UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary
GEOLOGICAL SURVEY
W. C. Mendenhall, Director

Bulletin 846—D



# SOME LODE DEPOSITS IN THE NORTHWESTERN PART OF THE BOISE BASIN IDAHO

BY

CLYDE P. ROSS

Prepared in cooperation with the
IDAHO BUREAU OF MINES AND GEOLOGY

Contributions to economic geology, 1933
(Pages 239-285)

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1934

For sale by the Superintendent of Documents, Washington, D.C. - - - - - - - Price 35 cents

## CONTENTS





## ILLUSTRATIONS

# SOME LODE DEPOSITS IN THE NORTHWESTERN PART OF THE BOISE BASIN, IDAHO

By Clyde P. Ross

**ABSTRACT**

The report is limited to the geology of lode deposits in the northwestern part of the Boise Basin which are in or near mines that were in operation at the time of visit, in 1930. Owing to the recent inactivity of the formerly rich placer deposits, there is nothing essential regarding them to add to Lindgren's report published in 1898.

The area studied is underlain by granitic rock of the Idaho batholith, which is cut by dikes of Miocene(?) age. These dikes are dacite porphyry (intruded early); rhyolite porphyry, granophyre porphyry, and granite porphyry (closely related in character and age); and several basic varieties (of which some, at least, are of relatively late origin). Diorite porphyry dikes, of undetermined age but probably older than all of those named above, are also present.

At least three classes of lodes are represented—(1) early lodes composed of coarse-grained quartz and sporadic sulphides, represented by the Blue Rock mine; (2) lodes with abundant sulphides, including ruby silver, represented by the Comeback mine; (3) Miocene(?) lodes associated with and younger than the Miocene (?) dikes, represented by the Gold Hill, Mayflower, Newburg, Belshazzar, Mountain King, Mineral, and Missouri mines. Most of the lodes of the third class are persistent both in strike and dip. The same statement may apply to representatives of the other classes that were not visited during the present study. The ore bodies in these lodes, however, are individually of small to moderate size, but locally rich. Most of the developed lodes of the third class are fairly well defined veins, but the Pioneer lode of the Gold Hill mine lies along a group of subordinate oblique fractions in a shear zone. It is relatively inconspicuous at the surface and was overlooked for a long time. Lateral search in other mines may disclose lodes similar to the Pioneer. This possibility and the downward continuity of the lodes as a whole entitle the district to more extensive exploration, both horizontally and downward.

## INTRODUCTION

### SCOPE OF THE REPORT

The Boise Basin, one of the most famous mining districts in Idaho because of its large production of placer gold in the early days, is in the central part of Boise County, Idaho. Its center is about 25 miles in an air line northeast of the State capital (fig. 32). Placer mining

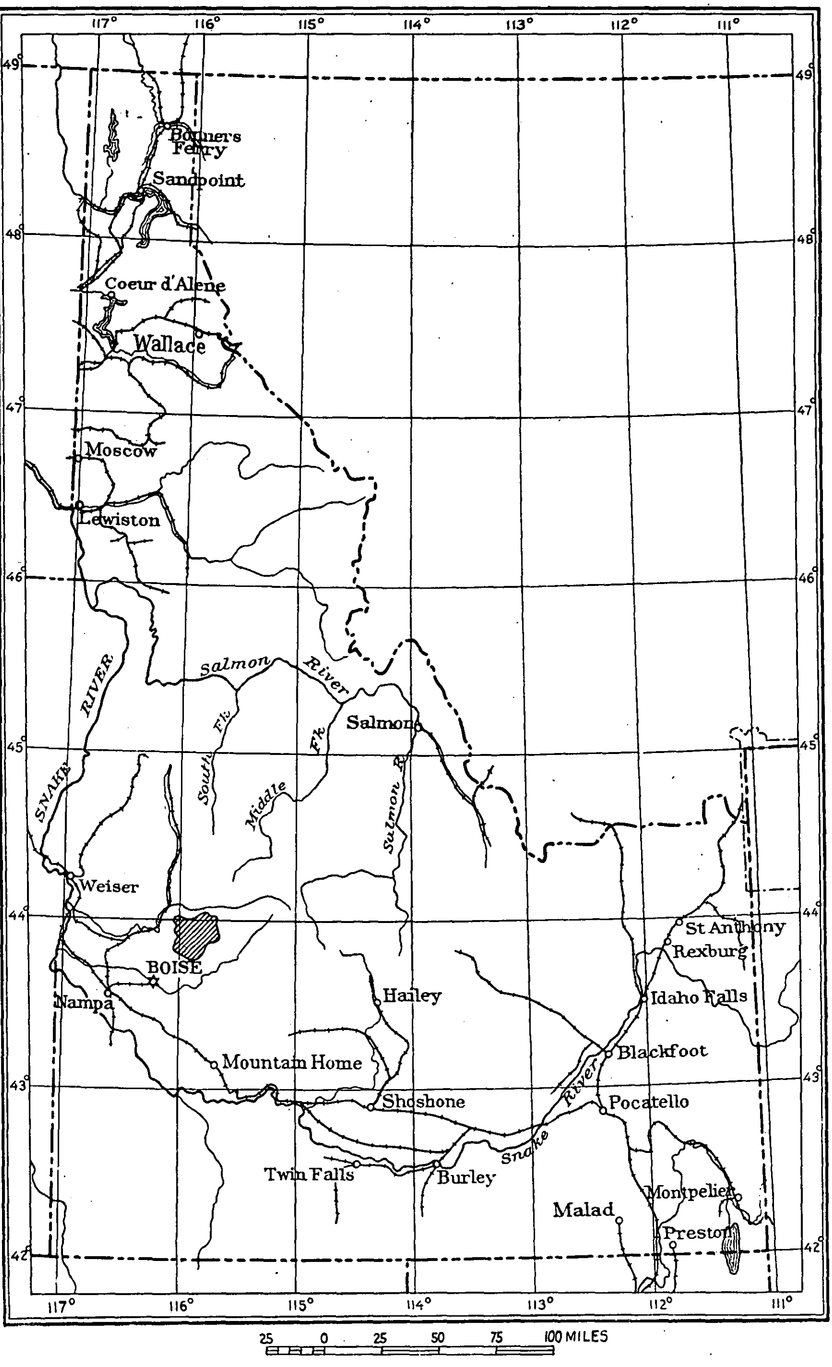



FIGURE 32.—Index map of Idaho showing location of the Boise Basin.

has declined, and in recent years activity in the lode mines has been increasing. Since 1910, according to C. N. Gerry in the annual chapters on Idaho in Mineral Resources of the United States, the lodes have produced over $7,000,000 in gold and silver. Records of earlier production are of questionable accuracy, but the total production is probably of the order of $10,000,000.

The writer, assisted by S. S. Philbrick, spent 16 days in the district in May and June 1930. During this time most of the lode mines then in operation were examined, and in addition a geologic and topographic sketch map of a small area extending from the Gold Hill mine past the Belshazzar to the Mountain Chief (pl. 40) was studied. This area includes the principal lode mines that have recently been productive and is representative of the so-called "porphyry belt" in the northwestern part of the basin. It is hereinafter referred to as the Quartzburg area, from the only town within its borders.

The geology and mineral deposits, both lode and placer, of the Boise Basin have been described in several publications, listed below, to which the reader is referred for more detailed data on history, production, and general geology than are given here. The present examination was intended solely to gather information as to recent developments in the lode mines, with particular reference to the character and age of the mineralization, in connection with a study of the ore deposits of south-central Idaho carried out in cooperation with the Idaho Bureau of Mines and Geology. As many of the lode mines are inaccessible and there are no topographic maps of the basin sufficiently accurate or on a scale large enough to serve as a base for detailed geologic work, study of the basin as a whole was not attempted. The mines in the eastern and southern parts of the basin, which include some of those most active in the early days, have been little worked recently and were not visited. The placers have been discussed in considerable detail by Lindgren[1] and were not examined during the present investigation.

## BIBLIOGRAPHY

Ballard, S. M., The Boise Basin district in Idaho: Eng. and Min Jour., vol. 109, pp. 881–882, April 10, 1920. A brief presentation of the principal data given later in Bulletin 9 of the Idaho Bur. Mines and Geology by the same author.

Ballard, S. M., Geology and gold resources of Boise Basin, Boise County, Idaho: Idaho Bur. Mines and Geology Bull. 9, 100 pp., 1924. The most recent and complete report on the lode mines, written by an engineer familiar with the district through having operated mines in it. Gives a geologic sketch map.

[1] Lindgren, Waldemar, Mining districts of the Idaho Basin and the Boise Ridge, Idaho: U.S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 651–680, 1898.

Bowron, W. L., Boise Basin, Idaho: Pacific Miner, vol. 18, pp. 51–52, February 1911. Description of dredging and of lodes in the porphyry belt.

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, 1931. Mainly a summary of methods employed and results obtained at the Gold Hill mine under his management. Gives some geologic data.

Hastings, W. L., The Boise Basin in Idaho: Eng. and Min. Jour., vol. 58, p. 56, 1894; Sci. Am. Suppl., vol. 38, pp. 15540–15541, Aug. 18, 1894. Brief geologic description.

Jones, E. L., Lode mining in the Quartzburg and Grimes Pass porphyry belt, Boise Basin, Idaho: U.S. Geol. Survey Bull. 640, pp. 83–111, 1916. Summarizes the available data regarding the basin as a whole and describes the principal lode mines near Quartzburg and Grimes Pass. Gives a reconnaissance geologic map based on that previously published by Lindgren.

Lindgren, Waldemar, Mining districts of the Idaho Basin and the Boise Ridge, Idaho: U.S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 625–736, 1898. Discusses the general geology of the Boise Basin (Idaho Basin) more fully than any of the other papers, with special reference to the placer deposits, and gives a reconnaissance geologic map. Also gives data on neighboring areas.

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

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

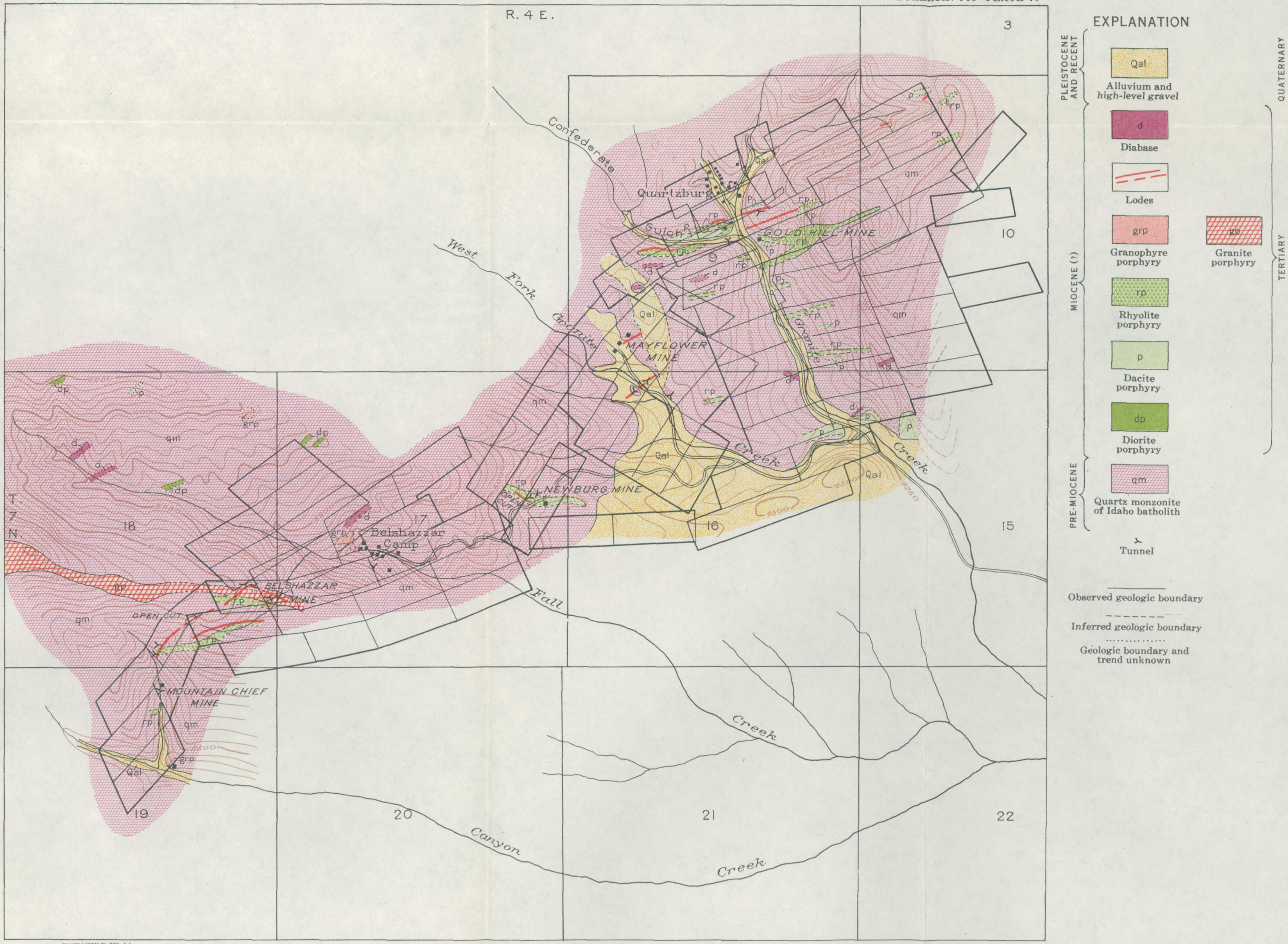
Scott, W. A., Boise Basin: Idaho Min. and Sci. Press, vol. 101, pp. 76–78, July 16, 1910. Data on current mining activity, both placer and lode.

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, 1921. Describes a heretofore unrecognized bismuth mineral from the Belshazzar mine, Boise Basin.

## GEOLOGIC SUMMARY

The Boise Basin occupies about 300 square miles. It is underlain throughout by the southern part of the Idaho batholith, which here as elsewhere has, for the most part, the composition of quartz monzonite. Its age, according to different writers, ranges from Jurassic to Eocene. It will suffice for present purposes to state that the batholith is much earlier and more extensive than any of the granitic masses that are intrusive into Tertiary lava in several localities in south-central Idaho. The granitic rock in the Boise Basin is cut locally by aplite, lamprophyre, and pegmatite dikes related thereto and also by younger porphyritic dikes. For reasons outlined below it is thought that the porphyritic dikes are approximately of lower Miocene age. Such distinction in the age of the dikes has not heretofore been made in the Boise Basin but is in accord with recent work in the general region.

The younger dikes are mostly concentrated in the so-called "porphyry belt", which also contains most of the active lode mines.




# GEOLOGIC MAP OF THE QUARTZBURG AREA, BOISE BASIN, IDAHO

Scale $\frac{1}{24,000}$

0 — 1 Mile

Contour interval 50 feet

Geology and topography by C. P. Ross and Shailer S. Philbrick
May and June, 1930

This belt extends from the vicinity of Lowman, on the South Fork of the Payette River, southwestward across the northwestern part of the Boise Basin. The principal mines in the belt within the basin lie in an area of about 25 square miles, which extends from sec. 12, T. 8 N., R. 5 E., to sec. 19, T. 7 N., R. 4 E. Boise meridian. Many of these and presumably some in other parts of the Boise Basin are genetically related to the Miocene(?) dikes, which in part form their host rocks. The claim map in plate 39, adapted from one prepared and kindly furnished by Gordon C. Smith, though not quite complete, shows the location and extent of the principal lode and placer properties in the northern, western, and central parts of the Boise Basin.

Ballard [2] maps dike zones both north and south of Idaho City also, but it appears from his and Lindgren's descriptions [3] that most of the dikes at these places are aplitic and lamprophyric and hence are to be correlated in age with the Idaho batholith rather than with the younger dikes. In and near these older dike zones, mainly in the vicinity of Idaho City and along upper Moore Creek, 6 to 10 miles to the northeast, there are several mines, now mainly inactive. It is probable that many of these deposits, like a few of those farther north and west, are genetically related to the Idaho batholith.

In several places in the central part of the basin, notably near Idaho City, there are exposures of somewhat consolidated clay, sand, and gravel, containing only negligible quantities of gold. They are in general appreciably tilted and locally have been faulted. The scanty plant remains in these beds led Lindgren to correlate them with the Payette formation.[4] Kirkham,[5] in his recent review of the subject, assigns the beds near Idaho City to the Payette formation as interpreted by him. His summary of the fossil evidence indicates that this formation is not older than middle Miocene nor younger than lower Pliocene and is probably mainly upper Miocene.

Small amounts of basaltic lava and probably also a little lava of more silicic composition remain locally in the basin and along its northwest rim. These are commonly assumed to be of similar age to the supposed Payette beds, although evidence on this point is inconclusive. Other basalt flows, whose appearance indicates that they are materially younger, fill the lower canyon of Moore Creek and have been trenched by the present stream. Gravel underlies some of these flows and has been found to be auriferous.[6]

---

[2] Ballard, S. M., Geology and gold resources of Boise Basin, Boise County, Idaho: Idaho Bur. Mines and Geology Bull. 9, pp. 20–24, pl. 4, 1924.

[3] Lindgren, Waldemar, op. cit., pp. 682–689.

[4] Idem, p. 666.

[5] Kirkham, V. R. D., Revision of the Payette and Idaho formations: Jour. Geology, vol. 39, no. 3, pp. 232–235, 1931.

[6] Lindgren, Waldemar, op. cit., p. 659.

In addition to the beds of supposed Payette age, there are extensive unconsolidated deposits of gravel with some sand, the oldest of which are in part independent of the present drainage and may have been laid down soon after the Miocene(?) sedimentary beds, and the youngest are the products of the present streams. Deposits intermediate in age between these two extremes are locally recognizable. All these unconsolidated gravel deposits have yielded gold in commercial quantity. Most of the placer workings are close to the old towns of Idaho City, in the southeastern part of the basin, and Centerville, Placerville, Granite, and Pioneerville, in the central part, mainly in the gravel of intermediate age. In the summer of 1930 a dredge was in operation in the channel of Grimes Creek near Pioneerville.

The mode of origin of the Boise Basin and the history of the deposition of the sedimentary beds in it are not yet entirely understood. It is probable that a topographic depression corresponding more or less closely to the present basin existed at the time the Miocene(?) sediments were laid down. Certainly some or, according to Lindgren,[7] all the lodes were formed prior to the deposition of these beds. Although direct evidence as to the relation between the sediments and the younger lodes in the Boise Basin is lacking, the writer's concepts as to the geologic history of the general region accord with Lindgren's conclusion on this point. Some doubt is raised by Kirkham's conclusion [8] that some of the intrusive rock in what appears to be a southwestward continuation of the "porphyry belt" [9] near Pearl, Gem County, cuts beds assigned by him to the Payette formation.

The scanty data available regarding the Miocene(?) sediments in the Boise Basin suggest that a large proportion of them were deposited in quiet water. As Kirkham [10] says, Lindgren's assumption that they were deposited in an arm of a great lake which inundated much of the region to the south seems improbable. However this may be, the preponderance of fine material in the beds suggests conditions unfavorable to the concentration of placer gold. This fact doubtless accounts adequately for the scarcity of gold in them. In such gravel as exists in these beds the proportion of gold is greater—locally so much greater that Lindgren records a little mining in such material. Conditions favorable to quiet sedimentation commonly also promote deep weathering. Hence the upper portions of the lodes may have been in a particularly suitable condition to furnish

[7] Lindgren, Waldemar, op. cit., p. 697.

[8] Kirkham, V. R. D., Igneous geology of southwestern Idaho: Jour. Geology, vol. 39, no. 6, pp. 578–579, 1931.

[9] Lindgren, Waldemar, op. cit., p. 630.

[10] Kirkham, V. R. D., Revision of the Payette and Idaho formations: Jour. Geology, vol. 39, no. 3, p. 217, 1931.

gold to the placers when conditions changed so as to accelerate erosion and the consequent accumulation of coarse gravel. Lindgren [11] has demonstrated that much of the gold in the famous placers of the basin was derived from known lodes close at hand. Since early Pleistocene time the history of the mountains of south-central Idaho has been dominantly one of intermittent uplift and rapid erosion.[12] Conditions locally, as in the Boise Basin, favored the accumulation of valuable placers.

## GEOLOGY OF THE QUARTZBURG AREA

The Quartzburg area (pl. 40) covers about 3½ square miles in the southwestern part of the "porphyry belt." It extends from the hill northeast of Quartzburg to Canyon Creek below the Mountain Chief mine and includes the Gold Hill, Mayflower, Newburg, Belshazzar, and Mountain Chief mines. This area is underlain by quartz monzonite, which is cut by dikes of several kinds and is covered along the valleys by high-level and low-level gravel. The distribution of the dike rocks as represented on plate 40 represents actual observation with the minimum of interpolation. The exposures over much of the area are poor, and there is a rather dense cover of trees and brush, so that many of the dikes could be traced only short distances. Most of the existing dikes have probably been found, although more complete data would show that they are individually longer and have more branches than are indicated on the map. Minor differences in rock character can be noted in almost every exposure of the dike rocks. These rocks are grouped for convenience into six major varieties, distinguishable primarily by differences in color and texture that can be used as guides in mapping. The principal lodes are plotted so far as they are revealed by present development.

The Quartzburg area is fairly typical of the "porphyry belt." The dike rocks in this area (described below) are representative of those throughout the belt, although other varieties exist. With the exception of pegmatite stringers, dikes related to the Idaho batholith were not recognized within the mapped area. A few that are probably of this character are mentioned in descriptions of mines outside of the Quartzburg area examined during the present study. Most such dikes in the Boise Basin appear, however, to be in the general vicinity of Idaho City. None of the Tertiary stratified rocks are exposed in the parts of the basin studied during the present investigation, although exposures of Miocene(?) sediments near Idaho City were briefly examined.

[11] Lindgren, Waldemar, op. cit., p. 680.

[12] Ross, C. P., Salient features of the geology of south-central Idaho [abstract]: Washington Acad. Sci. Jour., vol. 18, no. 9, p. 268, 1928; The physiography of south-central Idaho [abstract]: Idem, vol. 21, no. 15, p. 369, 1931.

## PETROGRAPHY

### GRANITIC ROCK

The granitic rock of the Idaho batholith in the Boise Basin resembles that of the same mass elsewhere in the State. It is a light-gray, rarely pinkish, moderately coarse grained rock whose average composition is that of a somewhat calcic quartz monzonite, with local varieties that are more calcic or more silicic. In most places it contains about 40 percent of oligoclase, 20 to 40 percent of microcline, 15 to 30 percent of quartz, and 3 to 10 percent of mica (mostly biotite). There is a little epidote and a myrmekitic intergrowth of quartz and plagioclase. The feldspars are generally sericitized, near the lodes thoroughly so, and the micas are shredded and chloritized. In the mineralized areas calcite is sporadically developed. Most of the rock has typical granitic texture, with average diameters of 3 millimeters.

In a few places, notably on the ridge between the Belshazzar and Mountain Chief mines, the granitic rock is cut by pegmatite stringers, rarely as much as 6 inches thick.

### DIKE ROCKS

The six varieties of Miocene(?) dike rocks here distinguished are described below in approximate order of age, so far as that has been determined. Underground exposures show that the dacite porphyry, rhyolite porphyry, granophyre porphyry, and at least part of the basic dikes are successively younger in the order named. The granite porphyry is presumably of essentially the same age as the granophyre porphyry, to which it is akin. All but the basic dikes were intruded before deposition of the Miocene(?) lodes. The diorite porphyry, of uncertain age, is listed last because of its superficial resemblance to the basic dikes, which are later than the lodes wherever the relations have been determined.

#### DACITE PORPHYRY

The rock that has been locally termed "diorite porphyry" is here designated dacite porphyry because of its aphanitic groundmass. It is a dark-gray rock with numerous phenocrysts of white feldspar and less conspicuous quartz, biotite, and hornblende. The feldspar and quartz phenocrysts average about 2 millimeters in maximum dimension, but most of the biotite flakes are smaller. The grains composing the groundmass are generally less than 0.02 millimeter in diameter. The phenocrysts make up from 40 to 60 percent of the rock and comprise over 50 percent of plagioclase (ranging from oligoclase-andesine to andesine in different specimens), over 30 percent of biotite, about 2 percent of hornblende, and from zero to 10 percent of quartz. Sericite, chlorite, epidote, and locally calcite are present, but the rock is generally fresher than most of the porphyries of the area. The microscopic character of the rock is shown in plate 41, *A*.

#### RHYOLITE PORPHYRY

The dike rock constituting the principal wall rock of several of the veins varies somewhat in composition and is everywhere altered, but on the whole it may be designated rhyolite porphyry, which is in accord with local usage. It is a fine-grained rock, generally bleached nearly white, studded with feldspar and quartz crystals.

In the Gold Hill mine the rhyolite porphyry is made up of about 25 percent of phenocrysts from 0.5 to 3 millimeters long in a groundmass in which the grains average less than 0.02 millimeter in diameter. The phenocrysts comprise feldspar, mainly oligoclase (60 percent), quartz (30 percent), and colorless mica, largely bleached biotite (10 percent). Quartz is abundant in the groundmass. The feldspar in the groundmass, to judge from its indices of refraction and appearance, is probably in large part potassic, and the rock as a whole is more rhyolitic than appears from the phenocrysts alone. The whole rock is intensely sericitized, and it contains some epidote, chlorite, calcite, and, near the ore bodies, pyrite. Plate 41, *B*, shows the general microscopic appearance of the rock. The textural resemblance to a lava and the sharp difference between this rock and the aplite that would be expected to be associated with the batholith are manifest.

Elsewhere the rock is similar in appearance except that locally it is darker-colored or coarser-grained. The dike in the Mayflower mine has a more irregular, slightly coarser texture, contains considerable chlorite, and may be a little more calcic than that in the Gold Hill. The rock in the Belshazzar mine contains no quartz phenocrysts, but nearly half the groundmass appears to be composed of quartz. About 20 percent of the phenocrysts forming over 5 percent of the rock are mica. The groundmass is distinctly coarser-grained than much of the rhyolite porphyry elsewhere, the grains averaging nearly 0.1 millimeter in diameter.

#### GRANITE PORPHYRY

The granite porphyry is similar to the rhyolite porphyry but is coarser-grained and mottled pink and green. The principal exposure of this rock is in a large dike near the Belshazzar mine. In much of this rock the grains composing the groundmass are from 0.1 to 0.3 millimeter in diameter and the feldspar phenocrysts are 2 to 3 millimeters long. Most of it contains more hornblende than biotite, but locally hornblende is absent. The proportions and composition of the minerals in this rock vary within about the same limits as those in the rhyolite porphyry just described. The groundmass, however, as can be seen from plate 41, *C*, contains much micropegmatite, which is not visible in the finer-grained rock. There is a close resemblance between this microphotograph and plate 42, *B*, which represents a dike of undoubted Tertiary age in Custer County.

## GRANOPHYRE PORPHYRY

The light-colored dike rock characterized by large feldspar phenocrysts (as much as 30 millimeters long) is locally termed the "lab dike" because of the erroneous concept originally held that the phenocrysts are labradorite.[13] Its silicic character has long been recognized, however, and the present study shows that the rock is a granophyre porphyry. This rock is especially abundant in the Gold Hill mine and, except for the phenocrysts, resembles the rhyolite porphyry there. The phenocrysts make up about 30 percent of the rock. In the Gold Hill mine they consist of about 54 percent of feldspar, 24 percent of quartz, and 22 percent of biotite. In similar dikes elsewhere quartz is rare among the phenocrysts. The large phenocrysts are mainly orthoclase, but sodic oligoclase is abundant among the smaller phenocrysts. The groundmass consists in part of granules about 0.02 millimeter in diameter, composed of rather poorly defined micropegmatitic undergrowths of quartz and alkali feldspar, and in part of a fine granular aggregate of quartz and sericitized feldspar like that of the rhyolite porphyry. The peculiar texture of this rock is shown in plate 42, *A*. It is strikingly like that shown in plate 42, *C*, which illustrates a Tertiary dike rock from the Casto quadrangle, Custer County, except that the latter is somewhat coarser-grained.

It is probable that the rhyolite, granite, and granophyre porphyries represent similar magmas cooled under slightly different conditions. In some places, as in the Gold Hill mine, differences in relative age can be proved, but these differences must be very slight. Even in the Gold Hill mine there are places where the rhyolitic and granophyric porphyries are so similar as to be difficult to distinguish.

## DIABASE

There are some calcic dikes in the Quartzburg area which may be termed diabase (following Ballard), although ophitic texture is not very well developed in most of them. All the dikes of this kind are small, and it is probable that more of them have been omitted in mapping than any other kind. Chips in the soil in several places

[13] Lindgren, Waldemar, op. cit., p. 683.

on the hill southwest of Quartzburg testify to the presence of such rock. The diabasic rocks are green to black fine-grained rocks in which phenocrysts, where present, are inconspicuous. The rock is more feldspathic than ordinary diabase and consists principally of labradorite laths about 0.1 millimeter long, locally with phenocrysts 1 to 2 millimeters long. In some there is chloritized biotite, and in others from 5 to 10 percent of augite. A dike on the ridge northwest of Quartzburg contains about 25 percent of augite and 5 to 10 percent of hornblende. Several of the dikes contain sparsely disseminated corroded quartz grains. There is considerable magnetite and some epidote. The rocks are fairly fresh but contain chlorite, sericite, and locally calcite.

### DIORITE PORPHYRY

Northwest of the Belshazzar mine there are several nearly black dikes with a distinctly coarser appearance than the diabasic rocks just described. Andesine phenocrysts from 0.5 to 2 millimeters long make up fully half the rock. The rest is composed of about equal parts of altered hornblende in grains of varying size and of a light-colored granular groundmass composed mainly of altered andesine grains 0.1 to 0.2 millimeter in diameter. The rock contains less than 1 percent of quartz.

### AGE OF THE DIKES

The dike rocks described above and similar ones elsewhere in the "porphyry belt" are closely associated with and in part form the host rock of many of the lodes in the northwestern part of the Boise Basin. There is reason to believe that these dikes, and consequently the related lodes, are of Tertiary age, probably Miocene. This belief is based largely on (1) the close accord between the dikes and fissures that are structurally discordant with the Idaho batholith but correspond closely to fissures of known Tertiary age elsewhere; (2) the petrographic dissimilarity between most of the dikes and any known to be related to the Idaho batholith; (3) the petrographic resemblance between many of the dikes and rocks elsewhere in Idaho that are known to be of Tertiary (probably Miocene) age.

It is manifest that the dikes of the "porphyry belt" follow a zone of structural weakness, which facilitated their intrusion. This zone trends about N. 60° E., transverse to the trend of the Idaho batholith. So far as known, there is no relation between fissuring along this belt and events related to the intrusion of that batholith. On the other hand, evidence is accumulating that in different parts of south-central Idaho one of the major components of deformation affecting the Challis volcanics[14] and more or less closely related to intrusion and ore deposition therein approximately accords in trend with the " porphyry belt " of the Boise Basin.[15]

The descriptions given above show clearly that the dacites and more silicic dike rocks of the " porphyry belt " do not have aplitic characteristics. Dikes of similar composition are rare in or near the batholith in most parts of south-central Idaho. In most areas where equally silicic dikes occur they are now known to belong to the period of post-Challis intrusion and deformation just referred to. In those areas farther north where aplitic rocks related to the Idaho batholith are comparatively abundant they have no petrographic similarity to the rocks characteristic of the " porphyry belt."[16]

The close resemblance between the granite and granophyre porphyries of the vicinity of the Belshazzar mine in the Boise Basin and two of the many kinds of dikes in the Casto quadrangle has already been cited (p. 248, pls. 41, 42). Almost equally close resemblances can be found between most of the dikes of the " porphyry belt " and those in the Casto quadrangle, which are known to be involved in the post-Challis disturbance.[17]

The dikes in the Casto quadrangle and similar intrusive rocks elsewhere in south-central Idaho are probably of lower Miocene age. Those in the " porphyry belt " of the Boise Basin may consequently be tentatively regarded as lower Miocene also.

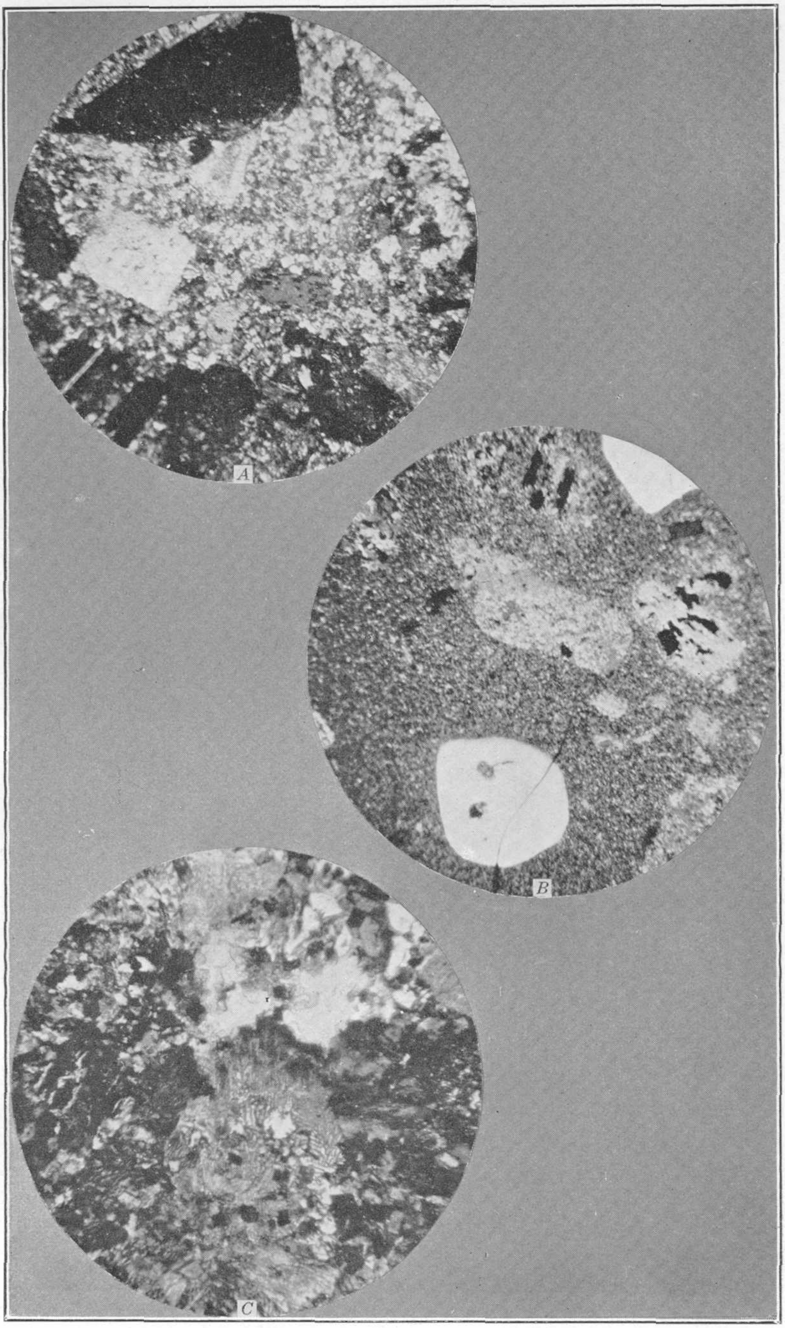
The relative age of the different kinds of dikes of the " porphyry belt " was not established from the surface mapping but can be determined in part from underground exposures. In the Gold Hill mine it is clear that the dacite porphyry is the oldest dike rock present, the rhyolite porphyry next, and the granophyre porphyry next. The granite porphyry in the vicinity of the Belshazzar mine is similar in relations and to some extent in character to the granophyre porphyry of the Gold Hill mine, and these two rocks are therefore probably essentially contemporaneous. In both these mines small basic dikes appear to be later than the mineralization and hence later

14 Ross, C. P., Geology and ore deposits of the Seafoam, Alder Creek, Little Smoky, and Willow Creek mining districts, Custer and Camas Counties, Idaho: Idaho Bur. Mines and Geology Pamphlet 33, p. 2, March 1930.

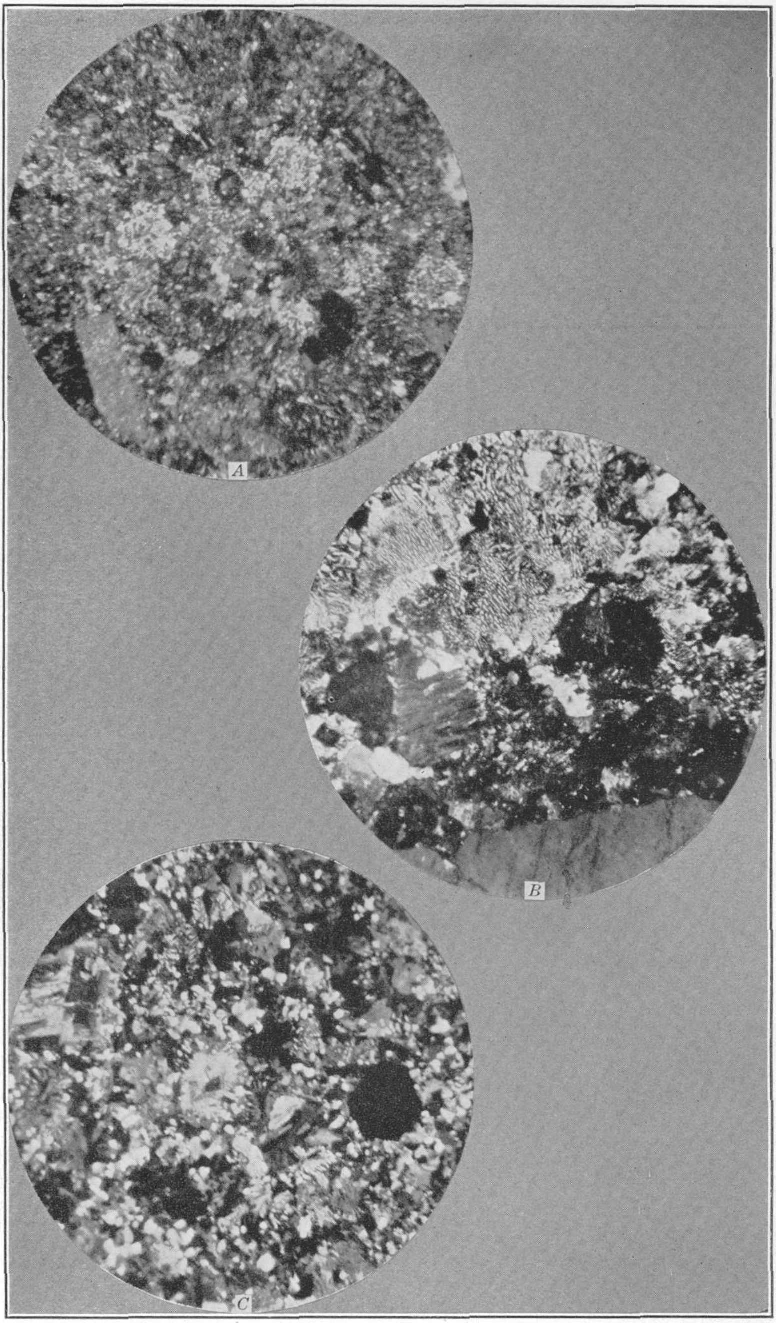
15 Anderson, A. L., Geology and ore deposits of the Lava Creek district, Idaho: Idaho Bur. Mines and Geology Pamphlet 32, p. 26, August 1929. Umpleby, J. B., Westgate, L. G., and Ross, C. P., Geology and ore deposits of the Wood River region, Idaho: U.S. Geol. Survey Bull. 814, p. 73, 1930. Ross, C. P., Geology and ore deposits of the Casto quadrangle, Idaho: U.S. Geol. Survey Bull. 854 (in preparation); A geologic reconnaissance in the eastern division, Idaho National Forest, Idaho and Valley Counties, Idaho: U.S. Geol. Survey Bull. — (in preparation).

16 Thomson, F. A., and Ballard, S. M., Geology and gold resources of north-central Idaho: Idaho Bur. Mines and Geology Bull. 7, p. 34, 1924. Anderson, A. L., Mica deposits of Latah County, Idaho: Idaho Bur. Mines and Geology Pamphlet 14, p. 6, undated [1925–]; The geology and mineral resources of the region about Orofino, Idaho: Idaho Bur. Mines and Geology Pamphlet 34, p. 22, June 1930.

17 Ross, C. P., The geology and ore deposits of the Casto quadrangle, Idaho: U.S. Geol. Survey Bull. 854 (in preparation).



*A*, Dacite porphyry, 100 level, Gold Hill mine; *B*, Rhyolite porphyry, 100 level, Gold Hill mine; *C*, Granite porphyry, 401 level, Belshazzar mine. *A* and *B* enlarged 18 diameters; *C* enlarged 46 diameters.




GRANOPHYRE PORPHYRY.

*A*, 700 level, Gold Hill Mine; *B*, Little Loon Creek, Custer County; *C*, East fork of Mayfield Creek, Custer County. *A* and *C* enlarged 18 diameters; *B* enlarged 46 diameters.

than all the other dikes. Whether or not all the various basic dikes grouped as diabase in the preceding description are equally young cannot be determined from the exposures seen. The relative age of the diorite porphyry is unknown, as it has been found only in a few isolated outcrops at a distance from other dikes or lodes.

## STRUCTURE

The granitic rock belonging to the Idaho batholith in the northwestern part of the Boise Basin has irregular but locally pronounced jointing. Commonly the most persistent joints trend northwest and dip southwest. Such joints are especially conspicuous along the ridge between Granite Creek and Confederate Gulch. In and near the Blue Rock group near the head of Confederate Gulch the mineralization followed joints of this character. On the lower reaches of this gulch, however, the most prominent joints strike nearly east and dip about 50° S.

The most conspicuous structural feature of the part of the Boise Basin studied is the "porphyry belt." The mapping of the Quartzburg area (pl. 40) shows that here, at least, the dikes are not quite as numerous nor do they make up so preponderant a part of the whole as might be inferred from previous published descriptions. Both this mapping and reconnaissance examinations in neighboring areas demonstrate, however, that the belt is traceable for fully 35 miles along its strike and commonly is 1 to 2 miles in width. The belt as a whole trends about N. 60° E. Most of the dikes, although irregular, curved, and branching, have an average trend of roughly N. 70° E. Some strike approximately east, and a few locally trend southeast. The diabasic dikes are especially variable in trend. Some strike nearly east, and others nearly north. Many are not sufficiently well exposed for their trend to be determined. Although most of the dikes in the Quartzburg area have small surface exposures, some, as can be seen from plate 40, are continuous for over a mile.

The size and persistence of the zone of fracturing followed by the dikes shows that it is one of the major components of the regional structure. If projected northeastward it would meet the zone of even greater deformation and intrusion along the Middle Fork of the Salmon River.[18] This zone contains the largest mass of Miocene granitic rock yet recognized in Idaho.[19]

The fracturing that furnished paths of access for the mineralizing solutions subsequent to the intrusion of the dikes of the "porphyry

[18] Ross, C. P., Geology and ore deposits of the Casto quadrangle, Idaho: U.S. Geol. Survey Bull. 854 (in preparation).

[19] Ross, C. P., Mesozoic and Tertiary granitic rocks in Idaho: Jour. Geology, vol. 336, No. 8, pp. 682–684, 1928.

belt " is doubtless to be attributed to a recurrence of movement along this zone of major structural weakness. The strikes of the largest and most persistent of the mineralized fissures, like those of the principal dikes, approach but rarely coincide with that of the zone as a whole. The Gold Hill and Belshazzar veins, the largest of the developed deposits of this kind, trend N. 70°–75° E. and dip commonly 60°–80° S. The upper part of the Belshazzar vein, with an average inclination of only about 30°, is a conspicuous exception to this rule. Although they thus closely parallel the average trend of the principal dikes, there is much discordance in detail, especially in the Belshazzar mine. (See pls. 44 and 47.) Locally, as in surface cuts along the Gold Hill vein, the walls are exceptionally smooth and persistent, and in most similar fissures in the basin smooth walls, irregular in detail, are present at short intervals. Gouge is rarely abundant but commonly present.

The subordinate fissures are somewhat irregular and of variable trend, but most of those strong enough to be distinctly visible in underground exposures have trends between N. 30° E. and N. 60° E., and most of the more persistent ones average near N. 35° E. Some of these fissures dip northwest, but the greater number dip southeast. The inclination is commonly 75°–90°. The slips that offset the granophyre porphyry dike in and below the western part of the 600 level of the Gold Hill mine (pl. 45) are exceptionally irregular in trend and gentle in dip. In the Belshazzar mine, contrary to the general rule, many of the cross slips strike northwest and dip southwest.

A considerable number of the fissures belonging to this subordinate set are mere slips lined with a little gouge, with little or no mineralization, and traceable only short distances. Some veins structurally similar to those along the major set of fractures correspond in trend to the subordinate set. The Mayflower mine furnishes a good example. In addition, there are the deposits represented by the Pioneer ore bodies in the hanging wall of the Gold Hill vein and originally discovered by exploration from that vein. These deposits, from which nearly all of the ore produced from the Gold Hill mine in the last 30 years has come, are isolated ore bodies that lie mainly in rhyolite porphyry but extend also into quartz monzonite and other dike rocks. These ore bodies correspond in trend to the second set of fractures, and the solutions that formed them were doubtless introduced along shear planes belonging to this set. They are unlike those previously referred to, however, in that mineralization was not confined to a narrow vein but spread through zones of shattering and alteration with less definite limits (pp. 273–274). A considerable proportion of the valuable minerals in such deposits are found in a third set of still more subordinate fractures.

This third set comprises small discontinuous seams, jagged in detail, which lie at slight angles to the trend of the slips of the second set.

The different fractures are rarely visible away from the mines, where all the rocks are considerably softened by alteration. Minor adjustments in these softened rocks complicate interpretation of the structural features, and nearly all dike contacts show evidence of such adjustments. Unquestionably, as can be seen from the mine descriptions that follow, most of the fracturing preceded and, in different ways, controlled the mineralization. The general relations, as shown in mine maps and sections such as those in plates 44, 45, and 47, indicate that none of the fissures have large displacements. Many apparent offsets in the dikes result from original irregularities in shape rather than from subsequent fracturing. This is indicated by the absence of fracture planes adequate to account for the observed irregularities. Furthermore, in several places in the Gold Hill mine ore bodies show less apparent displacement than neighboring dike contacts. Zones of crushing in the softened rock, mainly outside of the ore bodies, and local displacement of ore attest to movements subsequent to mineralization. Crushed and altered rock has locally added materially to the difficulty of keeping mine workings open, but, so far as available data show, postmineral displacements have nowhere been large enough to introduce any considerable complication in the search for ore.

## THE MINES

### GOLD HILL

#### LOCATION

The Gold Hill mine is on Granite Creek at the southern border of Quartzburg, near the center of sec. 9, T. 7 N., R. 4 E. Boise meridian, and is the principal mine controlled by the Talache Mines, Inc., of which A. H. Burroughs is president and manager. This company [20] has under lease and option the 19 patented and 26 unpatented claims of the Gold Hill & Iowa Mines Co. In 1930 operations were confined to work through the 700-foot Pioneer shaft, the deepest shaft in the Boise Basin. The Newburg mine, controlled by the same company, is described on page 264.

#### HISTORY [21]

Development on the Gold Hill group started in 1864, only 2 years after the discovery of the placer deposits of the basin. Some of the

[20] Campbell, Stewart, Thirty-second annual report of the mining industry of Idaho, for 1930, p. 102, 1931. This report also contains a description of the property by A. H. Burroughs, pp. 50–54.

[21] Summarized from the annual reports of the State mine inspector, published reports listed in the bibliography, and information supplied by Mr. A. H. Burroughs.

claims were patented as early as 1870. Most of the early work was confined to the Gold Hill vein, and its known ore shoots were so nearly exhausted that it was abandoned prior to 1900. Another vein, called the Last Chance, parallels the Gold Hill about 250 feet to the north. Most of the workings on this vein are on the west side of Granite Creek and are now caved and abandoned. Some of the old dumps and cuts northeast of Quartzburg are evidently on branch veins.

Diminishing ore reserves in the Gold Hill vein in the nineties led to exploration to the south and the discovery of the Pioneer ore bodies, but as the ore was of lower grade and more complex than in the Gold Hill little was done with it at that time. The mine was idle and full of water from 1900 to 1908. Since then the Pioneer ore bodies have been intermittently worked. The present company acquired control in March 1927. Unwatering the mine, reconstructing the mill, and doing preliminary development work occupied the time through the early part of 1929. Production was then maintained through early 1931, although operations were interfered with by a fire that destroyed most of Quartzburg in August 1929. The total production up to this time appears to have been fully $7,500,000. An even more destructive fire in 1931 temporarily halted operation, but underground development was promptly resumed.[22] The amount of development at the time of visit in 1930 is shown on plate 43, on which the old workings on the Gold Hill vein are incomplete. Subsequently development has continued on the 850 and higher levels, and the Pioneer shaft has been sunk to the 1,100-foot level. The latest work reported by Campbell is the start of a crosscut on that level toward the ore body.

### STRUCTURAL RELATIONS

The Gold Hill mine is in the midst of the "porphyry belt." The underground geology is illustrated in plates 44 and 45, which are based on the writer's mapping of the accessible workings supplemented wherever necessary by the excellent geologic mine maps of A. J. McDermid, who has also published a description [23] of the major features of the mine based on his studies as resident engineer.

In the mine workings the quartz monzonite of the Idaho batholith is intruded by two dikes of dacite porphyry, which appear to join in the eastern part of the mine. These are cut and locally split by two major dikes of rhyolite porphyry, which have several branches

[22] Campbell, Stewart, Thirty-third annual report of the mining industry of Idaho, for 1931, p. 91, 1932.

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

and offshoots. The irregularity of these intrusions is indicated by the marked differences in form in different parts of the mine (pls. 44 and 45). It seems probable that the two major rhyolitic dikes are linked together on the 400 level by a subsidiary dike (pl. 44, *B*). This interpretation has been adopted by McDermid [24] in his diagrammatic map of that level. The relations indicated in the two vertical sections in plate 45 suggest that below this level the major dikes first coalesce and then feather out downward in the western part of the mine. The long crosscut to the south on the 250 level crosses two rhyolite porphyry dikes not reached on any of the other levels. The granophyre porphyry dike in the southern part of the mine appears to be younger and somewhat less irregular than any of those previously mentioned. In addition, small diabasic dikes are exposed on the 100, 250, and 600 levels. The relations in the exploratory drift to the east on the 600 level (near the intersection of coordinates 2600 E. and 1300 N.) show that the diabasic dike here cuts the granophyre porphyry and hence is among the latest of the intrusions. Ore has been found in all the rocks above mentioned except the narrow diabasic dikes, which hence may be of later origin than the ore.

Both the major and subordinate sets of fissures formed subsequent to the intrusion of the dikes (pp. 251–252) are well represented on the property. The original Gold Hill vein and probably also the Roberts fault on the 250 level belong to the major set of fissures. The trend of some of the stopes in the Pioneer workings, especially on the 400 and 500 levels, corresponds in direction to this set, as is illustrated on plate 44, *B*, near the intersection of coordinates 1800 E. and 1000 N. Lindgren's descriptions [25] and the distribution of abandoned dumps and surface workings show that several other veins with similar trends were worked in the early days. All that received any considerable development are on the north or footwall side of the Gold Hill vein. None of them are now accessible underground.

As most of the Gold Hill vein was inaccessible, even to McDermid, and very little of it could be closely inspected during the writer's study, many details regarding it are lacking. The position and relationships shown on plates 44 and 45, including the variations in dip on section A–A, are, however, essentially correct. The vein has a developed length of about 3,500 feet in the main mine and a maximum thickness of about 6 feet and has been followed to a depth of about 400 feet. Its strike is N. 70°–75° E., and it dips steeply south. It consists of quartz lenses, mainly in granitic rock. Dikes of dacite and rhyolite porphyry are cut by it at angles of 15° to 20° within the mine workings (pl. 44), but farther east the

[24] McDermid, A. J., op. cit., fig. 2, p. 538.
[25] Lindgren, Waldemar, op. cit., pp. 691–693.

dikes appear to parallel the vein. In the early operations numerous stringers of good ore were found to project from the main vein into the porphyry on its south side, but when followed they were found not to be persistent.[26]

Stopes occupy an exceptionally large proportion of the developed length of the Gold Hill vein. As figure 33 shows, the over-all stope length is about 3,500 feet near the surface and decreases to about 1,000 feet at the 400-foot level, where stoping on this vein ceased. In addition, old stopes exist on the Gold Hill vein and branches of it at intervals both east and west of those in the main mine. These workings, however, are shallow, for the most part well within 200 feet of the surface, and yielded largely oxidized ore. The most conspicuous feature in surface cuts and stopes still open is the well-defined wall. The large stopes without much timber standing open at several levels near the old Gold Hill shaft are in striking contrast to the soft ground in many of the present workings.

On the 250 level a crosscut was carried farther south than anywhere else in the mine. This part of the mine is now inaccessible, but according to McDermid's unpublished map the crosscut crosses a fault zone (termed the Roberts fault) near coordinates 200 N. and 1500 E., over 650 feet south of the nearest stoping on that level (pl. 44, *A*). Except for a little pyrite on one seam, the map records no mineralization, but in attitude and relations to the rhyolite porphyry the fault resembles that followed by the Gold Hill lode. Further exploration to determine whether this fault is mineralized beyond the small area exposed by present drifts is worthy of consideration.

Most of the stopes in the Pioneer workings (the part of the mine south of the Gold Hill vein) are on ore bodies along fissures belonging to the second or subordinate set of postdike fractures (p. 252). Most of these ore bodies trend N. 30°–60° E., dip very steeply southeast, and pitch about 65° NE. Figure 33, which is adapted from a drawing by McDermid with recent work added, shows in generalized fashion the attitude of the ore bodies. However, it should be noted that in this figure the stopes are all projected onto a single vertical plane, resulting in a somewhat exaggerated appearance of continuity in depth. As the available data regarding the location of stopes are incomplete, the representation of ore bodies in plate 45 is incomplete also. Several of the masses of ore there indicated probably have much greater vertical dimensions than those shown.

As plate 44 shows, most of the ore bodies in the Pioneer workings have no direct interconnection. Their principal structural relationship consists in the fact that the fissures they follow all belong to

[26] Lindgren, Waldemar, op. cit., p. 692.

the same set of fractures in a regional fracture system. Although no connection between these individual ore bodies and the Gold Hill vein has been traced, their general relations and character suggest that the Gold Hill fissure may have been a master channel for the

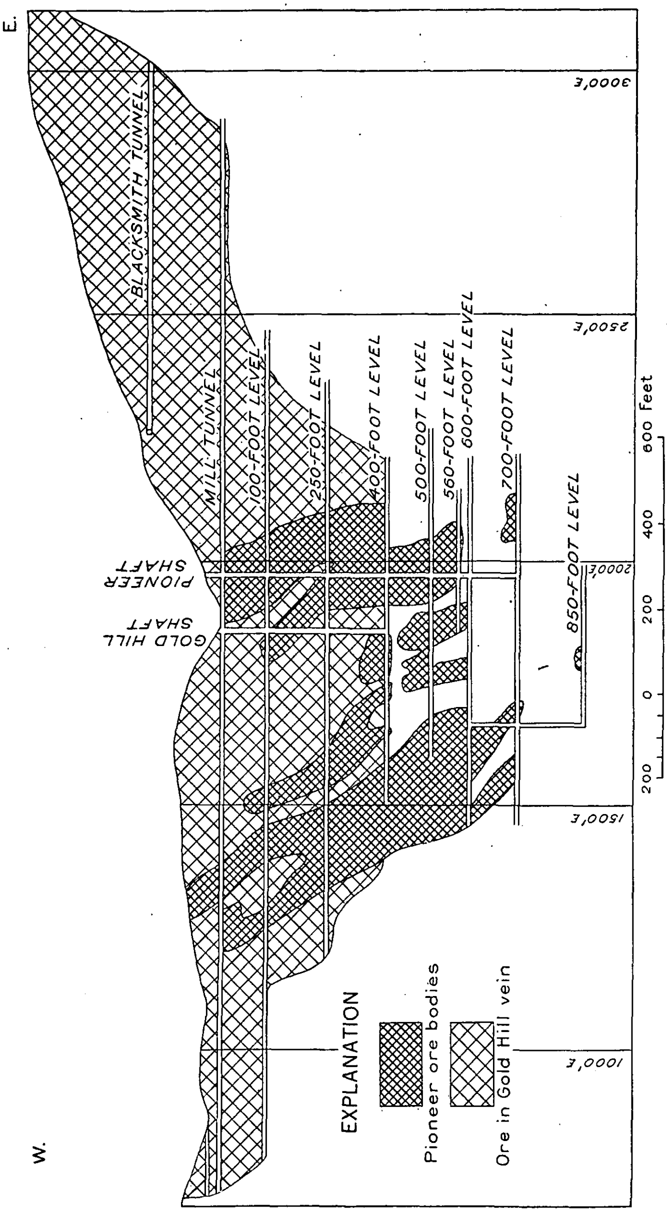



FIGURE 33.—Longitudinal vertical projection through the Gold Hill mine. From data by A. J. McDermid.

rising solutions which spread from it into the Pioneer fissures. The conditions on the 250 level along and south of the 1400 N. coordinate east of the Gold Hill shaft (pl. 44) are especially suggestive of such a relationship.

In most of the stopes in the Pioneer workings that were accessible in 1930 a large proportion of the valuable minerals were deposited in narrow subparallel seams. Daily observation by the engineering staff of the mine has shown that the trend of such series of seams generally makes an acute angle with the long axis of the stope, which is controlled in direction by the larger fractures already referred to. These relationships are shown in idealized fashion in figure 34, which

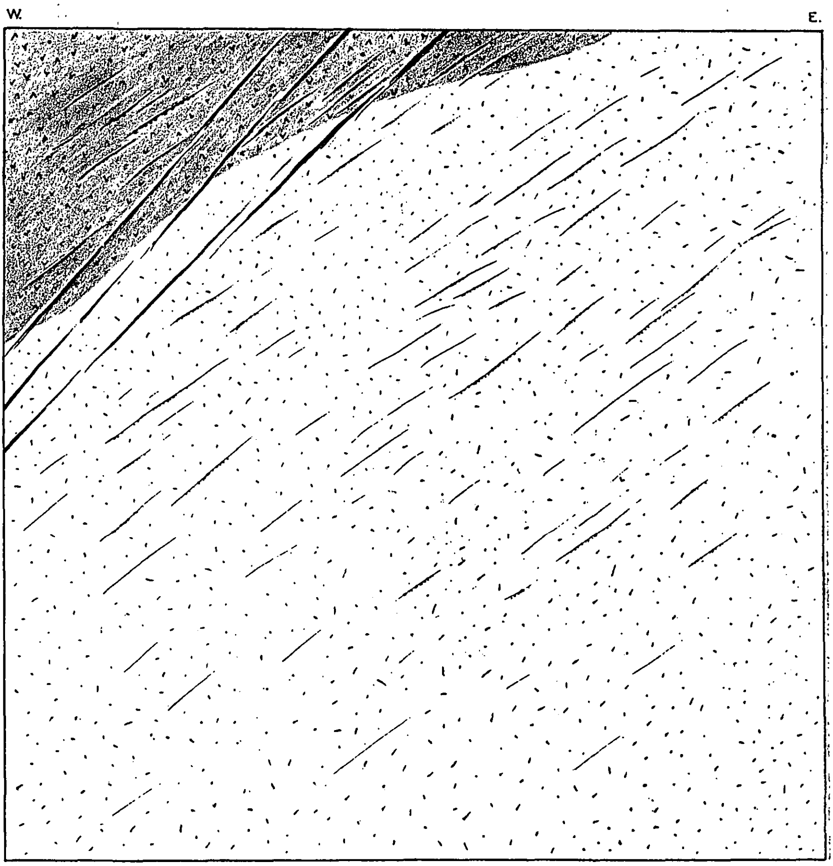



FIGURE 34.—Idealized relation of major and minor fractures and distribution of sulphides in an ore body in the Pioneer workings of the Gold Hill mine. (Corresponds roughly in area to a square set in a stope.) Lightly stippled area is rhyolite porphyry. Dark area is granitic rock.

does not represent any particular stope. The individual mineralized seams in such an ore body are rarely over a fraction of an inch wide and rarely persist much beyond a single square set, but many of the ore bodies, which consist of many closely spaced seams, are over 20 feet wide with stope lengths reaching more than 100 feet and vertical dimensions reaching 500 feet.

On the 700 and 850 levels conditions differ in detail from those in any of the ore bodies previously described. The deposits here, which had just begun to be developed at the time of the examination, may be intermediate in character between those of the Gold Hill vein and those of the Pioneer workings. Near the east end of the 700 level a stope exposes an individual vein a few inches wide containing high-grade ore for over 100 feet horizontally. This vein is in quartz monzonite, strikes N. 45° E., and stands nearly vertical. It resembles the Gold Hill vein except that it is smaller and does not have the same strike. Most of the developed portion of the vein is in the block bounded by coordinates 2100 and 2200 E. and 1400 and 1500 N. As can be seen from plate 43, it is thus almost vertically below the position of the Gold Hill vein on the upper levels. If the Gold Hill vein continued downward with the dip indicated in section A–A, plate 45, it should lie south of this vein on the 700 level and should have been exposed by the crosscut leading north from the Pioneer shaft. As noted on plate 44, *C*, there is some mineralized rock here, but nothing resembling the Gold Hill vein.

The sole mineralized material known on the 850 level at the time of visit is in the block bounded by coordinates 1900 and 2000 E. and 1200 and 1300 N., along the drift to the northeast shown in plate 43. In position and trend this would correspond closely to a southwestward continuation of the vein on the 700 level just described. On the 850 level the ore is in quartz monzonite. In the stope just above there is a rhyolite porphyry dike 6 inches to 5 feet thick. The ore lies in a group of minor seams such as those which characterize most of the deposits of the Pioneer workings, although the ore zone is somewhat narrower than most of those mined above. Development on the 700 and 850 levels subsequent to the examination here reported has led A. H. Burroughs,[27] the mine manager, to suggest that the two ore occurrences just described are parts of a single lode. The narrowness of the deposit and the fact that much of it is in quartz monzonite led him to regard it as resembling and possibly related to the Gold Hill vein.

### ROCK ALTERATION

All the rocks in the Gold Hill mine are altered—the basic dikes least and the rhyolite porphyry most. Increase in alteration has been found by experience to indicate approach to an ore body. The alteration consisted mainly in sericitization of the feldspar and bleaching and decomposition of the mica. Calcite is widely but rather sparsely developed. Pyrite crystals are sparsely disseminated through the altered rock, especially near the ore bodies. In one of

[27] Burroughs, A. H., Talache Mines, Inc., operations at Gold Hill mine, Quartzburg, Idaho, in Campbell, Stewart, Thirty-second annual report of the mining industry of Idaho, for 1930, pp. 50–51, 1931.

the old prospect cuts northeast of Quartzburg tremolite occurs in mineralized rock.

The greater susceptibility to sericitic alteration displayed by the rhyolite porphyry may be the major factor that controlled deposition in it of most of the larger ore bodies in the Pioneer workings. Wherever an ore body passes from the rhyolite porphyry into any of the other rocks the tenor decreases so markedly that few stopes have penetrated far into such rock. The granophyre porphyry, the latest of the silicic rocks, appears to have been less favorable to ore deposition than either the dacite porphyry or the quartz monzonite. The fundamental difference between ore and altered country rock along any of the shear zones in the Pioneer workings is in the proportion of minor seams at an angle to the main shearing. As already noted, a large part of the metallic minerals was deposited along these seams, although there was also some dissemination through the altered rock. Such seams might well increase in proportion to the softening of the rock as a result of alteration. At all events, as McDermid [28] says, both alteration and fracturing were essential to the formation of the ore bodies.

## VEIN MINERALS

Most of the veinlets that compose the greater number of the ore bodies consist of quartz, with locally some gougelike material. In some places, notably the stope near the northeast end of the 700 level, there are seams filled with soft white material that resembles clay in appearance. Its microscopic characteristics, however, are those of sericite mica. Some of this material, freed as far as possible from admixed quartz and dried at 105° C., was found by Charles Milton, of the United States Geological Survey, to contain about 4.5 percent of potash ($K_2O$) and only 0.2 percent of soda ($Na_2O$). As this is a low content of alkalies for pure sericite, the material is doubtless somewhat kaolinized.

The metallic minerals are disseminated through the quartz of the seams and even more sparsely in the altered rocks. Rarely seams are composed essentially of pyrite, or even more rarely of galenobismutite. The hypogene metallic minerals identified in the ore include pyrite ($FeS_2$), galenobismutite ($PbS.Bi_2S_3$) and related minerals, sphalerite ($ZnS$), galena ($PbS$), tetradymite ($Bi_2TeS_2$), and native gold.

It is reported that pyrite was more abundant on the upper levels than it is in the present stopes. The pyrite is regarded locally as one of the sources of the gold in the ore. This view is strengthened by the fact that a sample of pyrite taken from a seam on the 100

[28] McDermid, A. J., op. cit., pp. 538, 539.

level outside of the stoped area, assayed in the laboratory of the Geological Survey, was found to contain 0.205 ounce of gold and 4.33 ounces of silver to the ton.

The principal bismuth mineral in the material obtained during the present investigation is galenobismutite ($PbS.Bi_2S_3$) or a closely similar mineral, according to microscopic tests by M. N. Short. There are slight differences in the color of different grains of this material, but they do not appear to record differences in composition. Ballard[29] states that there are several sulphide minerals of bismuth in the ore bodies near Quartzburg, including bismuthinite ($Bi_2S_3$), beegerite ($6PbS.Bi_2S_3$), cosalite ($2PbS.Bi_2S_3$), lillianite ($3PbS.Bi_2S_3$), and others. In support of this statement he presents photomicrographs of etched polished sections, some of which show considerable heterogeneity in appearance. Although the precise character of the bismuth mineral is therefore somewhat variable, the essential fact is that it is an isomorphous mixture of the sulphides of lead and bismuth. Tetradymite ($Bi_2TeS_2$) was identified by M. N. Short, but, in the specimens available, is visible only under the microscope and is probably nowhere abundant.

Although the gold content of the ore varies roughly in proportion to the pyrite and particularly the galenobismutite, it is clear that nearly all the gold is in the native state. This is proved by the fact that fine grinding and long exposure to the action of mercury results in the recovery of 95 percent of the gold by simple amalgamation, although much of the ore contains no visible free gold.[30] Wherever in the Pioneer workings the gold is coarse enough for its relations to the sulphide minerals to be observable under the microscope, it is so intricately intergrown with them as to show that it was formed under essentially identical conditions. This is illustrated in plate 46, which is a copy of Ballard's plate 8.

The ore mined in 1930 averaged $15 to $20 to the ton, with a few high-grade pockets. The stope limits are fixed by the grade of the ore, not by natural boundaries. Although here, as in many other gold mines, the samples vary markedly in tenor, systematic assaying has been found by the present management to be the most reliable guide, contrary to former practice. Such local decreases in average tenor as that which was found in the vicinity of the 600 level in the Pioneer workings[31] or that which caused cessation of work on the Gold Hill vein at the 400 level are to be expected, but so far as can be judged from present data ore deposition may well have continued far below the deepest existing development. The

[29] Ballard, S. M., Geology and gold resources of Boise Basin, Idaho: Idaho Bur. Mines and Geology Bull. 9, pp. 35–36, 1924.

[30] Burroughs, A. H., op. cit., pp. 51–54.

[31] Idem, p. 50.

changes in geologic conditions that are being found below the 700 level may, however, have exerted a material influence on the ore deposition from this level downward. The rhyolite porphyry dikes, which are so favorable at higher levels, appear to feather out near the 850 level, though it is obvious that downward extensions of them toward their original magmatic source must somewhere exist. The sections in plate 45 indicate that the downward projection of the Gold Hill vein should have crossed both of the two principal rhyolite porphyry dikes at about the depth of the 850 level.

The foregoing discussion indicates that the ore bodies characteristic of the Pioneer workings resulted from deposition mainly in these dikes of emanations from the Gold Hill vein which followed a subordinate set of fractures into the hanging wall of that vein. According to this interpretation structural conditions favorable to this type of deposit may not have existed below the 850 level in the immediate vicinity of the present workings. Both the crosscut to the south on the 250 level (pl. 44, A) and surface exposures (pl. 40) prove, however, that similar dikes exist farther south. These may have furnished favorable sites for ore deposition at greater depths. The two rhyolite porphyry dikes in the crosscut on the 250 level, if continued downward approximately parallel to those in the workings, should reach the position of the downward extension of the Gold Hill vein at least 200 and 500 feet, respectively, below the 850 level.

## MAYFLOWER

The Mayflower group of 12 claims (pl. 39) adjoins the Gold Hill group on the southwest. There are a number of short tunnels and two or more lodes on this property, but recent development has been concentrated on one set of workings on the east side of the West Fork of Granite Creek a mile above its mouth. These workings, as shown in figure 35, comprised in May 1930 a tunnel 600 feet long, a drift 360 feet long about 110 feet below the tunnel, and a shaft about 150 feet deep and inclined 78° connecting the tunnel and drift.

The vein has an average strike of N. 35° E., dips 70°–90° NW., and ranges from a few inches to 3 feet or more in width. The principal country rock is altered quartz monzonite, but in the lower drift, as shown in figure 35, there is a dike of sheared and pyritized porphyry that appears to be a somewhat calcic variety of the rhyolite porphyry, and similar dike rock is abundant in the southwest end of the tunnel. The inner 240 feet of the tunnel is in granitic gravel, compacted but uncemented. The vein stops abruptly at the contact, and there is no suggestion of mineralization within the gravel. Evidently the gravel is part of the high-level gravel de-

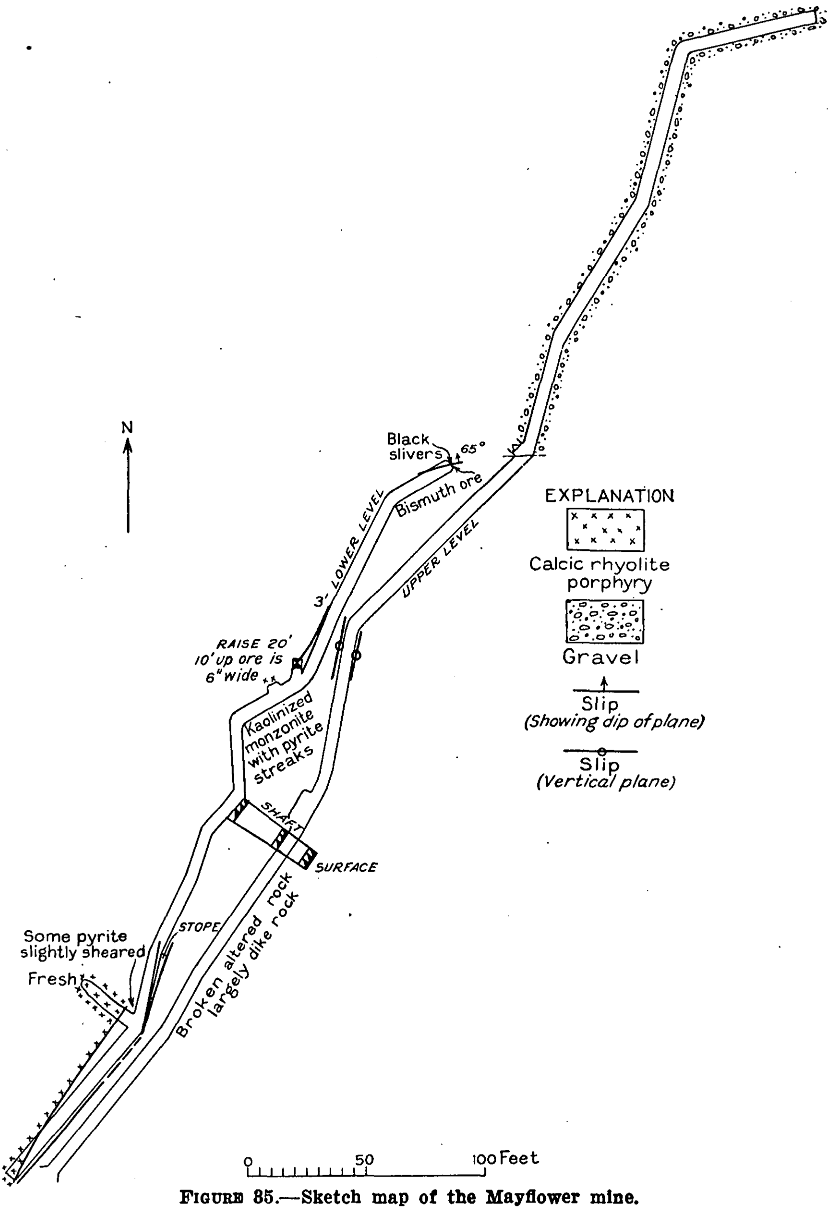



FIGURE 85.—Sketch map of the Mayflower mine.

posits which, as shown on plate 40, are extensive in this vicinity, and is much later than the ore deposits. The abundant detritus and vegetation on the surface prevented tracing the gravel in detail, but it presumably occupies a steep-sided ancient channel cut in the mineralized rock.

Ballard [32] states that the Mayflower vein was discovered in the early eighties by placer miners and has yielded more than $15,000. The mine was closed at the time of his study (1923) but was in operation in 1929 and 1930, when a little ore was mined. The hypogene metallic minerals in the ore exposed when visited in May 1930 were mainly pyrite, galena, and sphalerite. Bismuth minerals are reported to have been abundant in some of the high-grade pockets encountered earlier in the present development. The ore in the lower drift, 150 feet below the surface, shows incipient oxidation.

### NEWBURG

The Newburg mine is about half a mile east of the Belshazzar camp. It is controlled by Talache Mines, Inc., but has not been worked for a long time and is caved. The open cut here, which apparently follows the vein, trends N. 65° W., mainly in rhyolite porphyry.

### BELSHAZZAR

#### LOCATION

The Belshazzar mine, owned by the Idawa Gold Mining Co., comprises 22 unpatented claims [33] on upper Fall Creek, mainly in secs. 17 and 18, T. 7 N., R. 4 E. Boise meridian (pl. 39). The camp and mill are near the old road to Jerusalem, 4 miles from Placerville and less than 3 miles from Quartzburg. The principal workings are over 400 feet vertically up the slope to the southwest and are connected with the mill by a tramway.

#### HISTORY

The surface was worked by placer methods in the seventies, and $60,000 was recovered.[34] In 1905 to 1909 the three upper tunnels were opened and $25,000 was recovered by amalgamation, concentrates being stored for future treatment. Since 1917 the present company has operated the mine. In 1921 tunnel 5, at the level of the mill, was driven at a reported cost of $250,000. This tunnel, with its crosscuts, has a length of over 3,000 feet. A vein, presumably the lower extension of the Belshazzar, was found, but al-

[32] Ballard, S. M., op. cit. (Bull. 9), p. 69.

[33] Campbell, Stewart, Thirty-third annual report of the mining industry of Idaho, for 1931, p. 89, 1932.

[34] Ballard, S. M., op. cit. (Bull. 9), p. 59.

though good assays were obtained in places, the quantity of ore was small. The 401 tunnel, the present operating level, was next driven, and most of the recent production has come from stopes between the 401 and no. 3 levels, although connection has been made with tunnel 5, 400 feet below, and a little ore has been mined from two intermediate levels, of which the lower is 140 feet below the 401 level. The numbering of levels adopted in the above description and in plate 47 is that now in use by the company. In 1930 the mill heads averaged about $10 a ton, but at times pockets of extremely high-grade ore have been found. From 1926 to 1930, inclusive, 27,116.32 ounces of crude bullion, valued at $402,270.29, was shipped to the United States assay office at Boise, and concentrates yielded a total of $63,253.87, of which $48,605.60 was in gold and $14,648.27 in silver. From January 1 to April 5, 1931, there was shipped 1,564.27 ounces of bullion, valued at $24,193.74, and concentrates containing $4,430.03 in gold and $370.85 in silver.[35]

### STRUCTURAL RELATIONS

The quartz monzonite of the Idaho batholith, containing a few pegmatite stringers, is the principal wall rock and is cut by later dikes of at least three kinds. The most abundant of these dikes underground in the mine is a light-colored rhyolite porphyry similar to but somewhat more calcic than the rhyolite porphyry of the Gold Hill mine. Sericitized phenocrysts of sodic plagioclase, 3 to 15 millimeters long, compose 25 percent of the rock. Quartz phenocrysts are absent except in a few places. Altered mica, in part originally biotite, makes up 5 or 6 percent of the rock. The groundmass is a fine granular aggregate of quartz and sericitized feldspar in roughly equal amounts. This rock forms irregular branching dikes, which are cut by the lodes (pl. 47). One dike, with a maximum width of about 60 feet, extends diagonally through the mine, mainly to the east of the principal stopes. It has a curved course averaging somewhat north of west, and its dip ranges from nearly vertical to 45° S. More irregular and smaller masses of similar rock are exposed at intervals in and west of the stoped area. They doubtless represent branches of the large dike. The drift on the 401 level well to the south of the other workings cuts two masses of the rhyolite porphyry, one of which appears to be part of a dike considerably wider than any exposed elsewhere in the mine.

In the drift on the 401 level that exposes the eastern extension of the main vein there is a pinkish porphyry dike which evidently corresponds to the granite porphyry on the surface (pl. 40), although underground it is rather fine grained and probably of smaller dimen-

[35] Nordquist, E. A., letter of Apr. 14, 1931.

sions, being perhaps an offshoot of the large mass above. It contains altered phenocrysts of feldspar and mica (mainly biotite), with a few of quartz, in a groundmass consisting mainly of micropegmatite. Like the rhyolite porphyry, it was intruded prior to the mineralization.

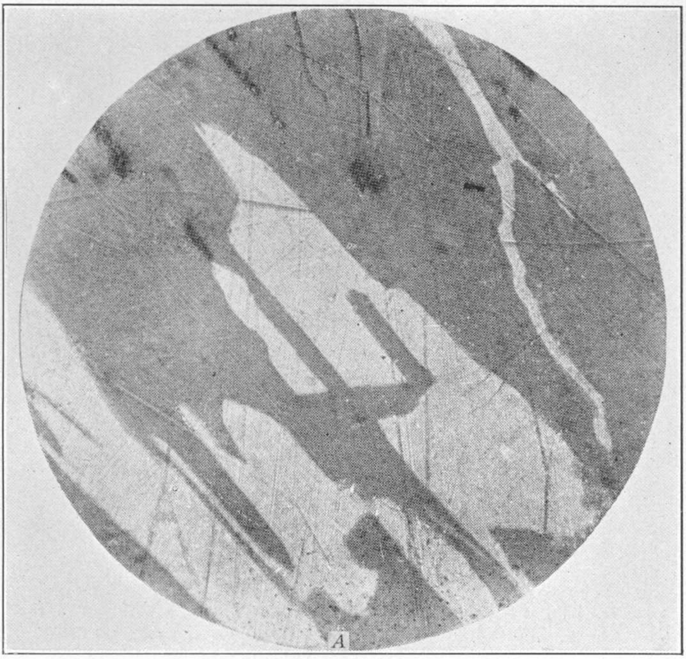
Several small dark-colored diabasic dikes from a few inches to 8 feet in width are disclosed in the workings and apparently are everywhere later than the ore. Near the west end of the intermediate level above the 401 level stringers of diabase follow faults that offset pyrite seams.

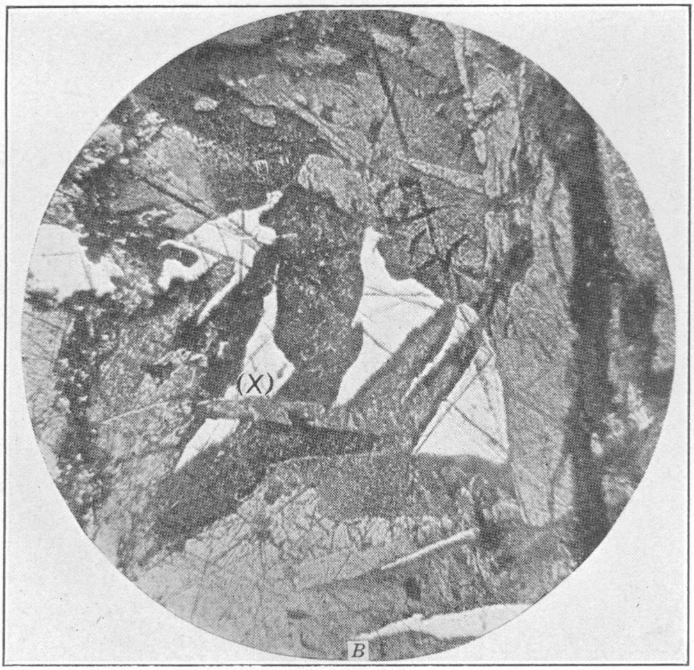
Two lodes, the Belshazzar and Centennial, are exposed in the mine, but the Centennial has been followed only on the 401 level (pl. 47) and has not been stoped. The lodes strike N. 70°–75° E. and dip south. A parallel lode about 600 feet north of the Belshazzar has received almost no development.[36] The average dip of the Belshazzar lode, as judged from the mine workings, is about 30° from level 1 to the intermediate level below level 3, and 50° to over 60° thence downward. The shearing planes along the Centennial lode are steeply inclined. All three lodes correspond in attitude to the main system of postdike fissures (p. 252).

As plate 47 shows, there are numerous slips of diverse trends independent of the shearing followed by the lodes. Some of these trend essentially parallel to the main shearing, but others strike across it, commonly without appreciable displacement. Some of the crosscutting slips correspond in trend to the second set of fractures mentioned in the discussion of the regional structure (p. 252), but so far as the present workings show this set is less well developed here than in the Gold Hill mine. Some of the slips are mineralized, but most are not. Some postore movement has taken place, but the displacements are small, and it is probable that nearly all the fractures originated prior to the mineralization. Most of the dike contacts show evidence of movement, and some of these have been mineralized.

The Belshazzar lode is a shear zone from a few inches to 4 feet wide. As is indicated on plate 47, it is not continuously mineralized, there being considerable stretches along the drifts in which the lode is marked only by shearing and a little gouge. The irregular shape of the ore bodies in the Belshazzar lode is illustrated in plate 47, although the mapping of the stopes is somewhat incomplete. Stoping had not yet commenced below the 401 level at the time of visit in 1930, but some ore had been mined in driving the intermediate drifts in that part of the mine. Ballard[37] has pointed out that the known ore bodies lie close to intersections between the lode and dikes. The dikes in this vicinity are, however, so numerous and

[36] Ballard, S. M., op. cit. (Bull. 9), pp. 58–59.
[37] Idem, pp. 41–42, 60.




PHOTOMICROGRAPHS OF ORE FROM GOLD HILL MINE.

From Idaho Bur. Mines and Geology, Bull. 9, pl. 8. *A*, Light gray, native gold; dark gray, bismuth sulphide, reported to be mainly lillianite. *B*, Lightest-colored areas, native gold; dark veinlet on right, quartz; rest of section, bismuth sulphide, which shows various shades of gray as a result of etching with hydrochloric acid fumes. X marks point where the bismuth mineral appears to cut the gold. Both enlarged 195 diameters.

irregular that such rough correspondence as exists has little bearing on the localization of ore shoots. Much of the ore is in the granitic rock. Premineral cross fracturing may have had quite as potent an influence as dike intersections in the localization of ore shoots. Hence it may be that here, as in the Gold Hill vein, it is not necessary to confine exploration to the immediate vicinity of dikes. On the other hand, ore bodies analogous to those in the Pioneer workings have not yet been sought in the Belshazzar mine. The general geologic conditions are so similar that it is quite possible that ore bodies of the Pioneer type may lie somewhere in the larger rhyolite porphyry dikes in the hanging wall of the Belshazzar lode.

### MINERALOGY

The wall rocks in the Belshazzar have been sericitized and locally carbonatized in a manner similar to the alteration in the Gold Hill mine, but less intensely. The lodes are shear zones more definitely bounded and continuous than the Pioneer ore bodies but without such persistent quartz lenses as appear to characterize the Gold Hill vein. Quartz seams follow the shearing planes, and most of the valuable minerals lie in the quartz. Pyrite is the most abundant metallic mineral and, according to assays quoted by Ballard,[38] has gold associated with it. Many of the irregular pyritic stringers contain little quartz. In some places, as near the east end of the Belshazzar vein on the 401 level, pyrite cubes over half an inch wide are distributed through sheared quartz monzonite. Arsenopyrite is locally abundant, especially in some of the high-grade pockets containing native gold. There is a little pyrrhotite in the arsenopyrite ore. Locally sphalerite, with minor amounts of galena, fills the interstices in shattered pyrite. Bismuth has been found in several places but is far less abundant than in the Gold Hill mine. Shannon's determination of galenobismutite from this mine[39] is the first recorded recognition of the presence of bismuth minerals in the ore of the district.

Most of the gold occurs in the metallic state, although commonly so fine-grained as to be difficult to detect even with the most careful panning. From 70 to 75 percent of the gold is recovered by amalgamation.[40] Tests to determine the best way to recover the remainder from the concentrate had not been completed at the time of visit in 1930. In contrast to the extreme fineness of much of the gold, pockets

[38] Ballard, S. M., op. cit. (Bull. 9), pp. 59–61.

[39] Shannon, E. V., On galenobismutite from a gold quartz vein in Boise County, Idaho; Washington Acad. Sci. Jour., vol. 11, pp. 298–300, 1921; The minerals of Idaho: U.S. Nat. Mus. Bull. 131, pp. 147–148, 1926.

[40] Campbell, Stewart, Idawa Gold Mining Co., Belshazzar mill, in Twenty-ninth annual report of the mining industry of Idaho, for 1927, pp. 38–39, 1928.

containing coarse pieces are occasionally found. One of the largest of these rich pockets was mined in 1928 near the intermediate level above the 401 level. This is well below any evidence of oxidation. Specimens of the material consist of coarse arsenopyrite crystals projecting into open cavities, with the gold deposited on the surface of the crystals and also intricately intergrown with the arsenopyrite in the walls of the cavities. Though at least some of the gold may have formed after the arsenopyrite began to crystallize, the relations are so intimate as to indicate that the two formed under essentially similar conditions and almost simultaneously.

## MOUNTAIN CHIEF

The Mountain Chief mine is on a tributary of Canyon Creek at the southwest end of the known mineralized area in the "porphyry belt." The lode was located in 1870 and worked almost continuously until 1915.[41] The property comprises 11 unpatented claims and in 1928 and 1929 was reopened by the Federated Mines Co.,[42] but that company's operations terminated in the summer of 1929. In 1931 the mine was reopened by the Ideal Mining Co. and a small amount of ore was mined.[43] The principal developments comprise five tunnels, of which nos. 1 to 3 are caved. Tunnel 4 was open for a distance of about 600 feet in 1930 but is tightly timbered. The lowest tunnel, reported to be over 2,000 feet long, was open when visited but could not be entered on account of lack of ventilation.

The country rock is quartz monzonite cut by rhyolite and granophyre dikes (pl. 40). In a crosscut near the portal of tunnel 4 rhyolite porphyry is cut by stringers of a dark diabasic rock. The lode in tunnel 4 strikes N. 60° E. and dips 50° SE. It is probably the western extension of the Belshazzar. Ballard[44] notes that six basic dikes similar to that near the portal trend across the vein in the ore zone, but exposures were inadequate to permit him to determine age relations. He states that bismuth minerals were abundant in the ore. Tunnel 5, the lowest one, was driven to a point below tunnel 4, but no connection was made. It is reported that several bunches of ore were found, some of which assayed as much as $100 to the ton. Ore on the dump has a gangue of coarsely crystalline quartz with numerous cavities into which quartz crystals project. Barite is sparingly present. Coarsely crystalline pyrite, arsenopyrite, and stibnite are abundant, and there is some galena, sphalerite, and pyrrhotite.

---

[41] Ballard, S. M., op. cit. (Bull. 9), p. 61.

[42] Campbell, Stewart, Thirty-first annual report of the mining industry of Idaho, for 1929, pp. 100, 102, 1930.

[43] Campbell, Stewart, Thirty-third annual report of the mining industry of Idaho, for 1931, p. 89, 1932.

[44] Ballard, S. M., op. cit. (Bull. 9), pp. 61–62.

### BLUE ROCK

The Blue Rock group is on Confederate Gulch about 2 miles northwest of Quartzburg, beyond the limits of the mapped area. There are several cuts and tunnels here, but the largest working seen is a crosscut tunnel over 100 feet long connecting with a drift, which is open for about 170 feet, trending N. 60°–65° W. The drift is on a shear zone approximately parallel to the major joints in the monzonitic country rock, which includes lenses of massive white quartz 2 feet and more in width containing bunches of coarse-grained sulphides, mainly galena and sphalerite, with some tetrahedrite.

Nearly 300 feet vertically and perhaps 500 to 600 feet horizontally to the north there are short workings on another vein, which trends N. 50°–60° W., dips about 55° W., and is composed of quartz lenses, in part shattered and bordered with gouge, in partly silicified and pyritized quartz monzonite. The coarse granular quartz of the lenses contains pyrite, sphalerite, galena, tetrahedrite, and chalcopyrite. This vein is exposed at intervals for several hundred feet, and locally the quartz is several feet thick. It presumably belongs to the Silver Hill property, adjoining the Blue Rock.

### COMEBACK

The Comeback mine is on the ridge between Clear Creek and Charlotte Gulch, as shown approximately on plate 39. It is reached by an extremely steep road about a mile long, which branches from the highway along Grimes Creek some 3 miles north of Pioneerville. According to the manager, Louis Painich, the lode was discovered and located in 1924 and has produced ore of a gross value of about $40,000. The developments comprise four short and irregular tunnels. The lowest (tunnel 4) exposes the lode for about 800 feet. The vein strikes N. 65° E. and dips steeply northwest. About 40 feet southeast of the main drift on this level a parallel zone of mineralization has been drifted on. At one place stoping has been carried from level 4 through to the surface, a vertical distance of about 127 feet, but the stopes are small, as so far only the highest-grade ore has been sought.

The country rock belongs to the Idaho batholith but is more silicic than most of the granitic rock in the Boise Basin. It contains about 50 percent of microcline, 32 percent of oligoclase, 16 percent of quartz, and 2 percent of biotite, with a little myrmekite. In the principal shear zone on level 4 there is a small lamprophyric dike, which has been altered and pyritized but nowhere has been found to contain ore. The dike consists essentially of a mat of tiny sericitized labradorite laths with a little interstitial quartz. It contains some secondary calcite.

At one place on level 4 dacite porphyry appears to cause a pinch in the ore body. This fact and the striking freshness of the porphyry suggest that it was intruded subsequent to the mineralization, contrary to the relation existing in the Quartzburg area.[44a] The rock differs little in composition from the dacite porphyry of the Quartzburg area. The groundmass constitutes over 60 percent of the rock and consists mainly of plagioclase in grains averaging about 0.02 millimeter. The phenocrysts are 2 to 3 millimeters in maximum dimension and comprise 54 percent of oligoclase-andesine, 19 percent of quartz, 22 percent of biotite, and 5 percent of hornblende.

The ore differs materially in character from that in the mines of the Quartzburg area. Much of that being mined is rather massive, rudely banded sulphide ore consisting mainly of pyrite, galena, and sphalerite, with spots of chalcopyrite in a gangue of coarsely crystalline quartz. The pyrite is in distinct crystals and far less shattered than is common in the lodes near Quartzburg. Locally the ore contains pyrargyrite ($Ag_3SbS_3$) and arsenopyrite. An assay of a hand sample from level 4 is reported to show 48.2 ounces of gold and 217.7 ounces of silver to the ton, 2.4 percent of lead, and 1.09 percent of copper. Some of the ore on the dump at the time of visit contained more lead than this. A carload of ore shipped in December 1928 is reported to have had a gross value of $237.62 a ton, principally in gold, and some small shipments have been even richer. This high-grade ore appears to be restricted to small pockets, but there is a considerable amount of lower-grade material, which, in the absence of a mill, is being left unmined.

## MINERAL MINING CO.

The Mineral Mining Co.[45] controls 12 patented and 22 unpatented claims on Charlotte Gulch, in the northeastern part of the Boise Basin (pl. 39). The present development is on the west side of the gulch, in a tunnel below the old Enterprise workings, which are now caved. This tunnel passes through a spur of the hill and, with its crosscuts, has a length of nearly 1,200 feet. Raises had been driven to a maximum height of about 60 feet above the tunnel, and stoping from them was in progress when the mine was visited in June 1930. One of the raises reaches the surface. The lode consists of a shear zone in altered granitic rock with local quartz lenses. It strikes N. 40°–70° E. and dips 45° and more to the southeast. Although rhyolitic and granitic porphyry are present nearby, none has been found in the present workings. The descriptions of the older

[44a] See footnote 53a, p. 273.

[45] Campbell, Stewart, Thirty-first annual report of the mining industry of Idaho, for 1929, p. 102, 1930.

workings here and nearby, given by both Jones [46] and Ballard,[47] show that the porphyry dikes here as elsewhere in the basin are older than the ore. There is a basic dike in the present workings which is so altered as to indicate that it also was intruded prior to the mineralization.

Intensely sericitized and kaolinized granitic rock with irregularly disseminated sulphides constitutes most of the ore being mined at the time of visit, although locally there are quartz seams and lenses. The ore is reported to average $12 to $15 to the ton, mostly in gold, but locally it contains as much as 10 percent of lead and considerable zinc. The ore milled is reported to yield about 1 ounce of silver to the unit of lead. The sulphides in the ore being mined include pyrite, galena, sphalerite, chalcopyrite, and either tetrahedrite ($Cu_3SbS_7$) or tennantite ($Au_8As_2S_7$), listed in the order of decreasing abundance.

### MISSOURI

The Missouri mine is on upper Muddy Creek nearly 4 miles by road north of Placerville (pl. 39). The property comprises 10 claims.[48] It has been known for a long time and was originally located as placer ground,[49] but the present campaign of development started in 1929. Work has been carried on in the past in several places, apparently prospecting different lodes, but the principal workings under development in 1929 and 1930 comprise a shaft about 200 feet deep on the incline and drifts from it on the 40, 100, 150, and 200 foot levels, as shown in plate 48. This map also shows the previous development along the same lode farther northeast.

The lode is a shear zone in altered quartz diorite, which consists of more than 70 percent of labradorite, probably with a little orthoclase, and nearly 10 percent each of biotite, hornblende, and quartz. At one place in the shear zone on the 100 level there is a fine-grained pink rock cut by quartz stringers. This rock consists mainly of quartz and oligoclase with some orthoclase and looks more like an aplite than any other seen. Dikes of dacitic porphyry occur in the vicinity but are not exposed in the workings examined. The average strike of the lode is N. 35° E., and the average dip is 70° NW., although it ranges from 50° to 85°, and local seams dip steeply southeast. On the 100-foot level there is a split in the lode, and on the 200-foot level two parallel shear zones 65 feet apart are exposed. Ore has been found on the 40-foot and 100-foot levels and has been followed in a 35-foot winze below the 100-foot level to a point where

[46] Jones, E. L., op. cit., pp. 108–111.
[47] Ballard, S. M., op. cit. (Bull. 9), pp. 75–88.
[48] Campbell, Stewart, Thirty-first annual report of the mining industry of Idaho, for 1929, p. 102, 1930.
[49] Ballard, S. M., op. cit. (Bull. 9), p. 88.

it pinches out. Ore was also encountered and stoped in the workings in the northeastern part of the mine, shown in plate 48.

The hypogene metallic minerals noted comprise shattered pyrite with galena and sphalerite of somewhat later origin in a gangue of quartz and altered diorite. Most of the ore so far mined is somewhat oxidized, and some of the high-grade streaks contain wire silver, probably supergene.

## TYPES OF MINERALIZATION

It is clear from the foregoing descriptions that at least three distinct types of mineralization are represented by the lodes examined, which include (1) lodes characterized by coarse-grained quartz and sporadic sulphides, without known relation to the porphyry dikes; (2) lodes characterized by relatively abundant sulphides and probably antedating the dikes; (3) lodes related to and later than the intrusion of the dikes. Of these, the first two, like most of the other ore deposits of the State, are believed to be related to the Idaho batholith and are therefore assigned to the earlier group of ore deposits; the third type, and in this area the most valuable, being closely associated with dikes that are correlated with middle Tertiary (Miocene) intrusions elsewhere in Idaho, is assigned to the later or Tertiary group.[50]

A somewhat similar triple classification has been proposed by Ballard.[51] The fact that, as shown below, there are certain material differences between the diagnostic features of his classification and those of the one here proposed suggests that more complete data on the lodes of the Boise Basin would show that more than three types are present.

The Blue Rock lode and the similar lode nearby are the only representatives of the first type observed during the present examination. These isolated occurrences are outside of the porphyry belt and are related to northwesterly joints in comparatively little sericitized quartz monzonite. The ore has some resemblance to that of the Mountain Chief, but the quartz is more massive, the sulphides are less abundant and somewhat different, and the wall-rock alteration has been less intense than in any of the Tertiary lodes in the basin. These facts and the comparatively close resemblance to Mesozoic lodes in the Warren and Marshall Lake districts, Idaho County, indicate that the Blue Rock and its neighbor may be genetically related to the Idaho batholith. Ballard's statement[52] that veins of this type elsewhere in the Boise Basin contain pegmatite supports

[50] Ross, C. P., A classification of the lode deposits of south-central Idaho: Econ. Geology, vol. 26, no. 2, pp. 169–185, 1931.

[51] Ballard, S. M., op. cit. (Bull. 9), pp. 39–42.

[52] Idem, p. 40.

this conclusion and links the veins with molybdenite deposits in the vicinity of Rocky Bar, Elmore County,[53] which are closely related to pegmatite of the age of the Idaho batholith. Most of the molybdenite deposits contain pyrite, with which considerable gold and silver are associated.

The second type is represented by the Comeback.[53a] This lode is within the "porphyry belt" and, like most of the other lodes in that belt, strikes northeast, but the character of the ore and the relation to the Miocene(?) dacite dike show that the Comeback lode is fundamentally different from most of the lodes in that belt. Mineralization here appears to have preceded intrusion of the Miocene(?) dikes but was later than a lamprophyric dike that is presumably related to the Idaho batholith. This lode thus accords in age with Ballard's second type of lodes.[54] However, the absence of aplite and the more intense sulphide mineralization set the Comeback apart from that type. Furthermore, the lodes of Ballard's second type strike northwest instead of northeast. The presence of ruby silver relates the Comeback to the relatively rare group of lodes contemporaneous with the Idaho batholith that contain such minerals.[55]

The third group includes all the other deposits examined, although, as the descriptions show, subdivisions could be established on the basis of differences both in structural relations and in mineralogy. Most of the deposits are veins with rather definite lateral limits. They vary in dip, but most of them are inclined to the southeast at angles that range from 30° to vertical. They might be further subdivided according to strike, for many strike approximately N. 70° E., whereas others have an average strike of about N. 35° E. Both sets of shear planes are minor components of a major zone of disturbance, approximately of Miocene age, which stretches diagonally across south-central Idaho.[56] Most of the ore deposits in the Pioneer workings of the Gold Hill mine are structurally different from the others in this group in that they represent deposition guided by partings subordinate to the major fractions that have been occupied by the greater number of the known deposits. It appears entirely possible that deposits similar to those of the Pioneer workings exist

[53] Schrader, F. C., Molybdenite in the Rocky Bar district, Idaho: U.S. Geol. Survey Bull. 750, pp. 92–93, 1925.

[53a] Recent work by A. L. Anderson shows that similar lodes in the nearby Banner district are definitely younger than the Tertiary dikes, and he believes, on the basis of recent exposures in the Comeback mine, that the ore here is later than the dacite dike. This necessitates revision of the age assignment suggested in the text.

[54] Ballard, S. M., op. cit. (Bull. 9), pp. 40–41.

[55] Ross, C. P., The Vienna district, Blaine County, Idaho: Idaho Bur. Mines and Geology Pamphlet 21, April 1927. Ballard S. M., Geology and ore deposits of the Rocky Bar quadrangle, Idaho: Idaho Bur. Mines and Geology Pamphlet 26, March 1928.

[56] Ross, C. P., Geology and ore deposits of south-central Idaho: U.S. Geol. Survey Bull. — (in preparation).

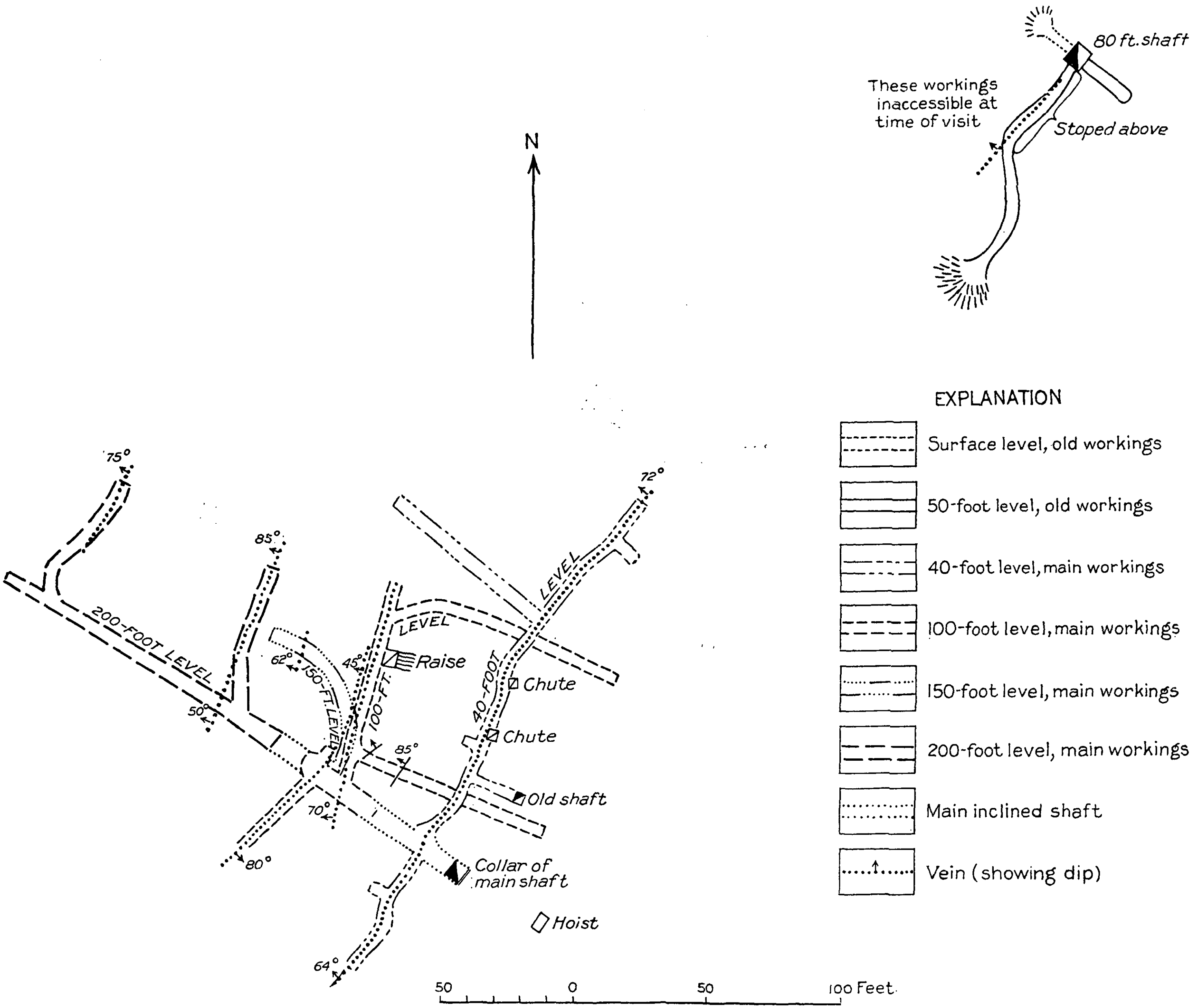
elsewhere but owing to the inconspicuousness of their surface expression have not yet been discovered. Even those at the Gold Hill mine appear to have escaped notice during the first 30 years of mining and to have been found only by underground exploration. Their development has shown that deposits of this type are sufficiently large and rich to justify search for them elsewhere in the "porphyry belt."

Genetic relation between both varieties of the third group and the porphyry dikes seems almost as clearly established as the fact that they are subsequent to the intrusion of the dikes. The "porphyry belt" follows a zone of crustal weakness apparently independent of and developed much later than the intrusion of the Idaho batholith. Movement along the same zone after the intrusion of the dikes provided openings for the introduction of mineral solutions. The differences in mineral composition among the deposits of this group, and the fact that in the group as a whole the pyrite was generally shattered before other sulphides were deposited in it, show that here as elsewhere ore deposition has been complex. The correspondence, both broadly and in detail, between the dikes and the lodes implies that both were controlled during formation by similar structural conditions. The rock alteration that was an integral part of the mineralization was concentrated in and close to the dikes, particularly the more silicic dikes. Ore shoots are confined within the zones of maximum alteration. The different phenomena are so closely allied as to indicate that both rock alteration and mineralization may have been effected by hydrothermal emanations following closely upon and directly connected with the intrusion of the dikes.

In all parts of the Boise Basin visited oxidation of the lodes has reached only shallow depths and has been relatively inconsequential. The early lode miners concentrated their efforts on the oxidized ore because it was accessible and easily treated by crude methods, and perhaps also because of rich ore shoots in it; but everywhere oxidized ore was bottomed within a short distance from the surface, and in numerous places residual sulphide persists in present outcrops. Lindgren[57] visited the region early in the development of the lode mines, and his descriptions record sulphides at the surface or in shallow workings. This paucity of oxidized ore accounts in part for the fact that most of the lodes in the Boise Basin, known for nearly 70 years, have received little development.

The geomorphic history of the region is in accord with the shallow oxidation. After the lodes were formed there was a period of deep weathering and overloaded streams, but in comparatively recent times erosion has been the dominant process. The granitic rock

[57] Lindgren, Waldemar, op. cit., pp. 689–695.




SKETCH MAP OF THE MISSOURI MINE.

From company's map.

at the surface has disintegrated, largely through frost action, but opportunity for deep weathering has been restricted. The scarcity of water during the summer, which has from the first hampered placer mining in the basin, was a factor in retarding such weathering. Locally, surface water penetrated deeply enough to produce incipient oxidation of the sulphides at depths as great as 150 feet, as in the Mayflower mine, but in general its effects were feeble. The easily oxidized mineral sphalerite was more abundant in the upper workings of the Gold Hill and Belshazzar mines than it is in the deeper levels. Evidence of enrichment by secondary (supergene) solutions is exceedingly meager. The wire silver found locally in the Missouri mine doubtless had such an origin, but the quantity of such material in any of the lodes is small. Secondary copper sulphides were not observed during the present study, even in the copper sulphide ore from shallow depths in the Mineral mine. Ballard [58] says that the copper ore throughout the basin is mainly primary, although the chalcopyrite in places is coated or recemented by chalcocite, covellite, or bornite, doubtless of secondary origin.

There is no positive evidence that any appreciable amount of high-grade gold ore is due to downward enrichment below the shallow oxidized zone. The solution of gold is facilitated by the presence of manganese compounds, and some outcrops in this region show dark stains indicative of the presence of manganese; but present data indicate that manganese is far from abundant in any of the deposits, whereas considerable quantities of manganese compounds appear necessary to effect the solution and transfer of gold to any marked degree.[59] It is clear that in the ordinary sulphide ore of such mines as the Gold Hill and Belshazzar the native gold was formed at about the same time and by the same processes as the associated sulphides, even where the gold is in exceptionally coarse flakes (pp. 261 and 267–268; pl. 40). Both are probably of primary (hypogene) origin. If dissolved gold were present in downward-percolating surface water, it could readily have been reprecipitated by arsenopyrite or other sulphides,[60] and it is conceivable that part of the gold in the high-grade pockets in the Belshazzar mine, for example, is of such an origin, although the textures observed in available specimens do not favor the suggestion. It is concluded, therefore, that, although present evidence does not preclude the possibility of local enrichment of gold, it is not probable that this process has been sufficiently effective to be of material

[58] Ballard, S. M., Geology and gold resources of Boise Basin, Boise County, Idaho: Idaho Bur. Mines and Geology Bull. 9, p. 47, 1924.

[59] Emmons, W. H., The enrichment of ore deposits: U.S. Geol. Survey Bull. 625, pp. 308–310, 318, 1917.

[60] Palmer, Chase, and Bastin, E. S., Metallic minerals as precipitants of silver and gold: Econ. Geology, vol. 8, pp. 160, 168, 1913.

commercial significance in future development; in other words, structural and other conditions independent of the depth below the present surface are the determining factors in the persistence of sulphide ore in this region.

## FUTURE OF THE AREA

Development of the lodes of the Boise Basin has, for the most part, been sporadic, shallow, and unsystematic. Some of the deposits were abandoned after the shallow zone of oxidized, easily amalgamated ore was exhausted. According to Ballard,[61] little except assessment work was done at most of the mines from the time that treatment of the sulphides proved metallurgically difficult until 1920, when some of the deeper ore shoots began to be successfully developed.

The data gathered during the present investigation do not warrant this neglect. Results of milling at the Gold Hill mine show that at least some of the sulphide ore will yield exceptionally excellent recoveries to amalgamation if properly treated, so that there is no longer any occasion to confine development to the oxidized parts of the lodes. The Belshazzar vein has been traced through 550 feet vertically, or over 1,000 feet on the dip, and the Pioneer deposits have been mined to a vertical depth of 850 feet, or 1,350 feet below the highest stopes on the Gold Hill lode. It is logical to hope that the relatively shallow development in most other parts of the " porphyry belt " has disclosed only a fraction of the potential ore reserves. This is particularly true of deposits resembling those in the Pioneer workings. Outcrops of such lodes would be generally inconspicuous, and they may locally exist in the walls of some of the better-defined veins without any clear superficial evidence of their presence.

Insofar as the prejudice against lodes within the main Idaho batholith is based on the belief that they represent merely the " roots " of lodes largely eroded away, it has some foundation in fact, especially as regards base-metal deposits genetically related to the batholith; but this prejudice, which has probably had a tendency to retard development in the Boise Basin, does not apply to the Tertiary deposits of the " porphyry belt." These deposits, furthermore, must not be confused with Tertiary deposits formed close to the surface and generally in Tertiary lava. Although deposits of the latter type in Idaho are locally rich and have a record of enviable persistence as compared with many of those of Mesozoic age,[62] very few of them

[61] Ballard, S. M., op. cit. (Bull. 9), p. 50.
[62] Ross, C. P., A graphic history of metal mining in Idaho: U.S. Geol. Survey Bull. 821, p. 7, 1930.

have been profitably worked through a large vertical range. The Tertiary deposits of the Boise Basin, on the other hand, are of mesothermal type,[63] formed at intermediate temperatures and at depths of some thousands of feet below the existing surface. Lodes of this type are obviously independent of the present surface. Where, as in this district, the containing rocks and governing structural conditions are such as to be persistent at depth, except for local interruptions, the lodes may well be similarly persistent.

[63] Lindgren, Waldemar, Mineral deposits, 3d ed., pp. 134–136, 1928.

# INDEX