface the dikes lie south of the Pioneer shaft, but the shaft passes through them, and on the lower levels most of them are north of the shaft.

The subsurface geology is fairly complicated. Two dacite porphyry dikes exposed in the upper workings appear to join in the eastern part of the mine and to connect at intermediate levels, but they split again and appear separately on the 1,100 level. The bottom of the shaft apparently is in a third dike. The dacite porphyry dikes are not very thick and are cut and locally split by dikes of rhyolite porphyry. The rhyolite porphyry dikes apparently have several branches and offshoots and are very irregular. Two of them are apparently

[87] Ross, C. P., Some lode deposits in the northwestern part of the Boise Basin, Idaho: U. S. Geol. Survey Bull. 846–D, p. 254, 1933.

[88] Lindgren, Waldemar, op. cit. (18th Ann. Rept.), p. 691.

[89] Ballard, S. M., op. cit., p. 57.

linked together by a subsidiary dike near the surface and are possibly joined at other places. With depth they appear to become smaller, but are still fairly prominent on the 1,100 and 1,250 levels. The long crosscut driven south on the 250-foot level passes through two rhyolite porphyry dikes not reached on any of the other levels.

The rhyolite porphyries have no compositional or textural abnormalities and are similar in appearance. They contain quartz and indistinct plagioclase phenocrysts in fine-grained groundmasses, which are commonly much sericitized even distant from known minerlized areas. One of the dikes, however, differs from the others in being strikingly porphyritic, containing large orthoclase phenocrysts in a somewhat micropegmatite groundmass, and also in being slightly younger, in places cutting them. This dike has been designated the "lab" dike on the mistaken belief that the large phenocrysts were crystals of labradorite,[90] but the dike has more recently been designated by Ross as "granophyre porphyry."[91] It is herein called the "younger" rhyolite porphyry. The lamprophyric dikes are the youngest and cut all the other dikes as well as the lodes.

The dikes, except the lamprophyres, have been extensively fissured and fractured and, along with the granitic rock of the batholith, are cut by the ore deposits (see pl. 44). Structurally the deposits are of two kinds, fissure lodes, of which the Gold Hill lode is the type, and lodes localized along zones of oblique fractures in broader belts of shearing, typified by the Pioneer ore bodies. The fissure lodes occupy the largest and most persistent of the fault fissures, trend about N. 70° E., and dip steeply south to vertical, a direction opposite to the dip of the porphyry dikes. These lodes, which include the Gold Hill, Iowa, and Last Chance, are contained therefore in one of the major fracture sets, but the Pioneer lodes occupy a more subordinate set of fractures along zones of shearing of more northeasterly trend, which pass through and across the Gold Hill lode.

The Gold Hill lode is somewhat irregular in trend, but its average strike is about N. 70° E. Near the surface its dip is 70° SE., though with depth the dip steepens and in places is nearly vertical. On the surface it lies in the Idaho batholith some distance north of the Pioneer shaft, but its southeast dip brings it close to the shaft on the deepest levels and causes it to pass through all the porphyry dikes in the main workings (pl. 44). Its footwall is well-defined in the upper workings and in the open stopes on the outcrop, but the fissuring becomes somewhat less conspicuous with depth, particularly in the dacite and rhyolite porphyry, because of its tendency to branch. Most of the lode apparently consisted of recurrent quartz lenses of variable thicknesses. In the early days of mining numerous stringers

[90] Lindgren, Waldemar, op. cit. (18th Ann. Rept.), p. 683.
[91] Ross, C. P., op. cit., p. 248.

of rich ore were found to extend from the fissure for short distances into the hanging wall; some of these seams opened into shoots of considerable size and were stoped to the surface. The lode had a developed length of about 3,500 feet in the main part of the mine and a maximum thickness of about 6 feet, but on the 400-foot level, where the bottom of productive ground was reached, the stope length had decreased to 1,000 feet. Although small quartz lenses and stringers appear on each of the levels below, none of stoping grade were found, except on the 850-foot level, where a Pioneer ore body crossed the Gold Hill lode and a small shoot was stoped upward along the Gold Hill lode for 5 sets. The fissuring is perhaps as pronounced below the 400-foot level as it is in many places above, but gold deposition was apparently restricted to the upper part of the fissure.

Most of the stopes in the Pioneer workings are along lodes in zones of shearing oblique to the Gold Hill lode. Most of the lodes trend N. 30°–60° E. and dip steeply southeast but pitch about 65° NE. They are confined to a general zone of shearing 200 to 300 feet wide, which crosses the property in a northeasterly directon. In the upper workings these ore bodies lie some distance southwest of the Pioneer shaft, but their dip and particularly their northeast pitch carry them progressively nearer the shaft with depth, and on the 1,100-foot level they are a short distance north and northeast of the shaft (see pl. 44). These bodies have no direct interconnection but are somewhat isolated from one another, though all are contained within the borders of the broad shear zone. On the upper levels the Pioneer lodes are all on the south or hanging-wall side of the Gold Hill lode, but on the 700-foot level some have penetrated to the footwall side, and on the 1,100-foot level all the lodes lie on that side. The Pioneer ore bodies, therefore, do not occupy gash fractures related to the Gold Hill fissuring, and there appears to be no direct connection between the Pioneer shearing and the Gold Hill fissuring.

The Pioneer ore bodies are complex in detail, and, although the stopes are alined in the general direction of the shearing, most of the ore is contained in a still more subordinate set of tensional fractures oblique to the direction of shearing and making an acute angle with the long axis of the stope. The individual ore seams that make up the ore bodies are generally less than a fraction of an inch thick and generally persist for less than 5 or 6 feet, but many of the ore bodies, which consist of a series of these closely spaced seams, are 3 to 40 feet wide and have stope lengths of more than 100 feet (exceptionally 300 feet) and vertical dimensions exceeding 100 to 800 feet. Although some stoping has been done at depth in both the granitic rock of the batholith and in the dikes of dacite porphyry, most of the lodes are confined to the two main bodies of rhyolite porphyry. The "younger" rhyolite porphyry dike has been less fractured than the others and contains little ore.

Because in the upper workings the lodes were confined almost wholly to the dikes of rhyolite porphyry (except the younger dike), the belief was held that these porphyries were the only rocks to contain ore of commercial grade. Deeper development proved otherwise and showed that ore occurred wherever the rock had been adequately fractured and had openings that would facilitate movement of the ore-forming solutions. However, the two dikes of rhyolite porphyry have provided the more numerous and more open fractures with less impeding gouge than either the dacite porphyry or the batholith and, therefore, have contained the bulk of the ore even at depth. Shearing of the rhyolite porphyries, excluding the younger dike, developed a zone of open, oblique tensional fractures, whereas that of the batholithic rock produced a fissure, largely filled with impeding gouge, in the direction of the shearing. In many places the ore bodies contained in the rhyolite porphyries have abruptly terminated on leaving the porphyry because of the failure of the open tensional fractures to continue in the granitic rock and in the dacite porphyry, but in one place an oblique fissure of considerable length was found to extend into the granitic rock, and near the east end of the mine on the 700 level (pl. 44) a narrow vein containing high-grade ore a few inches thick was stoped along it for more than 100 feet horizontally. Its strike of N. 45° E. is a continuation of the trend of the ore body in the rhyolite porphyry.

The distribution of the Pioneer ore bodies both geographically and structurally is shown on the maps of each of the mine levels (see pl. 44). The maps also show the distinct decrease in size and number of the ore bodies with depth, as only a couple extend from the 600 and 700 levels to the 1,100 and these shoots were bottomed only 45 feet below the 1,100-foot level. The maps suggest that the ore bodies converge downward in funnel-like form. Apparently much of the gold was deposited above the throat of the funnel and not in the main trunk channel below, where temperatures may possibly have been too high for gold deposition.

WALL-ROCK ALTERATION

All the rocks in the Gold Hill mine are altered, the rhyolite porphyries, excluding the "lab" dike, more so than the others, and an increase in the intensity of alteration generally indicates an approach to a zone of ore deposition. Most of the alteration has consisted in the conversion of the feldspars, particularly the plagioclase, to sericite and the bleaching and changing of the biotite to muscovite. Small crystals of pyrite have been somewhat scantly disseminated through the altered rock, especially near the ore bodies, and locally sparse amounts of calcite have been added. In places the rock has been appreciably silicified. The rhyolite porphyry exhibits the most striking susceptibility to sericitic alteration, in part because of widespread end-stage endomorphism but mostly because it was more extensively fractured than any of the other rocks and allowed freer movement of the mineralizing solutions. In some of the lodes the rhyolite porphyry has been changed almost entirely to sericite and is very soft, but the ore appears to be equally rich whether the rock has been softened or remains firm. The intensity of rock alteration appears to be largely a reflection of favorable structural conditions.

MINERALOGY AND PARAGENESIS

Two general stages of ore deposition are revealed locally, but the earlier base-metal minerals are not as conspicuous as in other mines of the region, and most of the seams and veins that constitute the greater number of the ore bodies consist of quartz with a scant sulfide assemblage that belongs to the younger of the metalizing stages. The earliest stage contributed rather widely scattered seams and stringers of pyrite, in places with small granules and scattered bunches of sphalerite and even more widely distributed grains of galena, tetrahedrite, and chalcopyrite. Some of these seams and stringers were invaded by the younger quartz and scantily associated sulfides and were thereby incorporated in ore shoots, but otherwise their distributiton has no particular bearing on the occurrence of ore, which is determined wholly by the distribution of the younger gold-bearing quartz seams.

The younger ore seams and veinlets are composed largely of fairly coarse-grained quartz, which in places is somewhat drusy, and small scattered bunches and patches of grayish bismuth minerals. Here and there are visible grains of gold. Only where the quartzose seams penetrate the earlier base-metal fillings do they contain other metallic minerals, particularly pyrite and to lesser extent sphalerite and galena. The bismuth minerals identified in the ores from the several levels include galenobismutite, bismuthinite, tetradymite, and native bismuth. The proportions of these minerals vary from place to place, and all may not be present at any one place. The galenobismutite and bismuthinite appear to be most abundantly and most widely distributed and commonly occur together, the bismuthinite having formed by replacement of the galenobismutite. The tetradymite appears to be much less abundant and much less widely distributed than the others but invariably occurs as replacement rims on the bismuthinite crystals. The native bismuth was observed only in ore on the lower levels. None of the minerals can be separately distinguished and positively identified without detailed microscopic examination of polished sections of the ore.

Much of the gold is intimately mixed with the bismuth minerals, but some also occurs free in the quartz. Above the 1,100-foot level the gold content of the ore apparently increased in proportion to the abundance of the bismuth minerals, and the richest ore shoots were generally those with the largest quantity of bismuth. The gold and bismuth minerals were, therefore, apparently deposited under essentially identical conditions, but the gold had a more restricted range of deposition than the bismuth minerals and did not persist to as great a depth. The quartz and bismuth minerals are reported to be as conspicuous on the 1,250 level as above, but according to Joe Skidmore, mine superintendent, when the Talache Mines, Inc., suspended operations in 1938, the gold did not continue for more than 45 feet below the 1,100-foot level. Though much of the ore had no visible free gold, all the gold is apparently in the native state, for as much as 95 percent was recovered by fine grinding and amalgamation. The gold was apparently the last metallic mineral deposited, and the only mineral of younger age is calcite, noticed only in small pockets and bunches on the 1,100 level.

TENOR AND DISTRIBUTION OF THE ORE

The ore shoots have no well-defined boundaries, but the stope limits are fixed by the grade of the ore. The individual ore seams may be very rich, and the size and tenor of the ore shoots depend largely on the number of spacing of the seams. Some stopes are along single thin but very rich seams, but most of them are on zones of more or less closely spaced seams. Much of the ore from the lower levels assayed 0.3 to 0.5 ounce in gold to the ton, though locally small quantities of ore were twice as rich. The ore shoots were disclosed only by crosscutting, along single seams or stringers, if followed, also led to others and opened into important ore shoots.

The Pioneer ore bodies had been abandoned as bottomed on the 600-foot level, but subsequent development by the Talache Mines, Inc., showed a progressive increase in values with depth until the workings extended below the 1,100-foot level. According to stope records the largest stope, 710 W, averaged $8.10 for the first four floors above the 700 level and $6.72 for the full distance to the 600 level. The 708 stope averaged $8.25 from the 700 to the 600 level. The 18,005 tons mined from the 850 level averaged $9.25 per ton, whereas 23,470 tons on the 700 level averaged $7.11. The 910 E stope averaged $10 to the ton from the 850 to the 700 level. Some of the ore on the 1,100 level was even richer than that on the 850 level.

The abrupt decline below the 1,100 level must be attributed to changed thermal conditions, for structurally the rocks below are about as thoroughly fractured as at higher levels and contain as much quartz and bismuth minerals. Possibly the temperature at the greater depth was too high to permit deposition of gold during the general period of gold deposition, just as the temperatures may have been too high in the Gold Hill fissure to permit gold deposition until the possibly more abundant openings were reached above the 400 level. Deposition of the gold probably occurred whenever the ore-forming solutions spread into the more highly fractured rock at the upper limits of the ore channels and became rapidly cooled. Because the shearing in the rhyolite porphyries provided relatively abundant open fractures to considerable depth, the cooling must have begun at greater depth in the Pioneer shear zone than in the Gold Hill fissure. This difference is believed to account for the fact that ore has been mined to depths about 700 feet greater in the Pioneer lodes than in the Gold Hill lode. It may be of interest to point out that the quantity of base-metals is reported to increase below the 1,100-foot level and that on the 1,250-foot level appreciable amounts of tetradehrite are present.

LAST CHANCE MINE

The Last Chance mine is in Quartzburg, just north of the Gold Hill mine. The principal lode, the Last Chance, lies only about 250 feet north of the Gold Hill fissure. It was worked extensively in the early days by shaft and drifts, but since 1931 work has been confined to another lode about 60 feet north of the Last Chance lode. In 1934 an adit drift had exposed this second lode for a distance of 300 feet, and small amounts of ore were treated locally in a small stamp mill. According to Ballard, the main production came from the upper 250 feet of the old workings and totaled $55,000.[92]

Some rhyolite and quartz monzonite porphyry dikes crop out on the surface and are probably cut by the lodes underground. The Last Chance lode strikes about N. 70° E. and dips about 70° NW. near the surface. It is reported to split near its west end, and one branch is said to dip steeply south. The lode about 60 feet north of the Last Chance lode strikes N. 40°–65° E. and dips 65° NW. It occupies a prominent fracture zone as much as 20 feet across, but the ore is confined to a zone 2 to 18 inches wide along the hanging wall where fissuring is most conspicuous and is accentuated by a band of gouge 2 to 6 inches thick.

Both branches of the Last Chance lode are reported to have been about equally mineralized and to have contained pyrite, sphalerite, and galena in irregular nests and streaks in a soft gouge, in part cut by seams and lenses of quartz in which were contained small tufts and bunches of bismuth minerals.[93] The wall alongside has been intensely sericitized and somewhat impregnated with pyrite. The ore along the second lode is not much different but is made up of scattered pyrite seams and stringers accompanied by a little sphalerite, especially in

[92] Ballard, S. M., op. cit., p 66.
[93] Ballard, S. M., op. cit., p. 66.

the more gougy zones, and contains in addition widely scattered quartz seams and stringers of younger age. Scant amounts of bismuth minerals may be observed in panning the gougy matrix.

MAYFLOWER MINE

LOCATION AND DEVELOPMENT

The Mayflower mine is in sec. 9, T. 7 N., R. 4 E., about half a mile southwest of Quartzburg, on the West Fork of Granite Creek about a mile above its junction with the main creek. Since 1931 the mine has been owned by the Mayflower Gold Mines, Inc., but in September 1936 was leased to the Texas-Owyhee Mining & Development Co. The property comprises 2 patented and 7 unpatented claims and in 1938 had approximately 4,000 feet of underground workings and an 80-ton fine-grinding and flotation concentrator. Several lodes have been exposed on the property (see pl. 46), but most of the development has been confined to the Mayflower claim, on the east side of the creek. The workings comprise a tunnel about 640 feet long and a steeply inclined shaft with drifts more than 1,000 feet long on the 200-, 300-, and 400-foot levels. Since the mine was visited in 1938, the 500- and 650-foot levels have been added. The shaft also joins the tunnel with the surface. Shallow tunnels more than 500 feet long have been driven on lodes on the Homeward Bound and Elizabeth claims, and a shaft 110 feet deep on the Homeward Bound lode has about 400 feet of drifts at the bottom (pl. 46). A crosscut from the 400 level of the Mayflower workings extends southward to the Elizabeth lode, and by early 1939 about 200 feet of drifts had been driven from it along the Elizabeth lode.

HISTORY AND PRODUCTION

The lodes were discovered by placer miners in the early eighties.[94] The Mayflower lode was worked from the creek northeastward along the surface for more than 500 feet, and the ore was treated locally in an arrastre. Later owners sank two winzes, one 50 feet and the other 30 feet deep, and stoped the oxidized ore, which was also treated in an arrastre. The Homeward Bound lode, about 600 feet south of the Mayflower, was worked in the early days to a depth of 30 to 50 feet, and the high-grade ore was sorted and worked on the ground in a large mortar. Sometime later the long tunnel was driven along the Mayflower lode and ore stoped above and below, but there was little more activity until about 1929, when work on the inclined shaft was begun and drifting started on the 200 level. In 1931 a 30-ton flotation concentrator was installed, and operation was begun in June 1932. The ore blocked between the 200 and the tunnel levels was soon stoped, and the mill suspended operations the latter part of August. Satisfactory

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[94] Ballard, S. M., op. cit., p. 69.

recovery had not been made, and a cyanide plant was then installed to treat the mill tailings, which had been stored. The shaft had been extended to a depth of 260 feet, and drifting was begun at the bottom of the shaft but ceased in September. Except for some development on the Homeward Bound claim in 1933 and 1934, which was continued by the Texas-Owyhee Co. in 1936 and 1937, no additional work was done on the Mayflower lode until 1936. The inclined shaft was then sunk to the 400 level on the Mayflower, and active mining was continued throughout 1938. Much ore was stoped above the 400 level and treated locally in the mill, which during the year was enlarged to an 80-ton capacity. Additional surface work on the Homeward Bound claim in the early part of 1938 disclosed a new lode. With the suspension of operations at the Gold Hill mine in 1938 the Mayflower mine became the largest and most active producer in Boise Basin. By early 1939 much of the ore had been stoped above the 400 level, and plans were then formulated to sink the shaft an additional 200 feet. Subsequently drifts were driven on the 500-foot and 650-foot levels. Much drifting was also done along the Elizabeth lode from the 400 level of the Mayflower.

According to Ballard[95] the early operations yielded more than $15,000, but the total value of the ore up to March 12, 1938, including the early output and smelter recoveries from shipments made by the Mayflower Gold Mines Co., Inc., and the Texas-Owyhee Mining & Development Co., is given as $83,500. By early 1939 the Texas-Owyhee Mining & Development Co. had milled 19,712 tons of ore for which the smelter returns were $132,606.19. This production included 3,470.237 ounces of gold, 25,447.604 ounces of silver, 1,750.149 pounds of copper, 98.627.103 pounds of lead, and 65,904.158 pounds of zinc.

GENERAL GEOLOGIC RELATIONS

The Mayflower mine is well within the "porphyry belt," but the local features of the geology are considerably obscured by low-level and high-level gravel deposits that are spread over much of the surface. The main country rock is the quartz monzonite of the Idaho batholith, but in several places where the gravels have been stripped away dikes of dacite, quartz monzonite, and rhyolite porphyry have been partly exposed, and a dacite porphyry dike and several rhyolite porphyry dikes are cut in the underground workings (see pl. 47). The main tunnel on the Mayflower lobe also extends into some high-level gravels, which apparently were deposited in an ancient steep-sided channel incised across the lode.

Three well-defined lodes are known on the property, but most of the production has come from the Mayflower. This lode is a probable

[95] Ballard, S. M., op. cit., p. 69.

extension of the Dunlap lode (the zone of shearing occupied by the Pioneer ore bodies) on the Gold Hill property.[96] It lies about 200 feet southeast of the Confederate (pl. 46). The Elizabeth lode, about 600 feet south of the Mayflower, may be a northeasterly continuation of the Homeward Bound and in turn a probable continuation of the Oregon lode on the Gold Hill property. The third lode lies about 150 feet south of the Homeward Bound. It was discovered in the early months of 1938 and exposed by surface trenching and in a crosscut from the bottom of the Homeward Bound shaft. These lodes are much alike in their structural relations, though they differ somewhat in mineralogic characteristics. They occupy parallel zones of fissuring of general northeast trend and appear to be more closely alined with the direction of shearing on the Pioneer claim at the Gold Hill mine than with the direction of the Gold Hill fissuring. Although their trend corresponds in direction with a subordinate set of fractures, the fissuring, nevertheless, is locally as prominent as along the major N. 70° E. set in other parts of the district.

MAYFLOWER LODE

Structural relations.—The essential structural features of the Mayflower lode are illustrated in the geologic sketch map of plate 47. The fissure zone occupied by the lode is very irregular, but its average strike is about N. 35° E. From the surface to the 300-foot level the dip is 70° NW., between the 300- and 400-foot levels the dip is vertical, and below the 400-foot level the dip is steeply southeast. It is sharply outlined by seams and bands of gouge, the most prominent of which parallel the direction of fissuring, and it also has numerous subsidiary fractures of diverse trend, many of which are also outlined by thin seams of gouge. The fissuring is much more pronounced in the batholithic rock than in the dacite and rhyolite porphyry dikes. In the dikes there is a notable tendency for the rock to splinter and the fractures to spread apart. The width of the fissure zone in general ranges from a few inches to 3 feet, locally as much as 6 feet, but some fractures may extend over a greater distance. Considerable prospecting has been done in the gravels exposed in the tunnel level on the assumption that the gravel deposit was pre-ore, but the fissuring stops abrupty at the gravel contact, and 10 feet below the tunnel the gravels rest directly on the beveled surface of the fissure.

The fractures that delineate the lode have complicated structural relations. The principal fractures parallel the direction of fissuring, and, because of notable displacement along them, are marked by broad bands of gouge. In some places the principal band of gouge is along the hanging wall, in other places along the footwall. In many places there are bands several feet apart on both hanging wall and footwall

[96] Rasor, C. A., written communication.

commonly linked together by sets of oblique fractures that cross from one wall to the other (fig. 4), a relation particularly important, because the oblique set has controlled the distribution of some of the gold in the lode. The oblique fractures were apparently produced by tensional stresses set up by the shearing movement along the fissure zone. Striations on slickensided surfaces on the gouge and walls dip about 37° S. and indicate that the movement has had a marked horizontal component, actually diagonally upward at a relatively low angle. There are also other fractures of more diverse trend, many of which were originally joint planes in the granitic and porphyritic rock whose walls were somewhat separated and moved during the general period of fissuring.

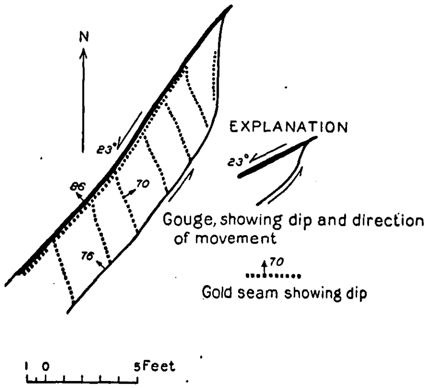

FIGURE 4.—Sketch plan of stope, Mayflower mine, showing distribution of gold in oblique gash fractures between gouge seams in hanging wall and footwall.

Distribution and structure of the ore.—The gouge is the most conspicuous structural feature of the lode and plays a very important role in the distribution of the ore. Most of it is an intermineralization gouge and serves to separate an older pyrite filling from the younger gold ore. Much of the gouge is black and filled with crushed sulfides and rolled boulders of early sulfides and wall rock and was clearly formed before the gold-bearing solutions were introduced. In places the gouge was impregnated with minerals associated with the gold metalization, but in general the gold ore lies alongside the gouge band, or fills fractures in the gouge, or occurs as seams in the oblique fractures that extend across the fissure zone from one wall to the other. The openings made available for the ore, therefore, were produced after the gouge had been formed and occur where slight diagonal upward movement along the more or less gouge-filled fissure had reopened older fractures and had created tensional fractures at an angle to the principal plane, or planes, of movement.

The ore seams are discontinuous and commonly extend across the fissure zone, to lesser extent along it. Individual seams cannot be traced for more than a few feet and end by pinching as the controlling fracture ends or pinches (fig. 4). Other seams, however, appear alongside and so carry the ore along the fissure zone. These seams are commonly rather closely spaced in the granitic rock of the batholith, but are more widely dissipated across the porphyry dikes. Some of the ore also occupies joint planes in the rock along the disturbed zone and passes from fractures to joint planes or from joint plane to joint plane but never for more than a foot or two from the main gouge-filled fissure.

Concentration and union of seams and stringers ordinarily provide the richer ore shoots. These shoots are erratically distributed and may terminate abruptly on either dip or strike. Nevertheless they are so closely spaced that continuous stoping is possible for considerable distances (pl. 48), and, should a pocket abruptly end, continued drifting along the fissure zone invariably reveals numerous small stringers, which as abruptly lead to another pocket of high-grade ore. The distribution of the ore pockets appears to be related to openings produced by movement along the uneven fault plane, and the ore occurs wherever there is a notable change in the strike and dip of the fissure, particularly where the gouge band splits and lies along both the hanging wall and footwall and the two bands are joined by the diagonal fractures. The shoots are apparently terminated as the gouge bands come together. Detailed mapping of changes in strike and dip of the lode should make it possible to anticipate the occurrence and distribution of ore in advance of mining. The so-called "rolls" in the lode have much to do with the localization of ore shoots. The stopes are narrow, but long and the distribution of the ore of mining grade is shown in the longitudinal section shown in plate 48.

Mineralogy.—The rock in and along the Mayflower lode has been intensely sericitized, in places slightly silicified, and everywhere heavily impregnated with pyrite, the alteration apparently having accompanied the early base-metal deposition. Pyrite is also the most abunnant mineral of the base-metal stage and occurs in seams, stringers, and massive bands, both as a filling of fractures and as a replacement of the altered country rock. In most places it is difficult to distinguish between the lode pyrite and the heavily disseminated pyrite in the wall rock. So far as the early stage characteristics are concerned the deposit could well be classed as a pyritic deposit, for other base metals, which include some sphalerite, galena, tetrahedrite, and chalcopyrite, are but scantily represented and are confined to widely scattered small pods and nests, commonly incorporated as rolled boulders in the gouge. Some structural disturbance intervened after the pyrite had been deposited but before the other sulfides were introduced, because in places seams of sphalerite and galena cut across seams of pyrite. The main disturbance, however, came at the close of the base-metal stage, when pyrite and so much of the galena, sphalerite, and other sulfides were ground up in the gouge. Scant amounts of siderite were also deposited at the close of the base-metal stage, more of it in the lower than in the upper levels of the mine.

The minerals introduced after the stage of gouge formation include abundant pyrite, much of it highly auriferous, and scant but variable amounts of quartz, arsenopyrite, sphalerite, and the bismuth minerals, cosalite, matildite, galenobismutite, and bismuthinite. The young pyrite is difficult to distinguish from the old pyrite but appears as uncrushed crystals replacing the gouge and in narrow seams cutting the older massive pyrite. Its crystals are in general larger than those of the early pyrite, and with some experience one is able to recognize the younger auriferous variety with a considerable degree of certainty. The two pyrites are separated in milling, a concentrate of the younger auriferous pyrite being made by flotation and the older pyrite dropped in the tailings. Both the gold and the bismuth minerals are intimately associated with the younger pyrite, and the presence of visible grains of the bismuth minerals is generally regarded as a sign of exceptionally rich ore. The bismuth minerals as well as the gold are commonly in fractures in the young pyrite and replace the pyrite. In places, however, the grains may occur between the pyrite crystals and even in fractures and between crystals of the very scantily associated quartz. Some of the gold and bismuth minerals have also penetrated the gouge, though in general the ore lies along the more or less impervious gouge seams. A considerable part of the ore is recovered by mining the gouge and the rock immediately alongside. The amount of quartz in the ore is surprisingly small in view of its abundance at the Mountain Chief, Belshazzar, and Gold Hill mines but is somewhat more abundant on the 500- and 650-foot levels than on higher levels. A little sphalerite occurs with the quartz at depth. Minor amounts of calcite also appear with the late-stage minerals but generally in seams and small bunches by itself.

The ore seams are notably rich, and spectacular assays may be had by proper selection. Parts of some stopes have averaged between 1 and 2 ounces of gold to the ton. The rich ore is so sporadically distributed, however, that the mill feed is relatively low, but it is kept above $4 a ton at the 1938 price of gold. Smelter returns based on 19,712 tons of ore milled by the Texas-Owyhee Mining & Development Co. showed 21.987 ounces of gold and 34.14 ounces of silver per ton of jig product besides 0.18 percent of copper, 8.37 percent of lead, and 0.42 percent of zinc. They also showed 2,589 ounces of gold and 29.73 ounces of silver per ton of flotation concentrates with 0.10 percent of copper, 5.53 percent of lead, and 4.50 percent of zinc. Flotation concentrates amounting to 706.635 tons and jig product amounting to 90.384 tons were shipped. There has apparently been no decline in the grade of ore on the 400 level, and nothing as yet has been found that might point to the lower limit of the commercial ore.

HOMEWARD BOUND AND OTHER LODES

The Homeward Bound lode could not be advantageously studied, for the shallow workings on the Elizabeth claim were caved, as were those directly across the creek on the Homeward Bound. The recent workings at the west end of the lode were also inaccessible on the days the property was visited. The geology of the west workings is shown in figure 5. The lode appears to be along a very prominent zone of fissuring and on the Elizabeth claim contains irregular masses and lenses of pyrite 3 to 4 feet thick, locally 9 feet, in intensely sericitized rock. Small seams of pyrite also extend into the wall. The gold values are reported to be lower than in the Mayflower and to range between 0.1 and 0.5 ounce to the ton. Like the Mayflower lode, the Homeward Bound contains much gouge. No opportunity was afforded to study the relations between the gouge and the younger ore minerals. At the west end of the property the fissure zone is as much as 10 feet wide and also has much gouge and crushed pyrite. It has numerous fractures of diverse trend, some occupied by ore seams and some barren, and in general seems more disturbed than elsewhere, probably because of its nearness to the Boise Ridge fault, which crosses the end of the property. Some porphyry dikes are exposed underground, and each is considerably fractured and contains scattered seams of sulfides. Bands of gouge as much as 12 inches thick lie along some of the faults. The gouge invariably contains much crushed sulfide and rolled boulders of sulfide and altered wall rock. The ore seams consist of pyrite, sphalerite, and galena associated with some carbonate, including a little rhodochrosite.

The new lode 150 feet south of the Homeward Bound appears to be several feet wide and contains seams of yellow sphalerite accompanied in places by a little pyrite and galena. The footwall is marked by considerable gouge. The sulfide seams apparently occupy fractures in the hanging wall. For some distance the lode lies along the contact of a granite or dacite porphyry dike.

Since the writer visited the property in July 1938, the Elizabeth lode has been exposed by 250 feet of drifts from a crosscut from the 400 level of the Mayflower workings. According to C. A. Rasor, who furnished the data, the lode is much like the Mayflower, but the drift had not yet undercut the ore shoot exposed in the shallow surface workings.

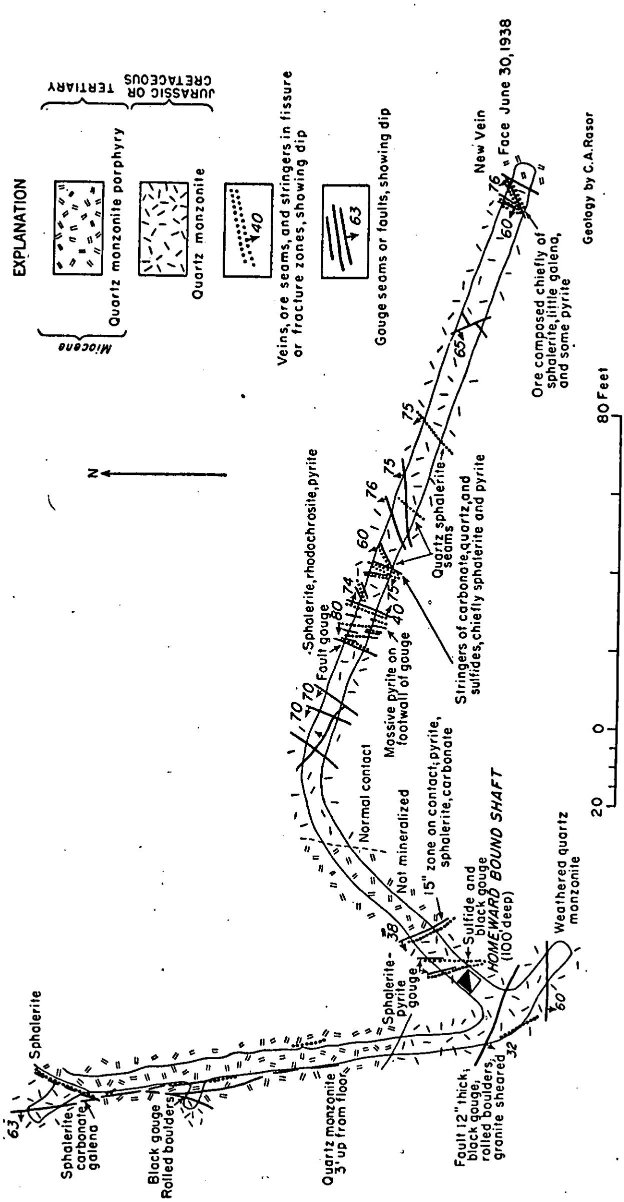

FIGURE 5.—Geologic map of the west workings in the Homeward Bound lobe, Mayflower mine.

MOUNTAIN CHIEF MINE

LOCATION AND DEVELOPMENT

The Mountain Chief mine is in secs. 18 and 19, T. 7 N., R. 4 E., on a tributary of Canyon Creek on the east slope of Boise Ridge, about 3½ miles west of Placerville. The mine was located in 1876 and has been worked more or less continuously to the present day. It has been developed by 5 tunnels, the first near the top of the ridge between Fall and Canyon Creeks, the others below, spaced at vertical distances of 120, 115, 168, and 200 feet. Data on the length of the No. 1 tunnel were not available, but the No. 2 is reported to have been 600 feet long and the No. 3 about 800 feet long.[97] All three of the upper tunnels are now caved, but the No. 4 and No. 5 were open in 1933 and measured about 1,000 and 2,300 feet, in length, respectively (pl. 49). A mill, which has been rebuilt and reconditioned several times, lies a short distance below the No. 5 portal on Canyon Creek. Ore from the four upper tunnels was carried to the mill by aerial train, but the ore from the No. 5 was hauled to the mill by wagon and truck.

HISTORY

Details of the mine's early history are meager. The mine was acquired by the present owners, the National Mining & Development Co. in 1911, and the next 5 years proved to be the most active and productive in its relatively long life. By 1916 most of the ore had been stoped above the No. 4 tunnel level, and work was then begun on the No. 5, which was completed in 1922. In the following year the mine was leased to the Mountain Chief Mining Co., but after a short period of activity was idle until 1928, when it was reopened by the Federated Mines Co. After rebuilding the mill and producing a few tons of ore, the new company abandoned operations in the late summer of 1929. The mine was reopened in 1931 by the Ideal Mining Co. and a small amount of ore mined, but since 1932 the original owners, the National Mining & Development Co., have continued operations. In 1932 and 1933 the No. 5 and No. 4 tunnels were connected by a raise, and some ore was stoped between them. The mine and mill continued in operation from April to December in 1934, but apparently little work has been accomplished since.

The mine had up to 1929 a recorded production of slightly more than $240,000. Much of this amount represents the production of the present company between 1912 and 1915. An additional estimated production close to $70,000 is made for a former management whose records are not available.[98]

[97] Jones, E. L., Jr., Lode mining in the Quartzburg and Grimes Pass porphyry belt, Boise Basin, Idaho: U. S. Geol. Survey Bull. 640, p. 99, 1917.

[98] Ballard, S. M., op. cit., p. 63.

STRUCTURAL RELATIONS

The mine lies well within the "porphyry belt," and rhyolite porphyry and lamprophyric dikes are exposed in the workings underground (pl. 49) and on the surface. The lamprophyric dikes are too narrow to be recorded, however, except on the maps of the underground workings. The maps show that the lodes, of which there are two, the Mountain Chief and Ebenezer, are largely contained in the porphyritic quartz monzonite of the Idaho batholite. The lodes also cut rhyolite porphyry dikes, but are cut by the lamprophyric dikes. The lamprophyric dikes are erratic in distribution, trend, and size, lie along or across the lodes, and swell abruptly into chimney-like masses and within a short distance disappear entirely. Where they lie in or against the lodes they have been somewhat fractured and bleached but contain no ore. In the granitic rock the lodes occupy fissure zones, but where the lodes enter the rhyolite porphyry dikes the fissures splinter up into broad zones of fractures.

The fissure zone occupied by the Mountain Chief lode strikes about N. 45° E. where first encountered underground and then gradually changes its strike to about N. 60° E. toward the northeast end line of the property (pl. 49). Its dip is 50° to 60° SE. and may steepen somewhat with increasing depth. The Ebenezer lode, exposed near the portal of the No. 5 tunnel, strikes about N. 40° E. and dips about 60° SE. Both lodes show the complex fissuring and fracturing of the Miocene shearing and have one principal plane of displacement with irregularly fractured rock alongside, in places accompanied by subordinate more or less closely spaced parallel sets of fractures. The fissure and fracture zones range from a few inches to 6 feet or more in thickness, and the ore occurs as fissure and fracture fillings. The Ebenezer lode occupies a prominent fracture zone 3 to 4 feet thick, which contains much gouge and scattered stringers of ore, some of it rich enough to be stoped (pl. 49). The principal ore bodies, however, are contained in the Mountain Chief lode, which had two ore shoots in the upper working, one about 150 feet long and the other about 400 feet long. The ore shoots are reported to pitch northeast and to be confined to the most highly fractured and permeable parts of the fissure with no relation to fissure-dike intersections. For the detailed relations of the lodes to the fissuring and fracturing and for the general structural relations the reader is referred to the geologic sketch map of the No. 4 and No. 5 tunnels, plate 49.

Much of the ore in the upper workings on the Mountain Chief lode is reported to have occurred in more or less compact veinlike bodies, with seams and stringers in the wall rock alongside. The two ore shoots occurred as lenticular veins that pinched and swelled from a few inches to 2 feet or more, whereas the fissure zone between contained small stringers and bunches of ore.[99] Similar characteristics were observed along the No. 5 tunnel, where lenticular seams as much as 12 inches wide in the main fissure were accompanied by smaller seams and stringers for several feet in the altered rock on each side. The lode has an average thickness of 2 feet, although in places the zone of fractures spread outward to 10 feet or more across. In an open stope about midway between the No. 5 and No. 4 levels where ore was being mined in 1932, the lode was made up of about 5 feet of fractured rock with numerous ore seams, some of which paralleled the lode and others of which extended diagonally across.

CHARACTER AND MINERALOGY OF THE ORE

The Mountain Chief lode varies markedly in the character of its filling from place to place. The two main stages of ore deposition are strikingly represented, though the ore of each is not uniformly distributed. In some places the ore seams are composed of sulfides and have but low values in gold; in other places the seams are made up almost wholly of coarsely crystalline and in part drusy quartz relatively high in gold content. The main ore shoots are the quartzose veins and seams. The early sulfides include abundant pyrite and some coarse granules and crystals of sphalerite, and locally minor amounts of tetrahedrite, chalcopyrite, and galena. Ross [1] also reports pyrrhotite. Much of the early base-metal filling has been brecciated and is cut and penetrated by the minerals of the younger generation or is contained in them as scattered fragmental inclusions. Most of the younger filling is composed of quartz accompanied in places by minor amounts of barite and sideritic carbonate, by pyrite, locally much arsenopyrite in coarse crystals, and by thin needles and tufts of bismuthinite and associated galenobismutite and tetradymite, which lies between the quartz crystals or project into and across small open vugs lined by drusy quartz crystals. The bismuth minerals also project into and replace inclusions of earlier pyrite and galena. The gold, which accompanies the young quartz, appears for the most part to be intimately associated with the bismuth minerals, but some is free in the quartz and some is held with the pyrite and arsenopyrite. The younger quartz and associated minerals were apparently most abundant in the upper workings but are still well represented in the lowest level.

The earlier sulfides appear to be more widely distributed than the younger quartzose seams and are more commonly found as fillings of fractures in the rock alongside the fissures, whereas the quartz stringers are fewer and most of the quartz is in lenses along the main fissure

[99] Jones, E. L., Jr., op. cit., pp. 99–100.

[1] Ross, C. P., Some lode deposits in the northwestern part of the Boise Basin, Idaho: U. S. Geol. Survey Bull. 846–D, p. 268, 1933.

zone. Most of the wall-rock stringers, therefore, are of little value. The rich ore is pockety, but the values are invariably highest in the quartzose ore. Picked ore samples may assay several ounces in gold per ton and 5 to 10 ounces in silver. Only the higher-grade ore has been mined, and much of it, according to the mine management, averaged between 0.5 and 2 ounces of gold per ton.

By far the greater part of the production has come from above the No. 4 level, and development below has been disappointing. Quartz, pyrite, arsenopyrite, and bismuth minerals are still visible below the No. 4 level and are plentiful on the No. 5, but the gold appears to have had a higher and more restricted range of deposition and apparently appears in progressively decreasing amounts below the No. 4 level.

BELSHAZZAR MINE

LOCATION AND DEVELOPMENT

The Belshazzar mine is in secs. 17 and 18, T. 7 N., R. 4 E., on Fall Creek on the east slope of Boise Ridge, about 2 miles west of Quartzburg. The mine was located in 1875 and has been worked intermittently to the present day. It is now owned by the Idawa Gold Mining Co., and the property includes 26 unpatented claims, a complete mine plant, and a 25-ton amalgamator and table concentrator.[2] The mine has been developed by 5 tunnels, approximating 12,000 feet of workings (see pl. 50). The three upper tunnels are each between 500 and 600 feet long, the No. 401, from which most of the recent work has been done, is about 1,700 feet long, and the No. 5, about 400 feet vertically below the No. 401, is 3,000 feet long. A long crosscut has also been driven from near the far end of the 401 drift to the Centennial vein, 680 feet to the south, and a drift extended along the Centennial for nearly 400 feet. An intermediate level has been made between the No. 401 and the No. 3, and two others below the No. 401, one 60 feet below and the other 140 feet below. All levels are joined by raises, and ore has been stoped above the 401 and partly above the intermediate 60 feet below. All but the two upper tunnels were open when the property was examined in 1932 and 1933. The No. 5 tunnel is at the level of the mill and camp on Fall Creek, but the others are more than 400 feet vertically up the slope southwest of the camp and are connected with the mill by tramway.

HISTORY AND PRODUCTION

Little could be learned about the early history of the mine, except that the lodes were discovered by placer miners when they sluiced off the disintegrated rock on the divide between Fall and Canyon

[2] Campbell Arthur, Thirty-ninth Annual Report of the mining industry of Idaho for the year 1937, p. 118, 1938.

Creeks. By 1880 the disintegrated lode matter had been sluiced, and the work on the lodes had started, but it was continued thereafter intermittently. The three upper tunnels were opened between 1905 and 1909. In 1918 the present company started a crosscut about 300 feet east of and 135 feet below the No. 3 tunnel. The No. 5 tunnel was begun in 1921 about 535 feet vertically below the No. 3 to explore the lodes at depth. The Belshazzar lode was cut about 1,000 feet from the No. 5 portal and traced westward by drift for more than 1,700 feet, but the quantity of ore exposed was small, and the work was then started on the 401 tunnel about 135 feet below the No. 3, and most of the recent production came from stopes beween he 401 and No. 3 levels. Connection was also made with the No. 5 tunnel, and a little ore was mined on the two intermediate levels. Active production started about 1926, but by late 1931 all the known ore reserves had been exhausted, and the mine suspended operations. The mine was idle in 1932 and 1933, but work was resumed for a short time in 1934, when about 300 feet of development was done on the 401 level and on the intermediate level 60 feet below. A small amount of ore was then run through the mill. In 1938 the mine was idle.

Exact production figures are not available. The disintegrated lode matter is said to have yielded $65,000 in gold,[3] and $25,000 is reported to have been recovered by amalgamation between 1905 and 1909, some 4,000 tons of ore valued at $10.48 per ton having been treated with little more than 50 percent gold recovery.[4] The main production, however, started in 1926, and from that year until April 5, 1931, 28,680.59 ounces of crude bullion valued at $426,464.03 were shipped to the United States assay office at Boise, and concentrates yielded an additional $68,954.75, of which $53,035.63 was in gold and $15,019.12 in silver.[5]

STRUCTURAL RELATIONS

The Belshazzar mine is about centrally located within the "porphyry belt," and dikes of quartz monzonite porphyry, rhyolite porphyry, and lamprophyre are exposed in the underground workings as well as on the surface, and, except for the lamprophyres, are cut by the Belshazzar and Centennial lodes (pl. 50). The quartz monzonite porphyry dikes are long and have, barring slight offsets, been traced for more than a mile. One passes beneath the camp along the bottom of the canyon, but the most prominent extends from the summit of Boise Ridge east-southeast through the mine. Another body of quartz monzonite porphyry is also exposed in the crosscuts and drifts in the No. 3 and No. 401 workings and two others in the No. 5 crosscut. The two bodies in the upper levels are somewhat irregular in thickness

[3] Jones, E. L., Jr., op. cit., p. 101.
[4] Ballard, S. M., op. cit., p. 59.
[5] Ross, C. P., op. cit., p. 265.

and are separated by reefs of quartz monzonite. Both cross diagonally through the workings. The rhyolite porphyry dikes are smaller and are not so conspicuous on the surface as the quartz monzonite porphyry dike. At least three irregular rhyolite porphyry dikes have been cut in the western part of the workings and still another in the Centennial drift. These dikes are of variable size and locally appear to branch. They also pass diagonally through the workings and curve somewhat south of east and dip steeply north to vertical. Where the rhyolite and quartz monzonite porphyry dikes have been cut by the lodes their rock is considerably altered, and one variety is difficult to distinguish from another. The lamprophyric dikes may be recognized from fragments in the soil debris but cannot be mapped, except underground. Several of them are exposed in the workings, particularly in the west part of the mine and along the 401 and Centennial crosscuts. They have diverse trends, but most of them strike somewhat north of west, locally north. They range from a few inches to 8 feet in thickness. Their rock is bleached, though younger than the lodes which they cut, and identification as to type is difficult.

There is a third lode on the property in addition to the Belshazzar and the Centennial, but neither this lode, which lies parallel to and 600 feet north of the Belshazzar, nor the Centennial, which also lies parallel to and 680 feet south of the Belshazzar, has been stoped. These lodes occupy fissure zones that trend approximately N. 70°–75° E., but the Belshazzar lode is curved at a considerable angle. It is supposed to be an easterly extension of the Mountain Chief lode on the opposite side of the Fall Creek-Canyon Creek divide, but the strike of the Mountain Chief lode is about N. 45° E. until it nears the common end line of the two mines, and then it curves in a broad arc as its strike changes to N. 60° E. and then to N. 70°–75° E. as it continues across the Belshazzar ground. The dip of the Belshazzar also shows a marked change with depth. Near the surface its dip is relatively flat, but between the No. 3 and 401 levels it increases from 30° SE. to nearly 70° SE. and remains unchanged to the lowest level. The dip of the Centennial is steeply southeast on the 401 level. There are also numerous fractures and slips of parallel and diverse trend, which are independent of the main fissuring. Some of these are shown on the maps of the underground workings (pl. 50). The No. 3 crosscut is partly along a minor fissure zone of west-northwest strike and steep southwest dip. Some of the fractures along the Belshazzar fissure zone strike N. 35°–55° E. and extend for some distance into the walls. Near the far end of the No. 3 drift one of the mineralized fractures strikes N. 20° W. and dips 70° NE. Similar cross fractures may be observed along the 401 level, some of them mineralized, others barren. Most of the dike contacts show evidence of movement, and some of the fractures alongside contain thin seams of ore. Movement has also taken place subsequent to ore deposition, but the displacements are of minor magnitude, commonly no more than a few inches, and are mostly along the planes of the older faults. One fault in the east workings on the 401 level has, however, offset the Belshazzar lode for several feet. This particular fault strikes N. 10° E. and dips 55° SE.

The fissure zone occupied by the Belshazzar lode ranges from a few inches to 4 feet in width but lacks continuous mineralization and contains stretches in which the lode is marked only by shearing and a little gouge. Much of the ore along the fissure zone is confined to relatively small shoots where the fissuring is most pronounced. These shoots are irregular and characteristically swell and pinch on strike and dip. The richest ore has apparently been in the widest swells, and the principal swells were found between the 401 and No. 3 levels where the dip is notably flat. The distribution of the ore has apparently been controlled by premineral fracturing, and the most extensive ore deposition has been in the zones where the rock was most fractured and rendered most permeable to the ore solutions, especially in openings produced by movement along a curved or irregular fault plane. The most favorable site for mineral deposition has been in the granitic rock of the batholith and not in the porphyry dikes or at lode and dike intersections. As elsewhere, the rhyolite porphyry tended to splinter rather than fissure, and, although wider zones of fractures were produced, the ore in them is more widely dissipated and the value, therefore, is not so high. On the No. 3 and 401 levels the ore in the larger bodies of porphyry was left unmined, and the stoping was confined to the more compact and better-defined fissure veins in the granitic rock and across some of the smaller rhyolite porphyry dikes. Stoping has been carried along the strike at intervals for a distance of more than 200 feet. Much of the ore occurred in more or less compact veinlike bodies, few of them more than 12 inches thick, but commonly surrounded by a fringe of smaller seams and stringers. In some places the ore occurred only as stringers and seams in the fractured rock. In and along the lode, and particularly along the ore shoots, the country rock has been intensely sericitized, locally permeated by carbonates, and widely impregnated with crystals of pyrite.

CHARACTER AND MINERALOGY OF THE ORE

The lode filling varies considerably in its composition from place to place, but most of it is a composite admixture of sulfide seams and nests cut and penetrated and in part included in younger seams and lenses of quartz, which also contains an essentially contemporaneous assemblage of pyrite, arsenopyrite, scattered small grains and tufts of bismuth and antimony minerals, dolomitic carbonate, and free gold. The distribution of the ore shoots, therefore, conforms with the distribution of the quartzose lenses and stringers and is largely independent of the older generation of sulfides.

The older sulfide filling is dominated by pyrite, and many seams and stringers contain pyrite alone. In places the pyrite is cut by small nests and granules of sphalerite and galena and locally by a little pyrrhotite, marcasite, tetrahedrite or tennantite, enargite, and chalcopyrite. These sulfides as a group have been rather extensively brecciated and in part cemented by siderite, possibly of the same depositional stage, and are commonly engulfed as scattered fragmental inclusions in the younger generation of quartz. Most of the stringers in the subordinate fractures in the walls and in the larger rhyolite porphyry dikes consist of pyrite alone and contain insufficient gold for profitable extraction. Reopening of the lode has apparently been confined to the more prominent fissures and failed to disturb appreciably the minor fractures that were sealed by the early sulfides. The second generation of minerals was deposited only where the structural conditions were especially favorable, and these minerals are not as widely distributed as the sulfide seams and stringers.

The younger quartz is rather coarsely crystalline and is not entirely massive. The needles and tufts of bismuth minerals generally lie in small openings between the quartz crystals or extend into and replace the earlier brecciated sulfides, particularly the galena and to lesser extent tennantite (?) and enargite. Galenobismutite appears to be the most abundant of the bismuth minerals but is accompanied by minor amounts of bismuthinite. Some boulangerite is also associated with the bismuth minerals and is present in the dolomitic carbonate as curved feathery laths and as similar laths in the galena. In places coarse crystals of pyrite and arsenopyrite are notably abundant in the quartz. Gold was observed in polished sections of the ore, mainly as very small grains associated with the galenobismutite and bismuthinite. In contrast to the extreme fineness of much of the gold, pockets containing coarse pieces were found, particularly near the intermediate level between the No. 401 and No. 3 levels. Some of the high grade ore specimens consisted of coarse arsenopyrite crystals projecting into open cavities with gold deposited on the surface of the crystals and also intricately intergrown with them in the walls of the cavities.[6]

TENOR AND DISTRIBUTION OF THE ORE

According to Ballard[7] the ore from the three upper tunnels is reported to have carried about 0.5 ounce of gold to the ton, of which only about half was recovered by amalgamation. During the most active production, about 1930, the mill heads also averaged about 0.5

[6] Ross, C. P., op. cit., pp. 267–268.
[7] Ballard, S. M., op. cit., p. 59.

ounce of gold to the ton, but there were in addition pockets of extremely high-grade ore.[8] The richest ore was found in the upper workings above the 401 level, particularly on the intermediate level and between it and the No. 3. Little ore of commercial grade has apparently been exposed below the 401 level, and although two small ore shoots were penetrated by the long drift on the No. 5 level on which good assays were obtained, the quantity of ore was small. Sulfide seams and stringers are as conspicuous below the 401 level as above, and the young quartz and associated pyrite, arsenopyrite, and bismuth minerals are still relatively abundant, but the gold content has apparently decreased to such an extent as to make the ore of doubtful commercial worth.

NEWBURG MINE

The Newburg mine lies in sec. 17, T. 7 N., R. 4 E., almost at the base of the steep escarpment that forms the east slope of Boise Ridge a short distance southwest of Quartzburg between the Mayflower and Belshazzar mines. It was worked by surface sluicing in the early days, and some ore was mined and treated locally in stamp mills. The old tunnels are caved, and only surface cuts show the nature and extent of the mineralization. The mine was acquired by the Talache Mines, Inc., about the time the company took over the Gold Hill mine, but no work was done on it.

The lode is contained in rhyolite porphyry and appears to be as much as 70 feet wide. The largest cut on it is elongated N. 65° W. and may be in the direction of the strike of the lode itself. Both the lode and the dike are cut off by the Boise Ridge fault. The lode consists of shattered and altered iron-stained rock cut by scattered narrow auriferous quartz seams, said to be individually very rich. According to Lindgren[9] the ore assayed from 0.2 to 0.5 ounce of gold to the ton.

MINERAL HILL MINE

The Mineral Hill mine is in sec. 31, T. 8 N., R. 5 E., along the main divide between the heads of Ophir and Alder Creeks, about 3½ miles northeast of Placerville. The mine has not been worked for a number of years, and the entire surface plant, including a 50-ton amalgamation mill, was destroyed by the 1931 forest fire. The workings are no longer accessible but formerly included a mill-level crosscut more than 400 feet long with drifts of equal length and stopes reaching the surface 165 feet above. The last work was in a shaft 120 feet deep sunk near the portal of the mill-level crosscut, but work was suspended before crosscuts were driven to undercut the older work-

[8] Ross, C. P., op. cit., p. 265.
[9] Lindgren, Waldemar, op cit. (18th Ann. Rept.), p. 691.

ings.[10] According to Ballard [10] the mine is reported to have produced about $85,000 in gold.

The mine is near the southwest end of the main quartz monzonite porphyry stock, and all lodes, of which there are several, are in the stock not far from a large body of granophyre and from several rhyolite porphyry dikes. The principal lode is exposed in a large glory hole more than 40 feet across and consists of a broad zone of greatly sheared and intensely altered rock. The zone strikes about N. 40° E. and dips about 70° SE. About 8 feet of the sheared and altered porphyry was exposed in the southwest side of the glory hole, and the lower 2 to 3 feet pan free gold. This lode is reported to have been stoped from the mill-tunnel level to the surface for a distance of 160 feet over a width of 30 feet. Two other lodes of similar trend were cut in the mill-level crosscut, one 250 feet and the other 300 feet from the portal, and ore in the second was stoped for a distance of more than 400 feet.[11] Still another lode was reported by Ballard in the lower part of the shaft, but no work was done on it. The lode is said to be 2 feet thick and to strike about N. 25° E.

According to Ballard the ore from the smaller lodes in the crosscuts and from the main lode exposed in the glory hole consisted of mixed iron sulfides and oxides and considerable bismuth and carried about 0.70 ounce of gold per ton. Some fragments of ore found on the premise showed pyrite and coarse, platy bismuth minerals and a little calcite and quartz. The bismuth minerals were identified microscopically as bismuthinite and tetradymite.

BUCKSKIN MINE

The Buckskin mine is in sec. 5, T. 7 N., R. 5 E., and sec. 32, T. 8 N., R. 5 E., on the ridge between Ophir Creek and a tributary of Muddy Creek, about 3 miles northwest of Pioneerville. The mine is an old one and has been idle for a number of years. It formerly belonged to the Diamond Mining Co., but the company gave up its charter in 1931 and the claims have since been relocated. The old workings comprise about 2,900 feet of tunnels, one about 900 feet long, another 500 feet long, and others of lesser length. These were caved when the property was visited, and the examination was confined to shallow cuts and short tunnels on at least three fairly prominent lodes. Some ore has been treated locally in a small mill, but the mill as well as the entire surface plant was destroyed by flames during the forest fire of August 1931. No data on production were obtained.

The mine is along the south margin of the "porphyry belt," through the Quartzburg-Grimes Pass area and the lodes lie in the early Tertiary (?) diorite, but one, at least, crosses into a dike of rhyolite

[10] Ballard, S. M., op. cit., p. 68.
[11] Ballard, S. M., op. cit., pp. 68–69.

porhyry. The Lost Cabin lode has been most extensively prospected and has been traced in an adit drift for about 900 feet and exposed in a series of open cuts and trenches on the surface. It apparently strikes about N. 30° E. and dips 60° NW. It occupies a well-defined fissure zone 1 to 5 feet wide penetrated by seams and stringers of ore. Another lode having a similar strike but dipping 75° SE. is exposed in open cuts near the site of the burned mill south and across the creek from the Lost Cabin. This second lode appears to be 12 to 18 inches wide. The third lode is a short distance west of the Lost Cabin in one of the rhyolite porphyry dikes and is exposed in a short tunnel and open cut. It is as much as 6 feet wide but is made up of only scattered ore seams.

The ore in the cuts and short tunnels consists of iron-stained seams in sericitized rock, but on the main dumps and at the site of the burned ore bin is ore with sulfides in a quartz gangue. The sulfides include pyrite, arsenopyrite, sphalerite, chalcopyrite, and galena and except for the arsenopyrite are fragmental remnants of an early base-metal filling cemented by coarsely crystalline and, in part, drusy quartz. Some pyrite as well as the arsenopyrite is associated with the young quartz. Ballard[12] reports that bismuth minerals particularly rich in silver are associated with the galena and that stibnite occurs sparingly.

COMEBACK MINE

LOCATION AND DEVELOPMENT

The Comeback mine is in sec. 25, T. 8 N., R. 5 E., about 3 miles northeast of Pioneerville. It lies high on the slope above Clear Creek at an altitude of about 5,490 feet, or 890 feet above the road on Grimes Creek. According to the State Mine Inspector's report for 1937, the property comprises the Comeback group of 12 patented and 17 unpatented claims and has an approximate total development of 5,226 feet of underground workings, mainly in 4 tunnels.[13] The principal workings, however, are in the No. 4 tunnel, which is shown in plate 51. This map was prepared by the writer and as none was ever made by the company is the only available mine map. It gives the entire plan of the No. 4 level, based on examinations in 1932, 1933, and 1938, and is pieced together from the maps of the workings open at each visit. As few stopes were accessible at any time, it was not possible to prepare a longitudinal section to show the distribution of ore shoots. Other workings to the west of the No. 4 were partly open in 1933 but were not mapped. The 285-foot No. 1 prospect tunnel was caved, as were a 900-foot tunnel (also designated as No. 1) and an 860-foot intermediate.

[12] Ballard, S. M., op. cit., p. 67.

[13] Campbell, Arthur, Thirty-ninth Annual Report of the mining industry of Idaho for the year 1937, p. 116, 1938.

HISTORY AND PRODUCTION

The mine is one of the most recent discoveries in the district and has been until 1938 one of the most active. The Comeback lode was discovered in 1924 by tracing some coarse gold found in the gulch below to its source high up the steep slope. The lode failed to attract much attention until several years later, when some rich pockets of high-grade ore were found during development. In April 30, 1928, the Comeback Mining Co. was incorporated and by 1930 had produced ore with a gross value of about $40,000.[14] In 1933 a mill was installed but was dismantled after a short run, and all ore mined since has been hand sorted and shipped directly to the smelters. Mining has been somewhat handicapped by litigation but has continued without much interruption, and by the end of 1937 all known ore shoots had been stoped. Prospecting for other shoots continued through 1938. More ore subsequently was found.

The total production is reported by the management to approximate $283,000 with $163,000 reported for the years, 1935, 1936, and 1937; $70,000 for the years 1933 and 1934; and $10,000 for the year 1932. Prior production is estimated at $40,000. The total includes considerable amounts of silver.

GEOLOGIC RELATIONS

The Comeback mine is along the south margin of the "porphyry belt," and the rather widely scattered dikes include diorite, quartz monzonite porphyry, rhyolite porphyry, and lamprophyre. A body of the early Tertiary (?) diorite is exposed in the No. 4 crosscut and is cut off by the lode in the west drifts (pl. 51). East of the crosscut the lode grazes the contact of an irregular rhyolite porphyry dike and in places extends into the dike. Because of intensive wall-rock alteration the rhyolite porphyry in and along the lode is difficult to distinguish from the altered rock of the batholith, and precise contacts between them are in places hard to recognize. In the west drift a narrow but irregular lamprophyric dike lies in and along the hanging wall of the lode. The dike has been somewhat fractured by post-ore movement but contains no ore.

The fracture zone occupied by the Comeback lode strikes about N. 65° E. in the main workings and dips steeply northwest. In the workings to the west of the No. 4, the fracture zone appears to strike about N. 45° E. and dips northwest, but whether it is a continuation of the Comeback fracture zone, or another, could not be determined because of the spacing of the workings. The N. 45° E. fracture zone is cut off on the west by an unmineralized fault that strikes N. 10°–20° E. On the other side are some mineralized fracture zones that

[14] Ross, C. P., op. cit., p. 269.

strike N. 10°–20° W. Some work was under way in the west workings in 1933, but when the writer returned in 1938 the ore had been mined and the workings had been abandoned and were caved. Little data therefore were obtained on geologic relations at the west end of the property, and further discussion is confined wholly to the main fracture zone exposed in the No. 4 tunnel and drifts.

The fracture zone occupied by the main Comeback lode is as much as 40 feet wide and has been drifted on for more than 1,400 feet underground without reaching end limits. It is marked by several more or less parallel planes of movement with less fractured rock between and shows particularly intense movement and fissuring along the footwall and to somewhat less extent along the hanging wall. Much of the ore appears to form seams and stringers in the fractured granitic rock, locally in the rhyolite porphyry, and is concentrated along the footwall and to lesser degree along the hanging wall. The seams and stringers along the walls are not uniformly distributed but tend to occur in bunches and from shoots of small size. The ore shoots, though small, have been rich, and these small shoots have provided the entire production of the mine. Many of the stopes have been driven on bands of ore no more than 2 inches thick. In few places does an ore shoot reach a thickness of 2 feet. Only the rich seams and pockets of ore have been mined, and few of the stopes exceed 30 feet in length. In stoping, the ore seams were broken from the rock and sacked underground. In general much gouge occurs along the lode and is especially abundant in and along the ore shoots. Because much of the gouge has been produced by intramineralization movements it has considerable crushed ore as well as rounded ore pebbles and boulders, and much of the gouge has been classed as ore. The lode is narrow where it grazes the rhyolite porphyry and contains less ore, apparently because the porphyry did not fissure as readily as the granitic rock. The ore shoots and pockets were apparently localized by movement of the walls along an unevenly warped fracture plane, and striations and grooves on slickensided surfaces dip about 40° SW., indicating that the relative direction of movement was obliquely upward. As there was no opportunity to map and study the stopes in detail, the precise relation of ore shoots to structure could not be satisfactorily determined. The lodes in the west workings are structurally similar, but the ore is more pockety and the shoots and ore seams smaller.

The country rock in and along the lodes has been intensely sericitized, softened, and in places impregnated with crystals of pyrite. The rhyolite porphyry is not in general as much altered as the quartz monzonite, probably because it was not so extensively fractured and permeated by the mineralizing solutions. In general the ore appears to favor the areas of most highly altered rock.

MINERALOGY

Although there is some resemblance to the silver ore at the Washington mine, the ore at the Comeback mine is unlike any of the ore in Boise Basin. It has but scant amounts of sphalerite, galena, tetrahedrite, and chalcopyrite but does have appreciable amounts of pyrite and especially arsenopyrite. The chief ore mineral is electrum, which in places is accompanied by minor amounts of pyrargyrite and miargyrite. The partly oxidized ore on the upper levels also contains considerable native silver and some argentite. Quartz is the most abundant mineral, and it is present in several different varieties. Some of it is rather coarsely granular, but much of it is finely crystalline, in places chalcedonic, and has a dull white to gray color. There is also considerable comb and drusy quartz. The ore shows evidence of repeated brecciation during the period of deposition and has, therefore, a typically brecciated appearance. Mineral deposition was apparently interrupted several times by the structural disturbances, and some minerals, as pyrite and perhaps some of the galena and sphalerite, were deposited in more than one sequence. Pyrite and base metals were for the most part early and are commonly crusted by drusy and comb quartz and by pyrite and arsenopyrite. The comb and drusy quartz also appears to be brecciated and cemented by the finely crystalline or chalcedonic quartz. The silver sulfosalts and the electrum are apparently associated with the youngest quartz. The deposit shows some tendency toward zoning, as the richer silver is near the west end of the lode and decreases in abundance eastward and with depth.

DISTRIBUTION AND TENOR OF THE ORE

The ore is erratically distributed, and the ore of highest grade appears to be restricted to small pockets. An assay of a hand sample from the mill level is reported to have shown 48.2 ounces of gold and 217.7 ounces of silver to the ton and 2.4 percent lead and 1.09 percent copper, whereas a carload of ore shipped in December 1928 had a gross value of $237.62 a ton, principally in gold.[15] Much of the ore mined in 1934 was from the upper levels and contained large quantities of native silver in thin sheets and slabs and small combs and wires in clefts between drusy quartz crystals and in the openings from which sulfides had been leached. The secondary silver added materially to the value of the ore, but the main production came from the small high-grade pockets of electrum in the fine-grained quartz. Little ore has been found below the No. 4 tunnel level, and no ore of commercial grade was encountered in a long crosscut driven under the lode several hundred feet below. On the other hand, the ore shows progressive increase in richness above the No. 4 level, with the best ore

[15] Ross, C. P., op. cit., p. 270.

more than half way to the surface, 125 feet above. The marked decrease in the tenor of the ore with depth implies a rather shallow range of silver-gold deposition, limited perhaps to less than 200 feet vertically, as the scarcity of placer gold in the gulch below the lode suggests that the top of the ore zone was barely exposed by erosion. Future prospecting might perhaps better be confined to lateral exploration than to search for ore at greater depth.

MISSOURI MINE

The Missouri mine is in sec. 27, T. 8 N., R. 8 E., about 1½ miles southwest of Grimes Pass, on upper Muddy Creek nearly 4 miles by road from Pioneerville. The property comprises 12 unpatented claims and has about 1,400 feet of underground workings. Some older workings on the ridge a short distance away were inaccessible and are not included in the total.

The mine is an old one and was originally located as placer ground, the lodes being uncovered during placer operations. Little is known of the early history of the mine, but since 1914 it has been operated by the Missouri Mining Co., and some work was performed annually from 1922 to 1930. In 1923 the work was carried on through two shafts on separate lodes a few hundred feet apart, each shaft being about 50 feet deep and having a few hundred feet of drifts at the bottom. In 1929 the camp was fully equipped, a 50-ton flotation concentrator installed, and the shaft on the principal lode sunk 210 feet on an incline with drifts on the 40-foot, 100-foot, 150-foot, and 200-foot levels. The mine was closed in August 1930 and has remained idle since, although it was reopened and sampled in 1934. The mine was one of the few to escape the forest fire of 1931. The working were inaccessible when the property was visited in 1932, 1933, and 1934.

Small shipments of ore were made as far back as 1906 and additional shipments in 1922. Small tonnages of concentrates were produced and marketed in 1930, but the total amount of ore and its value was not learned.

Two lodes are known to cross the property, but most of the work has been confined to the Missouri lode. Both lodes occupy prominent fissure zones, which are in part of the dark-colored early Tertiary (?) diorite and in part in the pinkish Miocene quartz monzonite porphyry. Most of the rock adjacent to the mine is concealed beneath gravel, but rhyolite porphyry dikes are numerous nearby, though not exposed in the underground workings. Ross[16] reports a fine-grained pinkish aplitic rock at one place in the fissure zone on the 100-foot level, which may perhaps be a differentiate of the quartz monzonite porphyry, or pyroxene diorite. Miocene lake beds lie beneath the stream and bench gravels a short distance below the mine.

[16] Ross, C. P., op. cit., p. 271.

The fissures that admitted the rhyolite porphyry dikes as well as the Missouri lode strike north-northeast, but the second of the lodes, the Silver King, several hundred feet north of the Missouri, occupies a fissure zone of more easterly trend. The Missouri lode has an average strike of about N. 35° E. and an average dip of about 70° NW., ranging from 50° to 85° NW., locally with seams dipping steeply southeast.[17] A split in the lode is reported on the 100-foot level, and two parallel fissure zones about 65 feet apart are exposed on the 200-foot level. Ross reports that the main lode ranges from 1 to 5 feet thick but at one place is 12 feet thick. It contains stringers, lenses, and small pockets of ore, some of the seams measuring as much as 8 inches in thickness. He also reports that ore was found on the 40-foot and 100-foot levels and was exposed in a 35-foot winze below the 100-foot level to a point where it pinched out. Ore was also encountered and stoped in the workings on the ridge northeast of the shaft.

The Silver King lode is reported to strike about N. 69° E. and near the surface to dip toward the Missouri lode at an angle of 45°. At depth the dip steepens to 85° SE. This lode, like the Missouri, occupies a well-defined fissure zone, made especially conspicuous by bands of gouge and crushed rock.

The ore at the Missouri mine is the base-metal type, and most of it consists of sulfide seams and stringers composed of about equal amounts of sulfides and quartz-carbonate gangue. The sulfides include pyrite, arsenopyrite, sphalerite, and galena, and scant amounts of chalcopyrite, and tetrahedrite or tennantite. Some free gold in grains of microscopic size is also contained in the ore. Most of the ore mined was somewhat oxidized and contained streaks with supergene wire silver and grains of argentite, the latter as a replacement of galena and tetrahedrite. Ore in the bin in 1932 consisted largely of arsenopyrite, pyrite, and dark grayish and brownish black sphalerite, but the better ore is reported to have had seams of massive galena 1 to 4 inches thick, in part crushed in gouge. The arsenopyrite is more abundant locally than at any other place along the "porphyry belt" of the Quartzburg-Grimes Pass area and was introduced into the brecciated sulfide filling along with most of the quartz and carbonate. The ore deposition was accompanied by extensive sericitization and pyritization, locally silicification of the enclosing rocks, and the sulfides in part replace the altered rock.

Ballard[18] reports that a shipment of 20 tons of ore from the shaft on the Silver King lode in 1922 gave smelter returns as follows: Gold, 1.11 ounces; silver, 58.6 ounces; lead, 11.3 percent; zinc, 1.3 percent;

[17] Ross, C. P., op. cit., p. 271.

[18] Ballard, S. M., Geology and gold resources of Boise Basin, Boise County, Idaho: Idaho Bur. Mines and Geology Bull. 9, p. 89, 1924.

iron, 11.0 percent; sulfur, 3.4 percent; and insoluble material 57.4 percent.

GOLDEN AGE MINE

LOCATION AND HISTORY

The Golden Age mine is about half a mile east of Grimes Pass, on the south side of Grimes Creek, in sec. 23, T. 8 N., R. 5 E. The mine was located in 1896, but active exploration did not get under way until 1909.[19] Work then continued intermittently until 1925. The mine was first worked by the Golden Age Mining Co., but since April 1915 has been worked by the Golden Age Junior Mining Co. The first work was carried on from a 200-foot shaft, but later an 1800-foot tunnel was driven from Grimes Creek, giving an additional depth of 65 feet. Still later a 100-foot winze was sunk below the tunnel level, and 500 feet of drifting was done from the bottom. In 1921 a new 250-foot two-compartment shaft was sunk a short distance below the older shaft and the development carried on through it.[20] This shaft reached a depth of 160 feet below the old winze level, or about 425 feet below the outcrop of the lode measured on the dip. Mining was continued through the shaft for 2 years, then underground work was suspended while a fine-grinding 100-ton flotation concentrator was installed. Earlier milling had first been carried on in a 15-stamp amalgamator equipped with Wilfley tables. When the oxidized ore had been mined a cyanide plant was added. The new concentrator was not completed until 1924, but mining operations were not resumed and the mine remained inactive through 1938. The underground development comprises about 6,500 feet of workings. During the 1931 forest fire the entire surface plant, except the camp cottages along Grimes Creek, was destroyed. Production records are not available, but prior to 1915 the recovery by amalgamation had exceeded $200,000.[21]

STRUCTURAL RELATIONS

There are several lodes on the property, but only the Trade Dollar has been worked. The Jerry Simpson was crossed in the long crosscut about 100 feet from the portal, but no attempt was made to explore it or several other fracture zones of minor magnitude farther along the crosscut. The lodes are contained in the quartz monzonite porphyry stock, but the Trade Dollar also crosses a dike of rhyolite porphyry. Postdike shearing has been prominent locally, particularly in N. 10° E. and N. 60°–70° E. directions, but only the N. 10° E. fractures contain ore.

The Trade Dollar lode strikes about N. 10° E. and is reported to

[19] Jones, E. L., Jr., op. cit., p. 105.
[20] Ballard, S. M., op. cit., p. 75.
[21] Jones, E. L., Jr., op. cit., p. 105.

show abrupt changes in dip. On upper levels its dip is vertical to steeply east, on the tunnel level 60° W., and on lower levels steeply east. According to Jones [22] the lode was split on and above the tunnel level, and each branch was drifted on for 200 feet before the parts rejoined. These branches were 20 feet apart on the level but came close together 60 feet above and joined some distance below, as only one lode appeared in the lower workings.

The lode is reported to range from 1 to 5 feet in thickness and to have an ore body 600 feet long. It is described by Ballard [23] as a gouge-filled fissure with crushed and broken nests, seams, and nodules of ore. Adjacent to the lode the country rock is thoroughly sericitized, in part silicified, and widely impregnated with small pyrite crystals.

MINERALOGY AND DISTRIBUTION OF THE ORE

Although the lode has contained considerable sulfide, gold has been the principal ore mineral. So long as the work was in the oxidized zone, particularly above the tunnel level, the recovery by amalgamation was high, but the occurrence of sulfides at depth made complications with which the earlier operators were unable to cope. Most of the unoxidized ore consists of pyrite, but in some of the main ore shoots there is considerable sphalerite and galena and in places minor amounts of chalcopyrite and tetrahedrite. These sulfides in part replace the altered wall, particularly where it has been silicified, and also replace a scant early quartz filling. The sulfides form massive pods, seams, and small lenses and bunches along the fractures as well as disseminated grains on either side, especially where the shearing and fracturing has been exceptionally prominent. The sulfides have been considerably brecciated and have been cemented and crusted by fine-grained younger quartz and pinkish carbonate. These younger minerals appear to be more abundant than in most base-metal deposits, a fact that probably accounts for the relatively high gold content of the ore. The younger quartz and carbonate also form small nests and lenses along the fissure zone. The lode has apparently suffered more active movement and reopening during mineralization than most other lodes in the district. Ballard [24] comments that the crushed sulfides commonly have a higher gold content than the uncrushed minerals and that the highly auriferous pyrite is in or near quartz. He has published assays on selected quartzose ore and sulfides from different parts of the lower workings, and these assays show results ranging from 0.53 ounce to as much as 3.58 ounces in gold per ton and rather low values in silver, lead, copper, and zinc. Ore collected from the burned ore bin at the former mill and assayed by the analyst for the

[22] Jones, E. J., Jr., op. cit., p. 106.
[23] Ballard, S. M., op. cit., p. 77.
[24] Ballard, S. M., op. city., pp. 77, 79–80.

Idaho Bureau of Mines and Geology carried 2.56 ounces in gold per ton and 43.7 ounces in silver.

MOUNTAIN QUEEN MINE

The Mountain Queen mine is on Grimes Creek, several hundred yards below Grimes Pass. The workings consist of two caved tunnels driven into the divide separating Grimes Creek from the Payette Canyon, one near creek level, and the other 200 feet above and about 150 feet below the crest of the divide. Stopes were carried through to the surface, and the course of the lode is prominently outlined for 300 feet along the divide by the caved stopes. The production is reported at $150,000.[25] The mine is an old one that has not been worked for many years. It was acquired by the Golden Age Mining Co. a number of years ago.

The lode strikes N. 40° E. across the divide and dips about 70° SE. It lies in the quartz monzonite porphyry stock, which locally along the walls is greatly sericitized and in part silicified. The outcrop is iron-stained, but no ore was left on the surface. Across Grimes Creek, on the Idaho and old Theron group, the lode strikes about N. 35° E. and dips 65° SE. In the face of a caved 250-foot tunnel the lode is reported to contain a 2-inch band of sulfides consisting of pyrite, sphalerite, and galena.[26]

BRUSER GROUP

The Bruser group of the Mineral Mining Co. is in sec. 23, T. 8 N., R. 5 E., on the divide between Grimes Creek and the Payette Canyon, several hundred yards east of Grimes Pass. Rich ore was reported mined in the early days, but the mine was inactive for a long time and little or nothing was done until 1933, when a tunnel 570 feet long was driven from creek level under the Grimes Creek-Payette divide. All of it except the first 170 feet was in the lode.

The lode lies within the quartz monzonite porphyry stock but should pass out of the stock into the granitic rock of the Idaho batholith in no great distance. The lode strikes N. 35°–40° E. and dips 55° NW., about parallel to the fractures occupied by nearby rhyolite porphyry dikes. The fracture zone containing the lode is as much as 4 feet wide, and the lode itself consists of greatly sheared and altered porphyry with scattered and partly crushed ore seams and stringers, some small ore pockets and lenses, and minor amounts of disseminated ore. Some of the ore lenses are as much as 1 foot thick and several feet long. The ore zone in general occupies 1 to 3 feet of the fracture zone. Intramineralization faulting has been exceptionally severe, and more ore has been incorporated in the gouge than usual. As much as 10 to 16

[25] Jones, E. L., Jr., op. cit., p. 105.
[26] Jones, E. L., Jr., op. cit., p. 105.

inches of black gouge filled with mashed sulfides and rounded ore pebbles and boulders lies along the hanging wall. Because of the abundance of the soft black gouge the lode is known locally as the Mud lode.

Most of the ore consists of greatly brecciated sulfides in a dark-gray, fine-grained to chalcedonic quartz and finely crystalline carbonate cut in places by scattered seams of a younger, light-colored medium-grained quartz. The sulfides are not particularly abundant and include rather finely disseminated grains of pyrite, arsenopyrite, sphalerite, galena, and a little microscopic tetrahedrite and chalcopyrite. A little auriferous pyrite and free gold are contained in the younger quartz.

SILVER GEM MINE

LOCATION AND DEVELOPMENT

The Silver Gem mine is in sec. 14, T. 8 N., R. 5 E., near the head of Slide Gulch, three-fourths of a mile northeast of Grimes Pass and about 700 feet below the Grimes Creek-Payette Canyon divide. Some work was done at the mine prior to 1920, but little other than annual assessments were performed from then until 1935. The development includes crosscuts and drifts in two levels connected by raises (pl. 52). The lower workings comprise a 440-foot crosscut and a drift 80 feet long; the upper workings, 35 feet vertically above, comprise a 60-foot crosscut and more than 370 feet of drifts. Some other workings on a lode about 200 feet above have a 55-foot crosscut and a drift 130 feet long. Several cars of ore were shipped from the property prior to 1920, and further shipments were made in 1935, but the production was not learned.

DESCRIPTION OF THE LODES

The two lodes occupy prominent fissure zones in a small early Tertiary (?) diorite stock (pl. 52). Both fissure have variable trends, the strike of the principal lode ranging between N. 10° E. and N. 35° E. and that of the second lode between N. 20° E. and N. 40° E. The dips also are different, the dip of the main lode ranging from 65° to 70° SE. and that of the second lode from 40° to 45° SE. The main lode is in a fissure zone not less than 8 feet wide, but the fissure zone does not contain ore throughout. In most places the ore is concentrated in a band along the footwall, in places accompanied by a smaller band along the hanging wall, the two joined by smaller seams and stringers in the fractured rock between. The ore is also concentrated into shoots, three of which are exposed in the upper tunnel, though only two contain notable amounts of ore. These shoots are 30 to 40 feet long, are as much as 26 inches wide, and are separated by sheared and altered rock with fewer and smaller ore seams and stringers.

The shoots have been stoped to the surface. In the lower drift the fracture zone has 2 to 8 inches of ore on the footwall, 2 feet of pyritic ore on the hanging wall, and 3 feet of sheared and altered diorite between. In the stopes on the level above, massive ore 4 to 15 inches thick is reported along the footwall and in places a band 4 to 5 inches thick next to the hanging wall.

The second fissure zone is not as wide or as conspicuous as the first, and the ore seams and stringers, which range from less than an inch to 6 inches in thickness, are scattered along in zones 1 to 2 feet wide. Broad bands of gouge are prominent along both lodes and contain much crushed and pulverized ore and rolled boulders. The distribution of the ore is controlled apparently by structural conditions determined by lateral displacement along an irregular fault plane. Grooves and striations along the walls of the fissures show a 25° dip to the southwest.

MINERALOGY

The ore in two lodes is somewhat different. Most of the filling in the main fissure consists of sulfides and in the second of quartz and carbonates. The sulfides include abundant tetrahedrite and locally as abundant pyrite, sphalerite, and galena. In general the tetrahedrite comprises from about one-third to one-half of the entire filling. The tetrahedrite is argentiferous, and analyses show a silver content of several hundred ounces per ton. The sulfides are fairly coarse and have been considerably shattered. The sulfide filling has been penetrated and the brecciated ore cemented by a scant quartz-barite-dolomite-calcite gangue. It is reported that the smelter returns on 3 cars of ore in 1919 were gold 0.2 ounce and silver 80.0 ounces to the ton, copper 6 percent, lead 3.5 percent, and zinc 6 percent. In the other lode the base-metals are scantily represented, and most of the ore is contained as seams and stringers of young-stage quartz accompanied by a little auriferous pyrite.

ORO MINE

LOCATION AND DEVELOPMENT

The Oro mine is in sec. 22, T. 8 N., R. 5 E., on Grimes Creek about three-fourths of a mile below Grimes Pass. The property consists of two unpatented claims, which were held by the Oro Mining Co. under lease during 1932 and 1933. The workings comprise two tunnels, the No. 1, near creek level with a 515-foot crosscut and a 185-foot drift at the end of the crosscut, and the No. 2, a 200-foot tunnel on the slope above. Two shafts, one 65 feet deep and the other 150 feet deep, lie near the upper tunnel.

A 25-ton mill was worked intermittently during 1932 and 1933, but the amount of ore treated and the amount of gold recovered was not learned.

STRUCTURAL RELATIONS

The claims lie along the contact of the dark-colored early Tertiary (?) diorite (locally granodiorite) and the Miocene pinkish quartz monzonite porphyry stock and cover a very prominent fissure zone in the quartz monzonite porphyry, in part along the porphyry-diorite contact. Three irregular rhyolite porphyry dikes are exposed on the crosscut of No. 1 tunnel but are concealed on the surface. Others crop out nearby. The dikes cut the diorite and strike about N. 40°–60° E., and those in the crosscut dip 60° SE.

The fissure zone and its contained lode strike about N. 10° E. and dip steeply west. The zone comprises 8 to 15 feet of highly crushed and fractured quartz monzonite porphyry containing some wide bands of gouge. Much of the ore formed small lenses, pods, bunches, and stringers, none of which were more than 6 inches thick. Some occurred along the hanging wall and footwall of the fissure zone, some as seams and stringers in the fractured rock between. A considerable part of the ore was crushed and incorporated in the gouge or reduced to rolled boulders. The wall rock alongside is extensively and intensively sericitized.

Several minor lightly mineralized fissures are exposed in the crosscut, mainly at or near the contact of the rhyolite porphyry dikes. These fissures strike about N. 40°–60° E. and dip southeast. The fissure zones are narrow, the walls alongside are not extensively altered, and the ore content is so low that none of the zones were prospected.

MINERALOGY

The deposits belong to the gold-base-metal type, but gold is the principal ore mineral. Most of the ore consists of widely scattered small sulfide boulders and seams and crushed sulfide fragments in dark-gray to black gouge. The sulfides include dominantly tetrahedrite and lesser amounts of galena, pyrite, sphalerite, and chalcopyrite (mostly microscopic). The sulfides are commonly cut by widely spaced pinkish carbonate and quartz seams. The gold is not present in the sulfides but is in the younger, inconspicuous, widely scattered thin quartz seams and stringers that penetrate the base-metal masses or lie alongside in separate fractures. The number and spacing of the quartz seams have determined the location of the workable ore shoots. Some of the massive sulfides were assayed to determine gold relations, and one composite sample showed 0.08 ounce in gold per ton and 39.3 ounces in silver. The young quartz assayed by itself contained 31.12 ounces in gold per ton and 7.8 ounces in silver.

COON DOG GROUP

LOCATION AND DEVELOPMENT

The Coon Dog group of claims is in secs. 12 and 13, T. 8 N., R. 5 E., and extends in an easterly direction on both sides of Grimes Creek and in part on the upper slope of the Payette Canyon about 2⅛ miles northeast of Grimes Pass. The group comprises at least 11 claims, and considerable work has been done on the Coon Dog No. 1, Coon Dog No. 4, Coon Dog No. 9, and Coon Dog N. 11. The Coon Dog No. 1 and No. 9 claims cover a part of the lower slope of the ridge on the south side of Grimes Creek, the Coon Dog No. 9 adjoining the No. 1 on the east. The No. 4 and No. 11 claims are on the steep upper slope of the Payette Canyon, the No. 4 claim on the east side of the No. 11. The main workings on the Coon Dog No. 1 are almost 100 feet above Grimes Creek and the Coon Dog No. 9 about 300 feet above the creek. The workings on the Coon Dog No. 4 and No. 11 claims are about 450 feet below the Grimes Creek-Payette divide. The workings on the Coon Dog No. 1 claim comprise a tunnel nearly 500 feet long with short drifts on different lodes.[27] On the Coon Dog No. 9 there are about 650 feet of drifts and crosscuts,[28] and several short tunnels (250 feet of workings in all) on the Coon Dog No. 4. The caved tunnels of undetermined length, one 75 feet above the other, are on the Coon Dog No. 11 claim.

HISTORY

Little data are available on the discovery and history of development of the group of claims. From 1903 until the group was taken over by the Diana Mines Co. in 1915 the assessment and development work was done by J. H. Ballinger. Some work was carried on at the No. 1 and No. 4 claims by the Diana Mines Co. for a year or two after 1915, but nothing more was done until 1922, when the main work was transferred to the Coon Dog No. 9. Annual assessments were performed thereafter, and in 1936 the claims were taken over by the Grimes Homestake Gold Mines Consolidated and the workings on the No. 9 claim partly rehabilitated.

During 1916 several cars of ore were shipped from the Coon Dog No. 1,[29] but no other records of production were obtained.

STRUCTURAL RELATIONS

A number of prominent fissure zones containing lodes cross the property, each of them striking about N. 70° E. and dipping 50° to 60° SE. These fissures and lodes cut across rhyolite and rhyolite porphyry dikes, which are rather closely spaced locally and which trend N. 20°–

[27] Jones, E. L., Jr., op. cit., pp. 109–110.
[28] Ballard, S. M., ap. cit., pp. 90–91.
[29] Jones, E. L., Jr., op. cit., 109–110.

30° E. On the Coon Dog No. 1 the 500-foot crosscut is reported to have cut 5 lodes, ranging from 18 inches to 7 feet in width, some of them in rhyolite and some of them in the granitic rock of the batholith.[30] According to Jones, the first lode, 84 feet from the portal, was 4 feet thick and was drifted on for 60 feet on both sides of the crosscut. Another lode about 280 feet from the portal was about 3 feet thick, and another 330 feet from the portal had in places 2 feet of high-grade ore from which shipments were made. Two other lodes are reported to lie beyond.

Some of the lodes on the Coon Dog No. 9 are probably continuations of those on the Coon Dog No. 1. These are reported to cut a wide rhyolite porphyry dike. The adit is along the main fissure zone for 250 feet but for the remaining 400 feet is driven in the more solid footwall with crosscuts through the lodes at regular intervals.[31] According to Ballard the crosscuts show 12 inches of ore in the hanging wall and then progressively toward the footwall 2 feet of lower grade ore, several feet of shattered rhyolite porphyry with small ore seams, 12 inches of good ore, 10 to 12 feet of sheared and altered porphyry containing ore seams in fractures, 5 feet of partly sheared but unmineralized lamprophyric dike, 3 to 4 feet of fractured and altered porphyry containing ore seams, 12 inches of low grade ore, and a greater thickness of sheared and altered rock with scattered ore seams. A single lode is exposed on the Coon Dog No. 4, but there may be others. In the one lode the fracture zone is about 10 feet wide.

MINERALOGY

The lodes belong to the base-metal type but differ among themselves in the proportions of different metals, particularly copper. In all of them much of the ore consists of massive sulfides in more or less compact seams, lenses, and nodules, concentrated in small lenticular shoots. In most places the sulfide masses have been somewhat fractured, in places rather extensively brecciated, and the fragments cemented or caught in a matrix of younger quartz and a little auriferous pyrite and free gold. On the Coon Dog No. 1 the dominant sulfide is chalcopyrite, which, however, is accompanied by considerable pyrite and sphalerite and a little galena and tetrahedrite. Some of the ore is severely brecciated and contains considerable quartz younger than the sulfides. The ore on the Coon Dog No. 9 shows considerable chalcopyrite, as well as tetrahedrite, pyrite, sphalerite, galena, and locally much young quartz. On the Coon Dog No. 4 the ore consists largely of tetrahedrite and chalcopyrite but has also a little pyrite, sphalerite, and galena and scant amounts of quartz and carbonate. The ore on the dumps at the caved portals of the two tunnels on the

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30 Jones, E. L., Jr., op. cit., pp. 109–110.
31 Ballard, S. M., op. cit. pp. 90–91.

Coon Dog No. 11 contains mostly pyrite but shows some tetrahedrite. Along some of the lodes a considerable part of the ore is incorporated in thick bands of gouge.

The ore contains appreciable amounts of gold and silver as well as base metals. According to Jones,[32] assays in the second lode on the Coon Dog No. 1 gave returns of $2.70 in gold (old price) and 11 ounces in silver to the ton and 12 percent of copper; whereas assays of two carload lots of ore from the third lode showed 0.12 ounce of gold, about 14 ounces of silver, about 5.2 percent of copper, and about 7.1 percent of zinc. From the first ore shoot on the Coon Dog No. 9 Ballard[33] reports an assay of 0.10 ounce of gold and 19.5 ounces in silver to the ton, 16 percent of lead, 13.2 percent of zinc, and 10.8 percent of copper. A selected mixture of sulfides collected by the writer at the Coon Dog No. 4 gave 0.54 ounce in gold and 102.2 ounces in silver per ton, but the sample can not be regarded as representative.

INDEPENDENCE GROUP

The Independence group lies partly on the divide between Grimes Creek and the Payette River, partly along Grimes Creek, and partly in the Payette Canyon along the north and west side of the Coon Dog group. The group was acquired by the Independent Mine Syndicate and actively worked in 1926, but operations have since been at a standstill. The property then comprised 14 unpatented claims and had been developed by three tunnels and two shafts, all of which were inaccessible when the district was studied from 1932 to 1934 and when it was revisited in 1938. One of the tunnels is reported to be 200 feet long, another 300 feet long, and the third 720 feet long. These tunnels are across the creek from the Coon Dog No. 1 claim and penetrate the low divide that separates Grimes Creek from the Payette Canyon. The main shaft is inclined and is on Grimes Creek several hundred yards above the portals of the tunnels. The shaft is reported to be 100 feet deep and to have a drift about 200 feet long at the bottom. Some ore mined in the early days from the outcrop and from shallow depths was treated locally in an arrastre. Some ore was mined from the shaft bottom and from the lower tunnels, but the amount of ore mined and its value was not learned.

Two parallel lodes about 300 feet apart are known to cross the group, each of which strikes about N. 70° E, and dips about 65° SE. These lodes cut across rhyolite porphyry dikes but are otherwise contained in the granitic rock of the Idaho batholith. It is reported that the fracture zone occupied by the main lode is as much as 18 feet wide and in the shaft has 26 inches of ore along the hanging wall and about 18 inches along the footwall with fractured rock and ore seams

[32] Jones, E. L., Jr., op. cit., p. 110.
[33] Ballard, S. M., op. cit., p. 92.

between. The fracture zones apparently possess great length and are more or less persistently mineralized throughout.

The ore in the bins at the shaft and at the tunnel portals is alike, and most of it consists of base metals, particularly pyrite, sphalerite, and galena, but contains some microscopic chalcopyrite and tetrahedrite and minor amounts of quartz and calcite. The ore is somewhat more siliceous than in most base-metal lodes and includes some early fine-grained quartz largely replaced by sulfides and much larger amounts of young quartz, which has penetrated the sulfide filling and has incorporated much of it as widely spaced breccia inclusions. Some of the ore is cut by widely spaced seams of calcite. Random ore collected at the bins assayed 1.35 ounces in gold and 4.3 ounces in silver per ton.

MISSING LINK GROUP

The Missing Link group is about 1½ miles northeast of Grimes Pass along the upper slope of the Payette River Canyon, just under the Grimes Creek divide. It adjoins the Independence group at the west and is supposed to cover the continuation of the lodes exposed on the Independence ground. In 1932 exploratory work was carried on in two tunnels about 200 feet apart on separate lodes, one of the tunnels having been driven more than 200 feet.

The lodes occupy exceptionally pronounced shear or fracture zones that trend east-northeast, alined approximately with lodes on the Independence group. Each of the fracture zones is about 24 feet wide and is contained in bodies of rhyolite porphyry. The lodes consist of the fractured, intensely sericitized porphyry, in which pyrite is abundantly disseminated and present also in small seams and veinlets. Both lodes have been considerably disturbed by faulting, and some of the pyrite has been thoroughly crushed and ground up in the gouge.

HOMESTAKE GROUP

The Homestake (Fulland) group is in sec. 13, T. 8 N., R 5 E., some distance up the slope on the south side of Grimes Creek, about 2 miles northeast of Grimes Pass. The group comprises 17 claims owned by the Grimes Homestake Gold Mines Consolidated. The company was incorporated in July 1936 and has in addition to the Homestake group of claims several other groups, which total 45 claims in all, plus 14 more held under option. When the Homestake group was visited in late July 1938 the development consisted of 730 feet of workings in one tunnel, and work was under way on another several hundred feet above.

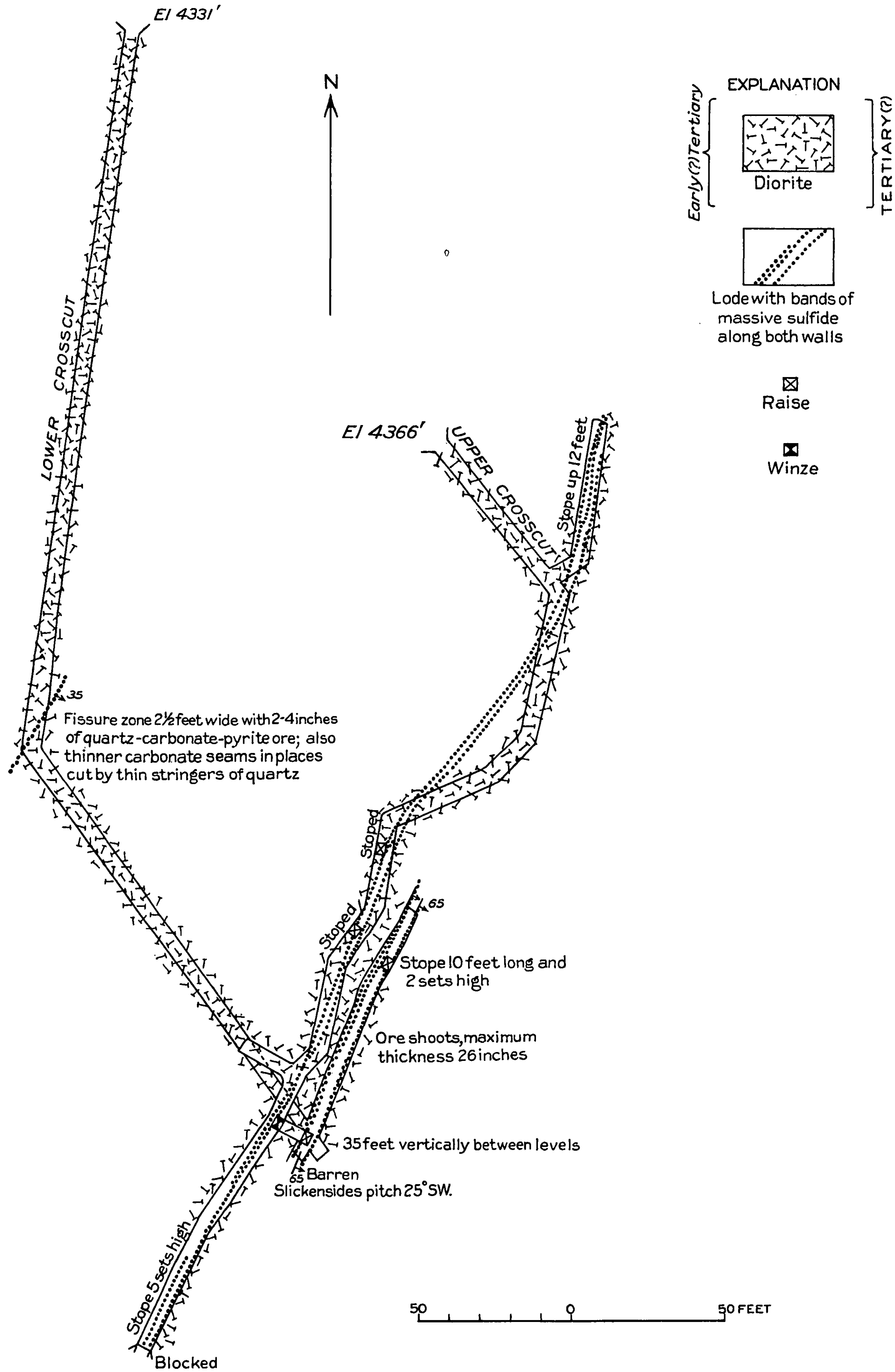
Numerous mineral-bearing fissure and fracture zones cut rhyolite porphyry dikes and the granitic rock of the batholith and are in turn cut by lamprophyric dikes. The distribution and structural relations of the dikes and fissure and fracture zones are shown in plate 53, and the reader is referred to the figure for specific details. In some places mineral-bearing fractures lie alongside dike contacts, but most of the ore is in well-defined fissures that trend approximately N. 70° E. and dip rather steeply southeast. One strikes west-northwest. As many as 7 of the fissures are exposed in the underground workings. Some contain narrow ore shoots 10 to 20 feet long and 6 inches to 2 feet wide, the ore occurring in bunches, seams, and stringers. In places the fissure zones are as much as 4 feet wide, but none is mineralized the full width. The lode exposed in the upper tunnel is like those exposed below, except that the ore is oxidized. It occupies a prominent fissure zone about 4 feet wide, which strikes N. 70° E. and dips 70° S. and apparently lies along the contact of a rhyolite porphyry dike. The distribution of the small ore shoots along these lodes appears to conform with strike and dip changes, and slickensided surfaces reveal that movement along the fault zones has been essentially in a horizontal direction. All the lodes contain considerable gouge, and appreciable amounts of ore are invariably enclosed in the gouge. The walls are intensely sericitized.

The ore seams and stringers are composed for the most part of sulfides, principally pyrite and sphalerite, but in places there is some galena and tetrahedrite. Some seams and stringers of younger quartz that contain widely scattered crystals of auriferous pyrite and free gold are also present.

PENCE LEASE

The Pence lease is on the German-American claim held by the Grimes Homestake Gold Mines Consolidated and lies east of the Homestake group. Some work had been done on the claim a number of years ago, but the old workings had caved, and the Grimes Homestake Gold Mines Consolidated was forced to drive new tunnels. When visited in 1938 there were two tunnels, one with about 195 feet of workings and the other on a different lode with an adit drift about 115 feet long. Ore was being trucked to and treated at the mill of the Mineral Mining Co. in Charlot Gulch. Production data were not available.

Only two of the series of 4 or 5 approximately parallel lodes spaced over a distance of about 1,000 feet have been opened underground. The one on which there was 195 feet of workings occupies a prominent fissure zone that strikes about N. 70° E. dips 50° SE. in the granitic rock of the batholith. The lode is 1 to 2 feet wide, the average width ranging between 1½ and 2 feet, and contains some sulfide pods in a gougy matrix and numerous short discontinuous quartz seams and stringers ½ to 1½ inches thick in the fractured rock. Some early crushed pyrite occurs as black streaks in the gouge, but there is also



SKETCH MAP OF THE SILVER GEM MINE, BOISE BASIN, IDAHO a white and light-gray gouge, which contains younger uncrushed pyrite crystals and is cut by some short discontinuous pyrite seams. Much of the quartz, pyrite, and gold is apparently younger than much of the gouge. The few sulfide pods and bands contain pyrite, galena, sphalerite, and tetrahedrite. The ore treated in the mill is reported by D. A. Walton, secretary and manager of the Grimes Homestake Gold Mines Consolidated, to carry 1 to 2 ounces of gold per ton. The rock along the lode has been widely and intensively sericitized and has some disseminated pyrite.

The other lode opened by the 115-foot adit drift and known as the Gold Vein No. 1 lies about 200 yards to the north. The lode shares a prominent fracture zone with a dark lamprophyric dike and trends slightly north of east and dips 50° to 55° S. The fractured zone is about 10 feet wide, and the dike occupies the central part, intruded squarely along the middle of the lode. Ore occurs on both sides of the dike, the more abundant ore on the hanging wall side. The ore is composed of quartz and minor amounts of pyrite (represented in most parts of the lode by leached vugs) and forms a band 4 to 12 inches thick. Near the face 2 feet of hardened gouge lies along the footwall of the dike.

GRAY EAGLE MINE

The Gray Eagle mine, known also as the Shepard lease, is in unsurveyed sec. 6, T. 8 N., R. 6 E., on the south side of Grimes Creek, about midway between the Independence shaft and the Branson ranch. It is one of the properties in the Grimes Pass area absorbed by the Grimes Homstake Gold Mines Co. Since 1936 a small amount of ore has been marketed from it. The workings comprise between 500 and 600 feet of tunnels, but in 1938 only the main tunnel with about 290 feet of workings was open.

Several lodes are known to cross the property, but most of the work has been confined to a single one, which strikes about N. 60° E. through a body of rhyolite. Both the strike and dip of the lode are somewhat variable, the strike varying from N. 60° E. to N. 70° E. and the dip from 55° to 45° SE. The ore appears to be localized in lenses where the changes in dip and strike are most pronounced, particularly where the dip flattens. The average thickness of the lode is 6 to 14 inches, but in the flats the lode swells to 3½ feet. The ore lenses are 10 to 12 feet long and in two places reach a maximum thickness of 3½ feet. The lenses contain appreciable amounts of base metals, particularly galena and pyrite, and lesser amounts of sphalerite and tetrahedrite. They are penetrated by thin seams of quartz containing scattered crystals of auriferous pyrite. The ore is valued chiefly for its gold, which is confined to the younger seams of quartz and pyrite.

ENTERPRISE GROUP

LOCATION AND DEVELOPMENT

The Enterprise group, held under lease and bond by the Mineral Mining Co. from 1919 until the early thirties, lies in Charlot Gulch, in sec. 24, T. 8 N., R. 5 E., a little less than 2 miles east of Grimes Pass. The group, formerly known as the Ingle, was worked as early as 1902, at which time there were three tunnels, each driven 800, 1,100, and 1,200 feet on the lode and connected by raises.[34] The ore could not be successfully treated at the mill at that time, and after a short run the mill was closed down and development work discontinued until the property was acquired by the Diana Mines Co. in 1915. This company reopened the old workings, rehabilitated the mill, and began work on a lower tunnel, the No. 4. In 1919 the Mineral Mining Co. acquired possession of the property and began a long prospect tunnel from the west of the group far down the gulch.[35] This tunnel, the No. 5, passed about 110 feet below the No. 4 tunnel, and in 1930 had a length of about 1,200 feet, joined to the No. 4 by raises. A 100-ton concentrator completed in 1925 proved unsatisfactory and was dismantled and changed for fine grinding and flotation. The mill was finally adjusted in 1930, and considerable ore was treated. A large amount of development was done in 1931, the mill was run intermittently, and some high-grade concentrate was shipped. The property was then idle until 1934, when a winze was sunk from the No. 5 level. Since then the mill has been doing custom work. When the property was examined the No. 4 and No. 5 levels were partly open. All the ore had been stoped above the No. 5. Production records were not available.

STRUCTURAL RELATIONS

The development has been confined to a single lode, which lies on the north side of the quartz monzonite porphyry stock in a prominent fissure zone in intensely sericitized granitic rock. Several rhyolite, rhyolite porphyry, and quartz monzonite porphyry dikes of north-northeast trend are nearby, but it is not known whether they are exposed underground or are cut by the lode, which trends about N. 70° E. and dips 45° or more to the southeast.

Where the lode has been exposed by sluicing at the caved portal of one of the upper tunnels it is contained in an iron-stained and copper-stained zone about 20 feet across. The average thickness of the lode, however, is said to be about 40 inches, though locally it may be several times as thick. In it occur quartz and sulfide lenses, but in places the sheared and fractured hanging wall is reported to con-

[34] Jones, E. L., Jr., op. cit., p. 108.
[35] Ballard, S. M., op. cit., p. 81.

tain disseminated ore minerals as far as 20 feet from the main fissures.[36] The ore otherwise tends to occur as compact seams, lenses, and kidney-shaped masses along the main fissure. Most of the individual seams and ore masses are several inches thick. Much gouge lies along the walls, and in it are numerous rounded boulders of ore. The principal ore shoot was about 400 feet long.

MINERALOGY

Most of the ore recently mined consisted of intensely sericitized rock with irregularly disseminated sulfides and compact seams and nodules, and locally small quartz lenses and stringers. The sulfides include chiefly galena, sphalerite, and pyrite, and minor amounts of tetrahedrite and galena, in part associated with scant auriferous quartz and carbonates. Some of the ore is coarse-grained, some fine-grained, and some is crushed and ground up in the gouge. Much of the quartz is younger than the sulfides and in part occurs as fine-grained druses in open clefts. The ore contains an average of 0.25 ounce of gold per ton, but the gold content is higher in the more siliceous ore. According to Ballard a quartz-pyrite shoot that overlapped a lead-zinc shoot in the upper workings was particularly rich in free-milling ore throughout the oxidized zone. He points out further that auriferous pyrite from such shoots was the source of much of the gold obtained from upper parts of the lode.[37]

TENOR OF THE ORE

The tenor of the ore based on smelter returns, is indicated in the following table.

	Tonnage	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)	Lead (percent)	Zinc (percent)
1930						
Apr. 30	27.964	1.68	15.6	0.45	25.26	6.4
July 9	38.197	2.36	14.5	.4	21.5	5.2
Aug. 4	45.581	3.13	13.9	.48	19.9	5.7
Aug. 20	38.921	2.14	11.55	.55	16.05	7.35
Sept. 9	25.843	1.98	9.9	.58	12.3	6.7
Nov. 21	13.048	1.4	10.65	.45	16.05	7.35

BABY WORKINGS

The Baby workings are on the Enterprise group near the top of the ridge, about 1,500 feet east-northeast of the workings described above. The development includes a 125-foot shaft and drifts of undetermined length. The workings are old and were not accessible when the property was visited. The lode is supposed to be a continuation of the one described above. According to Ballard, the shaft, which

[36] Jones, E. L., Jr., op. cit., p. 108.
[37] Ballard, S. M., op. cit., p. 83.

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was sunk in the lode, exposed considerable quartzose ore containing galena, some of which still remains on the dump. The drifts uncovered an ore shoot 110 feet long and 3 feet wide.[38]

MOHAWK GROUP

The Mohawk group, in Mohawk Gulch, a tributary of Charlot Gulch, adjoins the Enterprise group on the north. It contains a lode discovered in 1914, which was opened by a short discovery tunnel on the outcrop, a lower crosscut tunnel 100 feet long, and short drifts on intermediate levels. The workings were inaccessible when the property was visited. Some ore had been mined and milled, but the total production was not learned.

The fissure zone occupied by the lode strikes about N. 70° E. and dips about 60° SE. It lies near rhyolite and quartz monzonite porphyry dikes of more northerly trend but apparently is wholly in the granitic rock of the batholith. The fissure zone has been drifted on for 75 feet and has disclosed a quartz lens about 55 feet long and 3½ feet wide.[39] In the outcrop the ore consists of iron-stained, honeycombed quartz with free gold and remnants of residual sulfides, but the ore on the 50- and 100-foot levels is reported to be unoxidized. Some ore still on the dump of the lower tunnel is composed largely of quartz, with large shattered and broken granules of sphalerite and pyrite and lesser amounts of tetrahedrite, chalcopyrite, and galena. It is reported that 100 tons of ore mined near the surface was treated in a 2-stamp mill on Grimes Creek and yielded $22 to the ton on the plates.[40]

OVERLOOK GROUP

The Overlook group is in unsurveyed sec. 19, T. 8 N., R. 6 E., on a tributary of Charlot Gulch, about half a mile east of the Enterprise group at an altitude of about 6,200 feet. The workings comprise a crosscut 225 feet long with a 165-foot drift on a lode about 120 feet from the portal. From the drift are two short crosscuts, one 18 feet long and the other 35 feet long, driven to explore the entire fracture zone. Some stoping had been done, and a small pile of ore was on the dump. Data concerning past production were not obtained.

The fracture zone containing the lode strikes about N. 70° E. and dips 40° SE. It also contains a lamprophyric dike, which was intruded in and along the lode. Rhyolite, rhyolite porphyry, and quartz monzonite porphyry dikes are numerous in the vicinity of the lode, and a 30-foot quartz monzonite porphyry dike is cut near the far end of the crosscut. The mineralized fracture zone, however, is in the granitic rock of the batholith. This fracture zone is about 22 feet

[38] Ballard, S. M., op. cit., p. 86.
[39] Ballard, S. M., op. cit., p. 86.
[40] Jones, E. L., Jr., op. cit., p. 109.

wide at the crosscut and contains small pockets and shoots of ore 2 to 10 inches thick. Away from the crosscut the ore disappears, and marks of hydrothermal alteration gradually fade away. The lamprophyric dike has been somewhat bleached and in places contains fragments of ore. Near the crosscut the dike is about 12 feet wide, but along the drift it becomes larger and fills the entire fracture zone.

The ore in the lenses and pockets has about as much quartz as sulfides. The latter consist of nearly equal amounts of pyrite, sphalerite, chalcopyrite, tetrahedrite, and galena. The sulfides are coarse-grained and are in part a replacement of a somewhat earlier coarse-grained quartz and in part a replacement of the altered granitic rock. In most of the ore the sulfides have been more or less thoroughly brecciated and then cemented by moderately coarse-grained to coarse-grained white quartz, which has a notable gold content. In places the quartz-sulfide ore is cut by thin seams of calcite.

SMUGGLER GROUP

The Smuggler group is in Charlot Gulch below the Enterprise, about 1¼ miles east of Grimes Pass. No work had been done on the property for a number of years, and none of the workings, which include a tunnel and shaft with 1,400 feet of crosscuts, drifts, and raises, were accessible. Considerable ore has been mined, and some sacked ore still remains on the dump. Records of production were not obtained.

The fissure zone occupied by the Smuggler lode is said to parallel the Enterprise and Mohawk. Two ore shoots are reported, one, encountered at a depth of 65 feet, is 120 feet long and as much as 3 feet wide and the other at a depth of 100 feet is 70 feet long and as much as 2 feet wide.[41] The shoots are apparently composed of massive sulfides, as ore on the dump consists largely of galena, pyrite, and chalcopyrite and lesser amounts of sphalerite and tetrahedrite. The sulfide masses are compact and are enclosed in intensively sericitized granitic rock. Neither early nor late quartz appeared in the ore examined.

ADER PROPERTY

The Ader property, comprising the St. Clair group of claims, is in sec. 25, T. 8 N., R. 5 E., in Ader Gulch, a tributary of Charlot Gulch, about 1¼ miles east of Grimes Pass. The group has been prospected for a long time, and a number of mineralized fissures and fracture zones have been exposed in short tunnels directed into the slopes on each side of the gulch. Three very crooked tunnels penetrate the slope on the northeast side of the gulch at points 60 to 80 feet apart, spaced vertically at levels of 10 to 20 feet, and four others are driven into the base of the slope across the creek. These workings total in the aggregate about 1,000 feet of crosscuts and drifts.

[41] Ballard, S. M., op. cit., p. 86.

The property lies near the center of the large quartz monzonite porphyry stock and along the course of a swarm of rhyolite porphyry dikes, most of which trend about N. 10° E. but a few N. 70° E. The property is in a part of the "porphyry belt" where the post-dike fracturing and fissuring has been particularly intense. The porphyries have been complexly sheared over a broad zone of undetermined size and trend, and the fractures and fissures are comparatively closely spaced. The most prominent ones strike about N. 10°–20° E., and N. 70° E. and the more subordinate ones N. 30°–40° E. and N. 10°–20° W. All fractures dip westward, the prominent ones at angles as low as 10° and the subordinate ones at angles between 35° and 60°. The individual fracture and fissure zones range from a few inches to 4 feet in width. Those striking N. 10° E. are the widest, contain the most ore, and have the thickest bands of gouge. The set trending N. 10° E. about parallels the rhyolite porphyry contacts and crosses the set trending N. 70° E., which also contains appreciable amounts of ore. Along the more prominent fissure zones the ore tends to occur as scattered sulfide seams and stringers, locally as lenses from a few inches to as much as 18 inches thick and 20 to 30 feet long. In some places the ore is also disseminated for short distances in the wall. The wall rock is everywhere altered. In places it is intensively sericitized and locally more or less thoroughly silicified and impregnated with pyrite.

Most of the ore is the base-metal kind, but it also has appreciable, and in places, apparently considerable amounts of gold. The base-metal minerals include galena, sphalerite, pyrite, tetrahedrite, and chalcopyrite. The galena is everywhere most abundant, but locally the tetrahedrite is also notably conspicuous. In places the sulfides have been brecciated and cemented by late-stage quartz and by pinkish carbonate. In some of the fissures the young quartz is the most abundant mineral, and the gold content is relatively high. In places the younger quartz occurs in separate seams and stringers, in part accompanied by small cubes of pyrite. Some random samples of galena and other sulfides were assayed to determine associated gold content and showed 0.92 ounce in gold per ton and 17.8 ounces in silver. Free gold has been observed with the young quartz, and also on fracture surfaces of the jointed country rock.

The abundance of the fissure zones and the complexity of the fracturing and fissuring are difficult to describe without detailed structural maps of the underground workings. The tunnel farthest up the gulch on the northeast side of the creek is driven along a conspicuous fissure zone about 2 feet wide, striking N. 20° E., which contains bands and stringers of sulfides, mainly galena, the individual bands being as much as 6 inches thick. The tunnel passes diagonally across the fracture zone and in the next 140 feet crosses three minor fissure zones, one striking N. 35° E. and the other two striking N. 10° E. The first contains little ore; the second has 12 inches of crushed rock and gouge fringed by sulfide stringers for several feet on each side, and the third has sulfides scattered through a zone 6 to 12 inches wide. One hundred and forty feet from the portal the tunnel crosses another prominent lode striking N. 10° E., which lies in the footwall of a rhyolite porphyry dike. This lode is exposed by drifts on both sides of the crosscut, and locally as much as 18 inches of sulfides, mainly galena, is exposed. Elsewhere the lode is but 8 to 12 inches wide, and the ore is in smaller seams and stringers. The south drift passes into the footwall of the lode and exposes other fractures and fissures, some of which strike N. 10° E. Each of the fissures shows variation in dip, and some of them are notably flat.

The second tunnel lies about 80 feet from the first and about 20 feet lower. It explores the lode on which the first tunnel was started and is driven along the lode for 90 feet. For most of the distance the lode is 3 to 4 feet wide and contains sporadically scattered ore seams. The lode lies along the contact of a rhyolite porphyry dike of the same trend, but most of the fracturing has occurred in the bordering quartz monzonite porphyry. The third adit is about 60 feet from and 10 feet below the second. It curves and passes a few feet under the other workings and, therefore, prospects the same ground. It, however, reveals some additional mineralized fractures, most of which strike N. 70° E. In all, 10 prominent lodes are exposed on this 340-foot tunnel. Most of the lodes are 2 to 3 feet wide and contain thin sulfide seams and stringers.

Of the four tunnels across the creek, only one was open when the property was visited. It extended into the slope for 100 feet. A quartz-sulfide vein about 6 inches thick, contained in a much broader fracture zone, was exposed in the face. This fracture zone belonged to the set trending N. 10° E. In one of the other tunnels on the same side of the creek Ballard [42] reports a fractured zone about 45 feet wide, which had 12 parallel quartz veins 4 to 25 inches thick spaced 3 to 5 feet apart. He states that free gold was visible in fractures in the quartz.

J. S. MINE

The J. S. mine is in sec. 22, T. 18 N., R. 5 E., at the head of Muddy Creek, about half a mile southwest of Grimes Pass. The workings are shallow and comprise several short tunnels, shafts, and open cuts. In 1934 the work was confined to an 85-foot shaft from the bottom of which short crosscuts and drifts had been driven. Mining has been confined largely to the oxidized ore, which has been treated by stamp amalgamation.

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[42] Ballard, S. M., op. cit., pp. 87–88.

Two lodes about 35 feet apart are alined along fracture zones striking N. 40° E. and dipping 70° SE. in the quartz monzonite porphyry. The lodes are about 10 feet wide on the surface, and each has a conspicuous gossan cap. The lode nearest the shaft has 1 to 4 feet of ore made up of iron-stained seams in intensely sericitized quartz monzonite porphyry, the minable ore confined to small shoots, or pockets, each individually rich. Some of the ore shoots exposed near the bottom of the shaft were apparently localized by northwest fracture intersections. One chimneylike shoot had a strike of N. 30° W. and a dip of 45° NE. The underground workings had not extended to the second lode, which was reported to comprise 4 feet of sericitized porphyry heavily impregnated with pyrite and containing a little sphalerite.

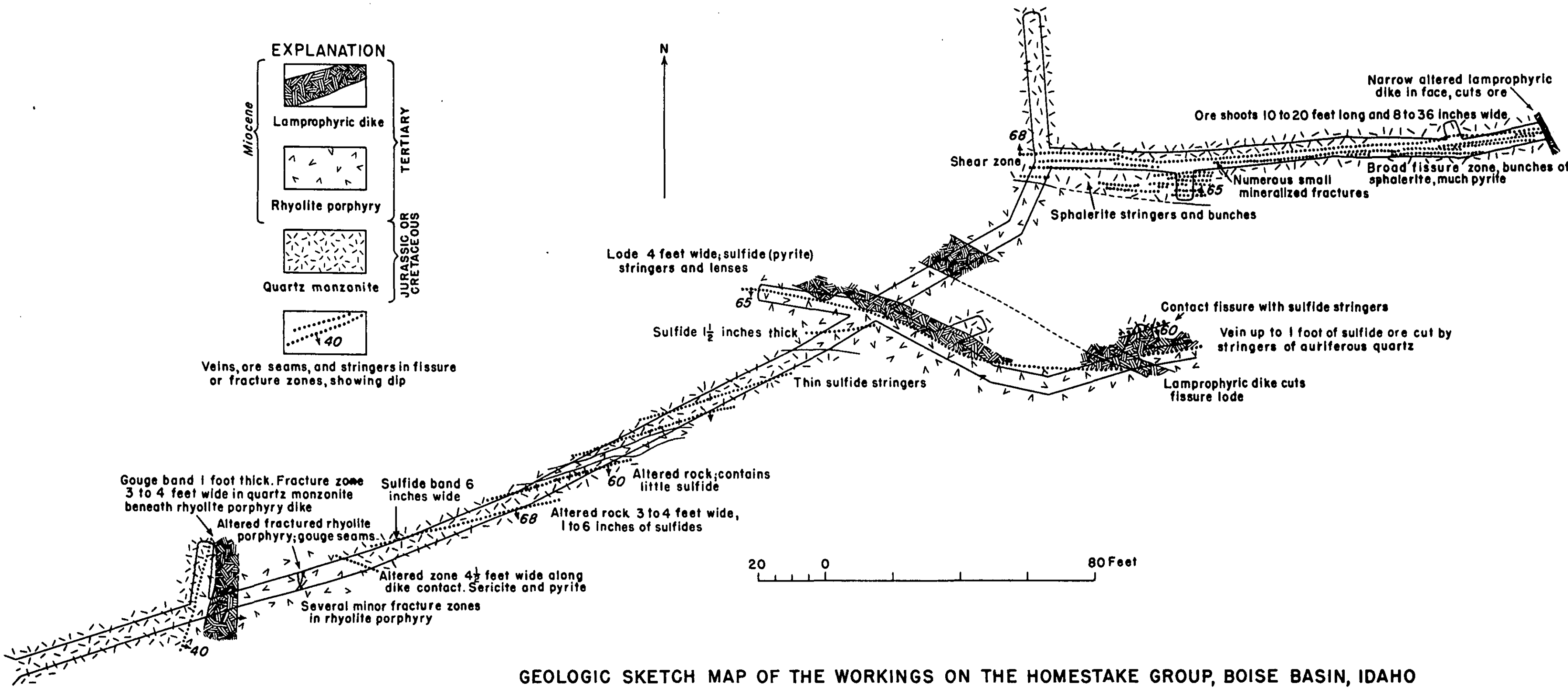
BLACK JACK PROSPECT

The Black Jack prospect is in unsurveyed sec. 17, T. 8 N., R. 6 E., on Grimes Creek about a mile above the power plant. Two lodes have been exposed in surface cuts and in short tunnels, one on the steep bank on the southeast side of Grimes Creek and the other a short distance from the creek on the north side.

The two lodes are quite dissimilar in structural relations and in substance. The one on the southeast bank strikes N. 10° E. and occupies a broad fracture zone in the quartz monzonite porphyry stock near its contact with the Idaho batholith. The other strikes N. 70° E. and lies in the batholith.

The first lode extends diagonally across Grimes Creek but has been prospected only on the slope on the southeast side. It is especially well exposed in several cuts on the rocky slope 50 feet above the creek and in a short crosscut at creek level. The lode is about 15 feet across, dips about 55° SE., and occupies a crush or breccia zone in the porphyry. It is unmarked by well-defined slippage planes, or bands of gouge. The ore occurs throughout the shattered rock as a filling of fractures and as a replacement of the rock fragments; much of it forms sulfide seams, stringers, lenses, and small pockets. Most of the ore seams are no more than 2 to 3 inches thick nor more than a few inches long, but in places the seams swell into irregular masses a foot or more across. The ore is distributed throughout the breccia zone and is sufficiently abundant to be regarded as mill feed, with much ore that could be hand sorted. The length of the ore body has not been fully determined, but the lode may be traced along the surface for at least 100 feet. The rock in and along the lode has been considerably altered and contains some chlorite and epidote, scant pyrite, and much sericite and especially quartz. Silicification has been by far the most prominent process of alteration.

The ore seams in the shattered porphyry are composed of compact, massive sulfides, principally dark brownish sphalerite and coarse



GEOLOGIC SKETCH MAP OF THE WORKINGS ON THE HOMESTAKE GROUP, BOISE BASIN, IDAHO

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OFFSET

cubical galena, each about equally abundant, and minor amounts of pyrite and chalcopyrite and here and there microscopic grains of tetrahedrite. Quartz in part earlier and in part later than the sulfides is present in only minor amounts. The chief gangue is the silicified porphyry. Some of the early quartz is coarse, drusy, and in places crusted with sulfides, but in most places the quartz, as well as the silicified porphyry, is replaced by the sulfides. The younger quartz is not as abundant as the earlier and has penetrated the sulfides in only a few places. The sulfides occur in the outcrop, along with minor amounts of greenish pyromorphite. The lode has escaped postmineral faulting, and the ore, therefore, is frozen firmly in place.

The second lode is exposed in cuts and in a 100-foot crosscut. It occupies a prominent fissure zone about 15 feet wide. This zone dips 35° SE. and holds 6 inches to 3 feet of quartz along the hanging wall and has crushed rock and gouge with rolled boulders of vein matter and altered country rock extending from the hanging wall to the footwall. The quartz contains scattered grains of galena and also a few grains of sphalerite, pyrite, and chalcopyrite. There has been an exceptionally large amount of intermineralization movement, particularly along the footwall. There the rock has been reduced to a thick band of gouge.

BRANSON PROSPECT

The Branson prospect is in unsurveyed sec. 7, T. 8 N., R. 6 E., on the north side of Grimes Creek about a mile above the Branson ranch. Several short tunnels and some surface cuts have exposed two narrow parallel lodes which strike about N. 30° E. and dip steeply southeast. One of the lodes is in a rhyolite dike, the other in sheared and altered rock of the Idaho batholith. Both lodes contain thin quartz seams in considerably fractured and sericitized rock. The quartz appears to be the younger crystalline variety and holds a few small widely scattered crystals of pyrite.

SILVER STAR MINE

The Silver Star mine is in sec. 16, T. 7 N., R. 4 E., on the West Fork of Granite Creek, just below the Mayflower group, about 2 miles west of Placerville. The development comprises open cuts and a 60-foot shaft and drifts, but the workings had not been reopened after the 1931 forest fire. It is reported that the lode was mined to a depth of 45 feet and was drifted on for a distance of several hundred feet.[43] The production was not learned.

The lode is in the batholith and strikes about N. 30° E. The upper part is reported to have contained small sulfide stringers, which united about 45 feet below the surface to form an ore body about 3 feet

[43] Ballard, S. M., op. cit., p. 71.

wide enclosed between well-defined walls, but the width decreased to 2 feet of compact sulfides at the bottom of the shaft.[44] The ore is in part a fissure filling and in part a replacement of the altered wall rock. Hydrothermal alteration has been particularly intense and widespread, and the rock on each side of the lode is thoroughly sericitized and impregnated with pyrite.

Ore on the dump and trapped in sluice boxes below the dump consists largely of pyrite but contains some sphalerite and galena and microscopic grains of tetrahedrite and chalcopyrite. Some of the sulfides form well-shaped crystals in open spaces, particularly on early quartz crystals. A minor amount of calcite occurs in thin widely spaced seams cutting the sulfides.

CROWN POINT PROSPECT

The Crown Point prospect is in sec. 20, T. 7 N., R. 4 E., on the steep slope on the south side of Canyon Creek, about a mile below the Mountain Chief mine. It lies several hundred feet above the road and creek bottom not far above the mouth of the canyon and is reached by steep trail. The prospect has not been extensively developed, and the workings comprise several open cuts and a short tunnel, all on a single lode.

The lode occupies a fairly prominent fissure zone in the batholith and strikes about N. 70° E. and dips 45° SE. It is made up of lenses, seams, and stringers of quartz and barite accompanied by scattered granules of sulfides, principally tetrahedrite and sparse amounts of arsenopyrite, pyrite, sphalerite, chalcopyrite, and galena. The filling ranges from a few inches to a foot in thickness and exceptionally is 2 feet thick. In places quartz predominates; in other places the filling consists largely of coarsely crystalline barite. Along the widest part of the lode the barite forms a central band about 12 inches thick between walls of coarsely crystalline comb quartz. In places the quartz is drusy, and the crystals in the druses are as much as an inch long. The sulfides, except the arsenopyrite, are older than the quartz and barite and occur as detached fragments scattered through the quartz and barite filling. The tetrahedrite is somewhat argentiferous. The gold content of the ore is apparently very low. Surficial alteration has been shallow, and, although the outcrop is somewhat leached in places, silver enrichment has been of no consequence.

HARTFORD MINE

The Hartford mine is in sec. 3, T. 7 N., R. 4 E., in China Gulch, a tributary of Wolf Creek, about 1¾ miles northeast of Quartzburg. Some work was done a few years ago, but the property was generally inactive until 1934, when a little drifting was done underground and

[44] Ballard, S. M., op. cit., p. 71.

a small mill erected. The property has been developed by numerous surface cuts and short tunnels, none of which have extended more than 60 feet below the surface. Records of recent and past production were not obtained.

The mine is located well within the "porphyry belt," and the workings have disclosed several lodes in greatly fractured and intensely sericitized rock of the batholith. The lodes are not far from dacite porphyry dikes of general west-northwest and east-northeast trend. Most of the work has been confined to a very prominent fracture zone that strikes N. 70° E., which is in part made up of numerous short individual fractures that strike N. 40° E. and N. 10° E. Because the fracture zones could not be examined satisfactorily underground, the size and distribution of the ore shoots could not be determined. One of the lodes is reported to reach a maximum thickness of 16 feet and to average between 3 and 4 feet.[45]

The lodes appear to consist for the most part of intensely sericitized rock containing coarse flaky sericite grains of exceptionally large size. In places the altered rock is impregnated with rather widely scattered pyrite crystals; but in other places it is cut by thin seams of quartz or by thin seams of tremolite. Some of the quartz in the seams is drusy or forms combs, the surfaces coated with small crystals of pyrite and quartz and pyrite in turn coated with rosette-like crusts of tremolite. In the tremolite seams the tremolite occurs in the form of slender crystals arranged in radiating or rosette-like groups about one-fourth inch in diameter.

SILVER BELL PROSPECT

The Silver Bell (Hiatt) prospect is in sec. 1, T. 7 N., R. 4 E., about 2 miles north of Placerville, on the divide between Wolf Creek and Boyles Gulch. Two lodes have been exposed in several cuts, and one of them is opened by an inclined shaft about 100 feet deep with short drifts at different levels. The underground workings were inaccessible from 1932 to 1934, and observations were restricted to the surface cuts and the small pile of ore on the dump.

The lodes are confined to fracture zones that trend N. 40° E. and dip 65°–70° NW. and cut across bodies of early Tertiary (?) diorite and dikes of Miocene quartz monzonite porphyry. The inclined shaft is on the more southerly of the rather closely spaced lodes, and from it several tons of high-grade lead-silver ore were reported mined from within 35 feet of the surface. The lode is reported to be 4 feet thick in the bottom of the shaft and to contain appreciable amounts of ore.[46] A short crosscut from the bottom of the shaft is reported to have exposed the second lode, which is as large as the first.

[45] Ballard, S. M., op. cit., p. 71.
[46] Ballard, S. M., op. cit., p. 72.

The ore occurs as compact sulfide seams and lenses accompanied by scant amounts of quartz and ferriferous calcite. Sphalerite appears to be the most abundant sulfide in the ore on the dump, but pyrite, arsenopyrite, chalcopyrite, and galena also appear in appreciable quantities. A little of the quartz is older than the sulfides, but most of it, as well as the calcite, was deposited later. The arsenopyrite is not readily detected except as microscopic crystals in polished sections. Although it was introduced with the late quartz, it penetrated extensively into the earlier sulfides.

SAUNDERS MINE

The Saunders (Hiatt) mine is in sec. 6, T. 7 N., R. 5 E., on a tributary of Ophir Creek, not far from the edge of the "porphyry belt." It was being developed from 1932 to 1934, but the workings were not extensive, comprising several cuts on the outcrop and several short tunnels below.

The lode occupies a fissure or fracture zone 1 to 4 feet wide, which strikes N. 40° E. and dips 50° NW. It is made up of fractured, considerably sericitized, granitic rock with small quartz seams and stringers in which are scattered grains of pyrite, arsenopyrite, sphalerite, and galena, and here and there small grains of gold. Two generations of quartz are present. The younger quartz, with which the gold is associated, is the least abundant.

COIN BOND GROUP

The Coin Bond group, formerly the Carroll-Driscoll groups, extends in a northeast direction from the end lines of the Gold Hill mine to Garden Valley pass. It lies 2 to 3 miles north of Placerville. The property was worked in the early days, principally on the Ivanhoe and Capital claims at the head of California gulch. When the property was examined by Lindgren in 1896 there was a shallow tunnel several hundred feet long, which was partly caved when visited by Jones in 1915. At the time of Jones' visit the work was directed by the Coin Bond Mining Co. along a lower crosscut, then 1,450 feet long.[47] In 1922 the Coin Bond Mining Co. was absorbed by the Boise Basin Improvement Co., which also held the Eakin group on the northeast side of the Coin Bond. The Boise Basin Improvement Co. began a new crosscut lower in the gulch to explore the extension of the Gold Hill dike zone in the search of ore bodies of the Pioneer type expected in the rhyolite porphyry dikes. This crosscut was driven 1,280 feet. No work other than that necessary to meet annual assessments was done after 1923, and in 1929 the entire group of claims was taken over by the Penn Mining Co. The tunnels were again rehabilitated, but all work was suspended after the 1931 fire. The

[47] Jones, E. L., Jr., op. cit., p. 104.

Penn Mining Co. now controls 34 unpatented claims having several thousand feet of tunnels, of which the two long crosscuts are the more extensive. Both were blocked in 1932. The upper tunnel is about 1,555 feet long and gains a depth of 160 feet below the outcrop. The other crosscut is 1,280 feet long. Several thousand feet of earlier workings have been permanently abandoned. During the early days $36,000 in gold was recovered from the surface workings, and an additional $27,000 was recovered from the sluiced outcrops.[48]

The group covers an appreciable part of the "porphyry belt" and has within its borders numerous bodies of rhyolite porphyry and some dikes of dacite and quartz monzonite porphyry. Small bodies of diorite are also exposed in the lower crosscut. Jones[49] reports that the upper tunnel passed through a shear zone 135 feet across, which contained several lodes in zones of more intense fracturing. The lodes are reported to trend N. 30° E. and to dip 80° SE. The largest lode is near the hanging wall of the main fracture zone, and its thickness is reported to range from 3 to 12 feet and to contain an ore shoot a few inches to several feet wide. This shoot was opened for a distance of 300 feet by drift.

According to Jones the ore is composed largely of a sericitic gouge, which encloses bunches of sulfides, dominantly pyrite in massive form and in crystalline aggregates. Scattered through the gouge are also fragments of vein material in which quartz, pyrite, sphalerite, tetrahedrite, galena, and calcite may be recognized.[50] Some quartz veinlets in the ore are reported to carry free gold.

EAKIN GROUP

The Eakin group, now combined with the Coin Bond, lies in sec. 35, T. 8 N., R. 4 E., near the crest of the ridge between Wolf Creek and Alder Creek a short distance west of Garden Valley Pass. Numerous cuts and trenches have been made on and along the south side of the divide, and a 1,100-foot tunnel has been driven from the Payette slope. The tunnel is reported to lack a few hundred feet of reaching ground beneath the shallow surface workings.[51]

The alinement of cuts and trenches indicates that the lodes trend about N. 50° E. The lodes are apparently rather small, but the old Black Bear, which probably is included in the group, had an ore shoot reported to be 4 to 5 feet wide.[52] The outcrops are much iron-stained, but a small pile of ore on the dump at the portal of the long crosscut is composed of pyrite in aggregates of very closely spaced crystals.

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[48] Ballard, S. M., op. cit., p. 65.
[49] Jones, E. L., Jr., op. cit., p. 104.
[50] Jones, E. L., Jr., op. cit., p. 104.
[51] Ballard, S. M., op. cit., p. 72.
[52] Lindgren, Waldemar. The mining districts of the Idaho Basin and the Boise Ridge, Idaho: U. S. Geol. Survey 18th Ann. Rept., pt. 3, p. 693, 1898.

GOLD DOLLAR GROUP

The Gold Dollar group lies along the Wolf-Creek-Alder Creek divide and extends for some distance down the Alder Creek slope. It is on the east side of the Garden Valley road, probably in sec. 35, T. 8 N., R. 4 E. The group covers an old location and has numerous cuts and short tunnels on different lodes, but none of the tunnels were open in the year between 1931 and 1934. The lodes apparently strike about N. 50° E. and dip steeply southeast, but whether they cut any of the rhyolite porphyry dikes in their vicinity was not determined. The outcrops are heavily iron-stained. Underneath the gossan the rock is considerably silicified and is cut by thin seams of quartz.

CLEAR CREEK PROSPECT

The Clear Creek prospect is in unsurveyed sec. 30, T. 8 N., R. 6 E., high on the slope north of Clear Creek. It was worked by the Clear Creek Development Co. from 1930 to 1933 but has since been idle. The workings comprise a short tunnel and cut in the outcrop and a crosscut about 700 feet long some distance below.

Two prominent shear zones about 15 feet apart are exposed in the upper tunnel. These strike about N. 30° E. and dip about 55° NW. The first shear zone is several feet wide and contains some gouge and thin seams of quartz in which are small scattered crystals of pyrite. The second is 10 to 12 feet wide, and its upper 3 feet has numerous quartz seams and stringers, which contain a little scattered pyrite. A similar zone of fractured rock with ore seams and stringers also lies just above the footwall and is separated from the other by a band of crushed rock in which gouge is conspicuous. The rock in and along the shear zones is considerably sericitized but has little disseminated pyrite. The property is near the margin of the "porphyry belt," but no dikes are cut by the shearing, and the local wall rock is the granitic rock of the batholith.

The ore is made up entirely of the young-stage rather coarsely crystalline quartz, which has in part a comb habit and contains a few scattered grains of pyrite. Earlier base-metal assemblages are not represented, but some calcite is present in thin seams cutting across the quartz.

EDNA MINE

The Edna mine is in sec. 33, T. 8 N., R. 7 E., on the north side of Edna Creek near the main highway between Idaho City and Lowman. The mine is an old one and had ore blocked out and ready for milling as early as 1906, but an 80-ton silver cyanide plant erected to treat the ore was not completed until 1909. The cyanide plant was forced to shut down after a short run, in part at least because of metallurgical difficulties. Work was resumed about 10 years later by the Idaho

Development Co. and was continued from 1926, when the property was taken over by the Edna Mines Co., until 1930. The mine was then idle until 1937, when the old workings were rehabilitated and the plant was reported in shape for production. The property comprises 1 patented and 8 unpatented claims and has a tunnel 1,100 feet long and a vertical shaft 350 feet deep with drifts on three levels. Only a part of the tunnel was open when the property was examined in 1932. Records of past production were not available.

The Edna lode is in part a fissure filling and in part a replacement of sheared granitic rock. It lies near scattered rhyolite porphyry and quartz monzonite porphyry dikes, but its relations to them could not be determined from the limited exposures underground. The lode is cut by a lamprophyric dike. The lode strikes about N. 70° E. and dips about 70° SE. The fissure zone occupied by the lode is very prominent and is about 8 feet wide where intersected by the crosscut and at the shaft about 750 feet from the portal. Postmineral faults have broken the filling and have in places slightly offset the lode along N. 10° W. slips. In the accessible exposures the lode appears to consist largely of narrow quartz seams, stringers, and lenses in the fractured and locally silicified and sericitized granitic rock. The main ore shoot is reported to be about 200 feet long and has been prospected to the bottom of the shaft, 100 feet below the tunnel level. The rock alongside the ore shoot is greatly fractured and intensely altered, but other characteristics of the shoot could not be ascertained.

The ore is valued chiefly for the silver and is composed largely of the young-stage quartz, which is accompanied by scant amounts of silver minerals, pyrargyrite and miargyrite being most conspicuous. Through the quartzose ore, however, are scattered fragments of an earlier base-metal filling made up of some pyrite, large granules and pods of black sphalerite, some galena, and microscopic grains of tetrahedrite. Most of the younger quartz is very fine-grained, but the grain size varies from fine to coarse, and in places the quartz is somewhat drusy. Some small crystals of pyrite are associated with the silver minerals, and the presence of greenish scorodite on the surface ore suggests that in places arsenopyrite may also be present.

McKINLEY MINE

The McKinley mine is in McKinley Gulch, near the south border of the Cold Springs district, about 7 miles southeast of Idaho City. The workings were only partly accessible when the property was visited in 1932. They are reported to comprise a crosscut 2,084 feet long and minor surface openings.

The crosscut was open for only a short distance from the portal, and little could be learned of the structural and mineralogical features of the veins or lodes. Rhyolite and dark-colored dikes are exposed on the surface near the tunnel, and one of each appears in the open part of the crosscut. The dark-colored dike lies along a fault striking N. 65° E., but the relations of the rhyolite dike could not be interpreted. Four mineralized fracture zones of northerly trend are reported in the crosscut and another beyond the face. Some small mineralized seams near the portal contain pyrite, sphalerite, chalcopyrite, and galena.

MUD SPRINGS PROSPECT

The Mud Springs prospect is about 4 miles below Idaho City, near the main highway on Moore Creek. It has a single base-metal lode, which has been developed by two crosscuts, both caved, one reported to be 40 feet and the other 125 feet long.

The lode has an east-northeast trend and appears at least in part to cut a coarse-grained granite porphyry. The lode is reported to be about 2 feet thick and to contain ore in lenses and pockets. From material in boxes near the dump the ore appears to consist of massive sulfides, mainly galena, and lesser amounts of pyrite, sphalerite, and chalcopyrite, cut by scattered, thin seams of calcite. The sulfides intimately penetrate and replace the rock, apparently without altering it.

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