

ORE DEPOSITS IN THE SAWTOOTH QUADRANGLE, BLAINE AND CUSTER COUNTIES, IDAHO.

By JOSEPH B. UMPLEBY.

INTRODUCTION.

This report embodies the results of a rapid reconnaissance of the mining districts in the Sawtooth quadrangle, in Blaine and Custer counties, Idaho. The exceptionally rough topography, the wide distribution of the ore deposits over about 868 square miles, and the short period (12 days) available for the work made the data collected extremely fragmentary. As the information obtained is fuller than any that appears in the literature, however, it is desirable to place it on record. The principal sources of published information are scattered statements under the heading "Alturas County" in the reports of the Bureau of the Mint.¹ Later reports by the Director of the Mint do not contain information concerning the mines, and before the United States Geological Survey commenced to collect such information the principal mines of the region had ceased to be producers.

GEOGRAPHY.

The Sawtooth quadrangle is a high, mountainous area with summits at elevations of 9,500 to 10,000 feet above sea level and includes the divides between three large drainage basins. Its southwestern part is drained by the headwaters of Boise River, its east-central and southeastern parts by Wood River and its tributaries, and its northern part by Salmon River. (See fig. 57 and Pl. III.) The Sawtooth Mountains run sinuously across the quadrangle a little north of its center. From the Salmon River side they rise abruptly from a broad valley floor, 7,000 feet in elevation, to heights of 9,000 or 10,000 feet, and here and there a peak rises 1,000 feet higher. As seen from the north the crest is exceedingly serrate and bears a striking likeness to the teeth of a saw. As seen from the south, however, the summits blend with others of the highland areas and give the impression that they are parts of a dissected plateau. The Smoky Mountains constitute a poorly defined range which extends north and south across the central part of the quadrangle.

¹ The production of the precious metals in the United States: Rept. Director of the Mint, 1881-1884, inclusive.

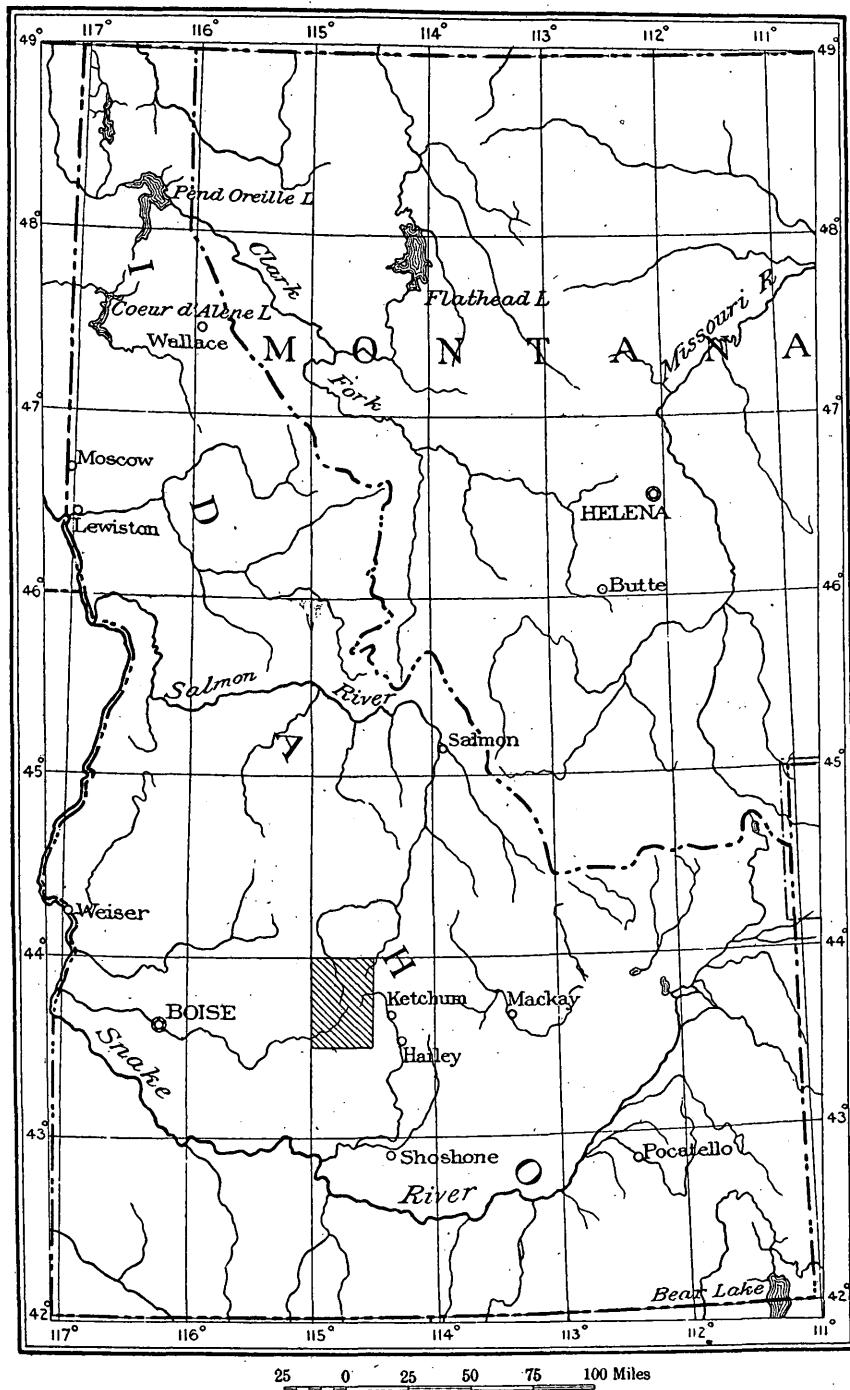
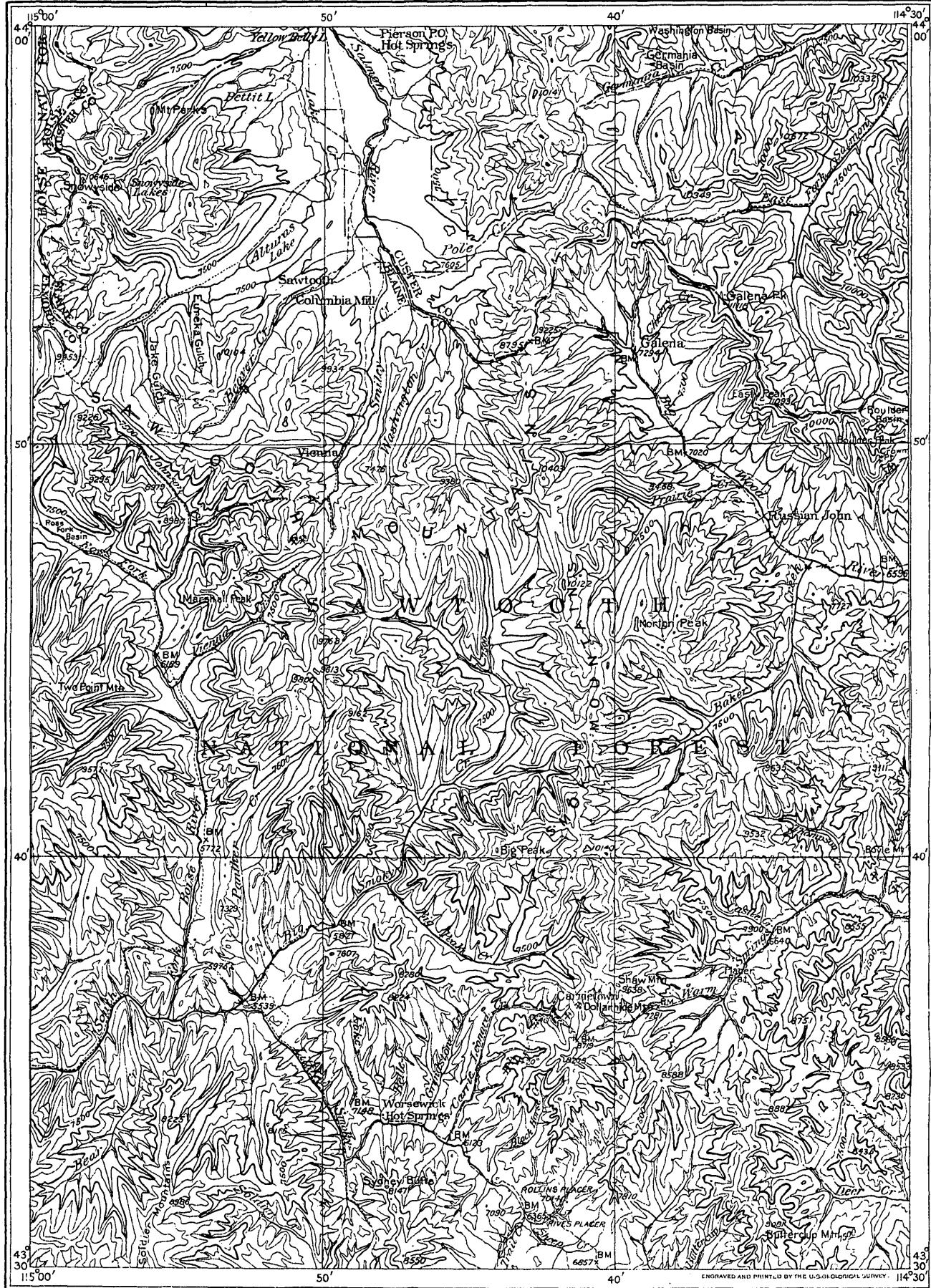


FIGURE 57.—Index map showing location of Sawtooth quadrangle, Idaho.



Base from Sawtooth topographic sheet, U. S. Geological Survey, edition of 1900.

TOPOGRAPHIC MAP OF SAWTOOTH QUADRANGLE, IDAHO

Scale $\frac{1}{250,000}$

Contour interval 500 feet
Datum is mean sea level

The canyons of the area are typically deep, narrow gorges occupied by rapidly flowing streams, the beds of which range upward from a minimum level of 5,200 feet above sea. The only exception is the valley of Salmon River, which is broad and open for the first 8 or 10 miles within the quadrangle. West of it glaciers descending from the high Sawtooth Mountains have left terminal moraines at elevations near 7,000 feet, behind which the drainage is collected in beautiful lakes, which abound in fish and whose shores afford delightful camping grounds. Yellow Belly, Pettit, and Alturas lakes are thus situated. The streams that feed them flow from scores of smaller lakes situated in cirque basins high up in the mountains.

There are three hot springs in the quadrangle, one near its northern edge, another southwest of Carrietown, and the third on Wood River near the eastern edge. The springs deposit but little material, though the waters reach the surface with temperatures between 125° and 150° F.

Pierson, which is near the northern edge of the quadrangle, in the valley of Salmon River, is the only post office now in the area, and it receives mail but twice a week. In 1912 the industrial activity in the quadrangle comprised only the work of scattered groups of prospectors and miners, probably not more than 50 in all, and the grazing of large flocks of sheep during the summer months.

The area has few trails and fewer roads. Travel is exceedingly difficult in most parts of it, although bands of sheep roam over it widely. A trail up Boise River branches to the old mining camps of Vienna, Sawtooth, and Carrietown. Washington and Germania basins connect by trail with Clayton on the north and with Galena on the south. A wagon road branches north from the Hailey-Soldier stage road and leads to Carrietown, in the southern part of the quadrangle. Carrietown may also be reached by a road, now locally impassable, from Ketchum. A good road, which forms the main thoroughfare from Hailey and Ketchum to Pierson and Stanley Basin, crosses the northern part of the quadrangle along the valleys of Wood and Salmon rivers. It passes through the old smelter town of Galena, and branches from it lead to the now abandoned camps of Vienna and Sawtooth and to Germania Basin, Alturas Lake, and Pettit Lake, all within the drainage basin of Salmon River. A branch from it also leads up Boulder Creek canyon to the deposits in Boulder Basin.

HISTORY.

The earliest locations in the quadrangle were made in Boulder Basin in 1879 and on the east slope of Dollarhide Mountain in 1880, thus following closely the discovery of the rich silver-lead deposits near Hailey in 1878. During the three or four years following lode deposits were located in many parts of the area, and thriving mining

centers sprang up near Carriertown, Boyle Mountain, Boulder Basin, Galena, Vienna, Sawtooth, and Germania Basin. The period of prosperity, however, was comparatively short, for in all the camps by 1890, and in most of the camps earlier, operations had almost ceased. The production during these few years can not be definitely ascertained, but fragmentary records and the statements of those who were connected with mining in the area indicate that it amounted to about \$5,000,000, nearly all of it from silver-lead and silver ores. The deposits were rich in silver near the outcrop, shipments averaging several hundred ounces to the ton being not uncommon, particularly from the Sawtooth district. Concentrating mills were built in each of the districts, except Galena and Germania Basin, to handle the lower-grade ore. A 30-ton lead smelter was erected at Galena, but did not produce much bullion. A smelter at Ketchum handled a great deal of the ore; some was shipped to the smelter at Clayton, north of the area, and some was sent to reduction works farther away.

During recent years only the mill in Boulder Basin has been operated. The small amount of ore recently extracted from the other deposits has been mostly hand sorted and shipped to smelters in Utah.

PHYSIOGRAPHY.

The relief of the quadrangle ranges from 5,200 feet above sea level in the canyon of South Fork of Boise River to a little over 11,300 feet on the south wall of Boulder Basin. Common elevations, however, range from 7,000 feet in the canyons to 10,000 feet on the summits. The summits show a general accordance in level, which determines an undulating plain, which rises notably along the axis of the Sawtooth Mountains. This old erosion surface, well defined in areas farther northeast,¹ is not well preserved in this area and would scarcely be recognized were it not for the proximity of the other areas and its definiteness in them, but there can be little doubt that it extended over the Sawtooth quadrangle.

The relations of lava-filled valleys to uplands are the same here as elsewhere in east-central Idaho, the summits are of comparable height, the ridges and divides are similarly discordant in direction and distribution, and the relative resistance to erosion of different rock formations does not determine the elevation of the summits.

The physiographic history of this area, as interpreted largely in the light of the areas to the northeast, is legible for only the relatively small portion of geologic time that has elapsed since the late Mesozoic. Near the close of the Cretaceous period extensive regional elevation, thought to have been accompanied by the intrusion of the great granite mass which crops out over about half the quadrangle, rejuvenated

¹ Umpleby, J. B., Some ore deposits of northwestern Custer County, Idaho: U. S. Geol. Survey Bull. 539, pp. 15-17, 1913.

venated the streams and began a period of erosion which by the close of the Eocene epoch had formed a far-reaching surface of slight relief.

This old surface now recorded by the summits of the area was raised to an elevation of nearly 10,000 feet at the close of the Eocene or early in the Oligocene, and the drainage ways again became channels of active erosion. During the Oligocene epoch the major streams, one of which flowed through the valley of the upper Salmon River and continued southward along the eastern side of the quadrangle to Camas Prairie, developed broad, deep valleys, which in the Miocene and possibly also in part of the Pliocene were the sites of lava flows and probably locally of lacustrine deposition.

The Pliocene, again, was a period of dominant erosion, in which the valley of Warm Springs Creek was cut to a depth of more than 2,000 feet into the Miocene lavas, and in the Pleistocene the upper ends of its branches were glaciated down to levels of 7,000 to 7,500 feet. During this epoch ice fields covered the uplands and the glaciers that occupied the higher portions of the valleys carved many of the features which now lend picturesqueness to the region.

GENERAL GEOLOGY.

SEDIMENTARY ROCKS.

Stratified rocks of probably Paleozoic age crop out in several parts of the quadrangle. (See Pl. IV.) The largest area is principally within the drainage basins of Germania and Pole creeks. Here the beds comprise fine-grained quartzite and dark-colored massive dolomitic limestone that grades upward into blue and white limestone beds and on into black slate, the slaty and quartzitic rocks being most abundant and apparently representing several thousand feet of beds. The sedimentary rocks also crop out in the vicinity of Boulder Basin, where a thick series of bluish and gray fine-grained quartzites and siliceous slates are exposed in the walls of Boulder Canyon. Another area of the Paleozoic beds extends from a point a few miles north of Boyle Mountain southward well beyond the quadrangle. Very little was seen of this area, but as the beds observed are similar in appearance to those in the vicinity of Hailey, a few miles to the east, it is believed that they represent the Wood River formation of Lindgren,¹ which is of Carboniferous age. The most abundant rock in the formation seems to be a reddish-gray and brown sandstone, in part calcareous. Perhaps second in importance is black calcareous shale, which apparently incloses beds of massive gray limestone. The remaining area of the Paleozoic rocks is in the vicinity of Carriertown. This seems to be a roof pendant of the granite mass which crops out

¹Lindgren, Waldemar, The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho: U. S. Geol. Survey Twentieth Ann. Rept., pt. 3, pp. 193-195, 1900.

on all sides except to the southeast, where the beds disappear beneath Tertiary eruptive rocks. The beds include limestone, magnesian limestone, slate, and quartzite.

Throughout all the areas the Paleozoic beds dip steeply, in most places away from north-south axes. Fossils were not discovered in them. They are not uniformly metamorphosed, and only locally along their contact with the granite do they contain secondary silicate minerals in quantity or size sufficient to be visible with a hand lens. At a few such places pyroxene, andalusite, epidote, and fibrous wollastonite and actinolite were detected.

Lacustrine deposits, probably of Miocene age, are believed to be present in the portion of the old valley which was not flooded with lavas. The presence of these deposits has not, however, been established, as the area believed to be occupied by them is now covered with recent alluvium and with a heavy mantle of outwash deposits, principally gravels, derived from the glaciers that occupied the adjacent uplands during the Pleistocene epoch.

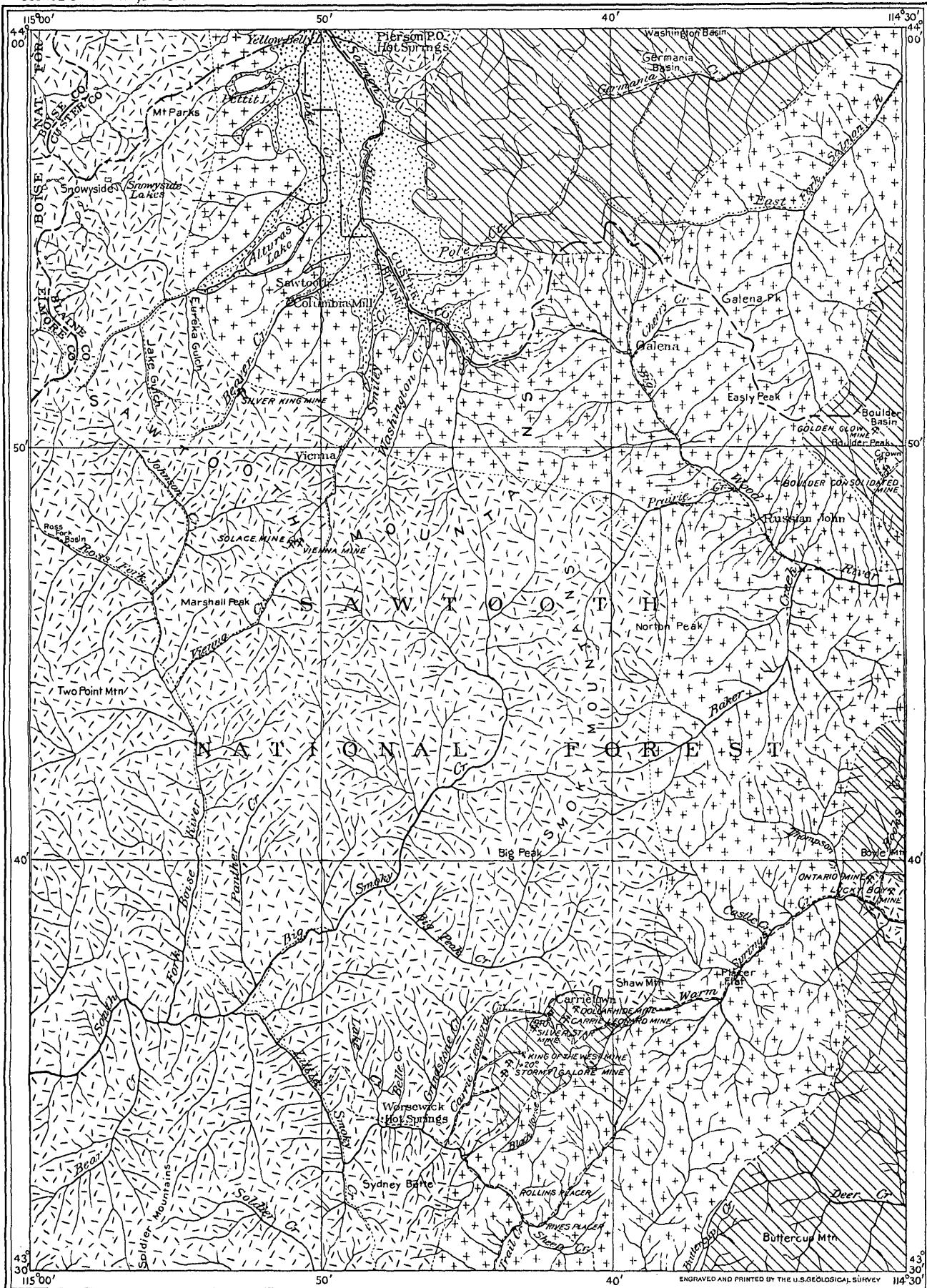
IGNEOUS ROCKS.

GRANITE.

The central granite batholith of Idaho, one of the great intrusive masses of the North American continent, extends into the quadrangle from the west and comprises about two-thirds of its area. (See Pl. IV.) In most places its contact with the older sedimentary rocks is concealed by the broad belt of Tertiary lavas which follows the course of Salmon and Wood rivers to a point near the eastern border of the quadrangle and there turns south and joins the Snake River Plains in the vicinity of Camas Prairie. South of Boyle Mountain, however, a small mass of the granite crops out among Paleozoic rocks, and in the vicinity of Carriertown a small area of the sedimentary beds rises westward from beneath the lavas and is bordered on three sides by granite. Near the northern border of the quadrangle the granite and the sedimentary rocks are in contact for a few miles.

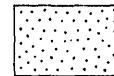
The granite area includes granite, quartz monzonite, and quartz diorite, each of the varieties resembling the others closely in megascopic appearance. The quartz diorite in general seems to contain more biotite and hornblende and is consequently somewhat darker, but its color is by no means a reliable distinguishing characteristic, for in places the granite is equally dark.

All the specimens from the vicinity of Carriertown are of quartz diorite. The rock is dark gray, equigranular, and made up of feldspar, quartz, biotite, and hornblende. Microscopic examination shows that the feldspars are oligoclase and andesine, no orthoclase being observed. Titanite, magnetite, and apatite are the principal accessory minerals.



LEGEND

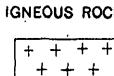
SEDIMENTARY ROCKS



Recent alluvium and Pleistocene
moraine and glacial outwash gravel



Chiefly slate, quartzite, and
magnesian limestone

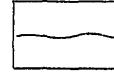


IGNEOUS ROCKS

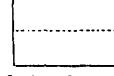
Andesites, rhyolites, and related
tuffs of Miocene age



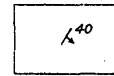
Chiefly granite but includes quartz,
monzonite and quartz diorite
(associated dikes not mapped)



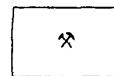
Known contact



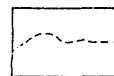
Projected contact



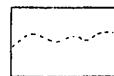
Dip and strike



Mine



Road



Trail

GEOLOGIC SKETCH MAP OF SAWTOOTH QUADRANGLE, IDAHO

By Joseph B. Umpleby

Scale 1:250,000

5

5 Miles

1914

Base from Sawtooth topographic
sheet, U. S. Geological Survey,
edition of 1900.

A specimen from near Boyle Mountain is a soda granite of dark-gray color and medium-grained texture, composed of feldspar, quartz, and biotite. In thin section the feldspars are seen to be orthoclase, notable amounts of albite, and a little oligoclase. In places the orthoclase and albite form microperthite. Apatite and zircon are the principal accessory minerals.

The rock inclosing the veins of the Vienna district is a light-gray medium-grained biotite granite, made up of orthoclase, microcline, a little albite, quartz, and biotite. Adjacent to the veins it contains much secondary pyrite, a little magnetite and chlorite after the biotite and sericite after the feldspars, and, in one section, epidote.

In Washington Basin quartz monzonite, characterized by a marked phenocrystic development of the feldspars, is exposed over a small area. This rock is gray and is made up of large crystals of orthoclase set in a groundmass of medium-grained feldspar, quartz, and biotite. The groundmass is packed with micropegmatite, which also occurs in zones surrounding orthoclase crystals. Plagioclase, mostly oligoclase, is somewhat less than orthoclase in amount and much of it shows marked zonal growths. Near the ore deposits the quartz monzonite becomes greenish gray in color and has a silky luster. It grades through zones in which patches of secondary pyrite and sphalerite occur in chloritized quartz monzonite into ledge matter made up of arsenopyrite, pyrrhotite, quartz, sphalerite, and pyrite, in which the original granite can be identified only locally.

DIKE ROCKS.

Dike rocks occur in several parts of the quadrangle, but only in Boulder Basin were they observed to be particularly numerous. They comprise perhaps one-third of the rock exposed in the basin and present a wide range in composition and in size, individual intrusions ranging from a few inches to a few hundred feet in width. The study of their relations and differences was too hurried to permit detailed descriptions, but granite porphyry, quartz monzonite porphyry, diorite, and a rare lamprophyre, spessartite, were identified.

The granite porphyry is steel gray and is made up of phenocrysts of feldspar and a little hornblende, closely spaced in a fine-grained groundmass. Orthoclase exceeds albite in amount, hornblende is abundant both in the groundmass and as phenocrysts, and quartz is confined almost entirely to the groundmass.

Quartz monzonite porphyry traverses the vein in Golden Glow tunnel No. 2. It is a light-gray rock with phenocrysts of feldspar and a little quartz, biotite, and hornblende set in a fine-grained groundmass. The feldspars include oligoclase and orthoclase in about equal amounts. In the specimen studied the biotite and

hornblende are largely altered to epidote, chlorite, and magnetite, and sericite is developed after some of the feldspars.

Diorite porphyry, a greenish-gray rock with numerous medium-sized phenocrysts of feldspar, occurs near the mouth of Golden Glow tunnel No. 2. Plagioclase, of about the composition oligoclase-andesine, greatly exceeds biotite in amount. Secondary minerals in the specimen are epidote, after the biotite and some of the feldspar, and sericite, after the feldspar. Pyrite also is present.

The specimen of spessartite was obtained near the face of Golden Glow tunnel No. 2 and is a dark-colored rock with phenocrysts of hornblende and sparsely scattered biotite in a holocrystalline ground-mass. The hornblende occurs in two distinct generations and about equals the oligoclase in quantity. One large grain of quartz and three small grains of pyrite occur in the section. The ground-mass is an aggregate of interlocking feldspar and hornblende crystals.

In the vicinity of Carriertown diorite porphyry, monzonite porphyry, and granite porphyry dikes were observed along the ridge north of Dollarhide Mountain, where they traverse both the quartz diorite and the Paleozoic sedimentary rocks. They are similar in appearance and mineralogy to those above described from Boulder Basin.

TERTIARY ERUPTIVE ROCKS.

Tertiary lava rocks and related tuffs form a wide belt that follows the valleys of Salmon and Wood rivers to the eastern border of the quadrangle and there turns south-southwest and leaves the area between Buttercup Mountain and Sydney Butte. A branch leads northeastward in the vicinity of Galena and another eastward along Wood River. Except within the drainage of Salmon River they fill an old erosion valley, the bed of which is nowhere exposed within the area. The contact of the lavas with the older rocks was seen only in places where the boundary is indicated on the map by solid lines, but as the areas of these rocks contrast sharply in color with the light gray of the granite soil, it is believed that their general distribution is about as indicated. Warm Springs Creek traverses the lava belt between Boyle Mountain and Dollarhide Mountain. Its canyon is from 2,000 to 3,000 feet deep, but in no place has it cut through the eruptive rocks. Within this drainage basin andesite predominates, but on the upper slopes there is considerable rhyolite and some poorly bedded rhyolitic tuffs.

The lavas are believed to occupy an old erosion valley, because much of the basin in which they occur lies athwart the structure axes of the region, and because there is no evidence of faulting in any of the several exposures observed along the sides of the basin. In places along their margins the basal lavas have picked up vast quantities of fragmental material from the underlying beds, as

near the mouth of Thompson Creek; elsewhere, as on the east slope of Dollarhide Mountain, they rest against a surface of weathered granite. Except in the extreme northern part of the belt the lavas essentially fill the old valley, and in the vicinity of Easly and Galena peaks they rise somewhat higher than the general upland level. Within the Salmon River drainage area much of the old valley was probably never filled with lava rock, for if it was it seems impossible to account for the broad valley, which is now so strikingly discordant with the other topographic features of the region. This discordance is particularly emphasized by the deep, narrow canyon, cut in rocks of similar composition and structure, which is entered by Salmon River about 25 miles north of the quadrangle. It is not unlikely that lacustrine deposits underlie this portion of the old valley, for there seems to have been no outlet from the basin until the Salmon River canyon was excavated, and this must have required a very long time. It is not impossible that the waters draining into the basin escaped southward beneath the lavas along the old channel, but there is no specific evidence in support of this idea. If a lake existed in this basin rock waste from the high mountains adjacent certainly accumulated in it as lacustrine deposits, and if no lake existed subaerial deposits as certainly formed. These older beds, believed to be present, are now well concealed by a heavy mantle of outwash derived from the glaciers which occupied the adjacent uplands during the Pleistocene epoch and by alluvium of more recent origin.

The lava rock comprises principally andesite and rhyolite, but experience elsewhere in the same general series suggests that many of the andesites as determined microscopically would prove on chemical analysis to be latites.¹ Associated with the lavas are their related tuffs, but these were not observed to be abundant anywhere within the quadrangle. The andesites are greenish, purplish, lavender, or gray; some contain important amounts of biotite, others considerable quantities of hornblende, and in a few specimens augite is conspicuous. In them the phenocrysts and groundmass are about equal in area. The feldspars in different specimens range in composition from $Ab_{70}An_{30}$ to $Ab_{55}An_{45}$, or from a calcic oligoclase to a calcic andesine. The groundmass in most of the thin sections is cryptocrystalline to glassy. Rhyolite was observed as a light-gray rock along the upper slopes of the valley of Warm Springs Creek. Orthoclase quartz and rarely sanidine appear as scattered phenocrysts in a cryptocrystalline groundmass which shows distinct flow structure and is made up of microlites of feldspar which in many places give way to glass.

¹ Umpleby, J. B., U. S. Geol. Survey Bull. 528, pp. 47-48, 1913, and Bull. 539, pp. 25-26, 1913.

ORE DEPOSITS.

CHARACTER AND DISTRIBUTION.

The principal ore deposits found in the Sawtooth quadrangle are fissure veins and replacements along shear zones. Only one epoch of mineralization is recognized, and this followed the intrusion of the granite batholith in late Cretaceous or early Eocene time and preceded the filling of the old valley, which, as indicated in areas farther north, probably took place principally during the Miocene epoch.¹ The veins may be grouped according to the leading metal contained, as silver-lead, silver, zinc, and gold deposits, and they will be described in the order named. Of the production of perhaps \$5,000,000 credited to the quadrangle, nearly all has come from the first two groups of deposits. The zinc ores have yielded \$40,000 or \$50,000, but the gold veins have not been exploited to economic advantage.

The known deposits occur in the southern, eastern, and northern parts of the quadrangle. Nearly all were staked out and exploited within five years after the discovery of the rich silver-lead deposits near Hailey in 1879. Even the gold veins of Washington Basin were known to the early prospectors, who spread into the surrounding country from the camps of Vienna and Sawtooth, but not until 1894 were claims staked to cover them.

SILVER-LEAD DEPOSITS.

Argentiferous galena deposits occur in all the districts in the quadrangle, though ores of this type afforded but a small part of the production from the mines near Sawtooth and Vienna. The veins are typical fissure fillings and replacements along sheared zones and are distinctly tabular in outline. Siderite and quartz are the characteristic gangue minerals. Sphalerite, tetrahedrite, and locally arsenopyrite and pyrrhotite are associated with the galena in most of the veins. The veins traverse the Paleozoic beds near Carrieton, Boyle Mountain, and in Boulder, Germania, and Washington basins. At Vienna and Sawtooth they are inclosed in biotite granite, and in the vicinity of Boyle Mountain some of them extend from the area of Paleozoic rocks across the igneous contact into the soda granite.

The amount of silver in the ores varies from place to place, even in the same district. Thus the Silver Star ore contained 15 to 16 ounces of silver to the ton, and the Isabella, less than a mile away, averaged from 200 to 400 ounces. Shipments from different shoots in the Golden Glow mine contained widely different amounts of silver, the range being from 56 to 360 ounces to the ton. The silver content of the ore is not invariably related to its content of lead; where it is particularly high it seems to be concomitant with the presence of gray copper. In the Boulder Basin and Sawtooth districts gold

¹ Umpleby, J. B., loc. cit.

accompanies the lead in noteworthy amounts. The Golden Glow ores as now worked contain 0.32 to 0.63 ounce of gold to the ton and assays of the Mountain King ores give returns of 0.58 ounce to 1.58 ounces of gold. Elsewhere in the quadrangle gold occurs in the silver-lead ores but in less amount than in these districts.

SILVER DEPOSITS.

It is impossible to draw a sharp line of demarcation between the silver and the silver-lead deposits. Many of the mines were worked primarily for silver but at the same time produced considerable amounts of lead. Others were worked exclusively for silver, the small amount of lead in the ore being lost in the metallurgic process used. Only deposits that were worked for silver alone are here discussed, and these include the veins of the Sawtooth and the Vienna districts. The Mountain King mine, in the Vienna district, however, has recently been worked for lead-silver ores which were left in the mine during the early period of activity, when only silver and gold were recovered.

The silver-bearing veins occur well within the main granite mass and are extensively developed by tunnels, few of which are now accessible. The veins range from a few inches to 15 feet in width and are characteristically quartz fillings containing tetrahedrite, proustite, and silver-bearing galena and sphalerite. Some of the ores are said to have contained as much as 4,000 ounces of silver to the ton, but the average was probably less than 75 ounces. Only the Mountain King mine (see p. 248) was accessible at the time of visit.

ZINC DEPOSITS.

Deposits of zinc occur in the Lucky Boy mine, which is on the east side of Rooks Canyon, southeast of Boyle Mountain. This mine has produced about 2,600 tons of 45 per cent zinc ore from veins worked intermittently for several years. The mine was not visited during the reconnaissance, but specimens of the ore consist of sphalerite, pyrite, and a little galena and arsenopyrite in a quartz-siderite gangue.

GOLD VEINS.

Large low-grade gold veins, entirely different in character from any other of the deposits, occur in Washington Basin about half a mile north of the quadrangle. Here five ledges from 6 to 72 feet in width cross a low ridge which divides a large cirque into two basins. All the veins are inclosed in porphyritic quartz monzonite, which at many localities is clearly replaced by the vein material. Three of the veins have been opened in several places by short tunnels, pits, and open cuts, and each opening reveals quartz which is either honeycombed and iron-stained or is heavily impregnated with pyrrhotite, pyrite, or arsenopyrite. The principal vein is called the

Empire and averages about 30 feet in width through an extent of four claims. Near the surface this vein is intensely oxidized, but at a depth of a few feet primary minerals appear. Arsenopyrite, sphalerite, and galena occur as small patches, but near its southern end pyrrhotite and about an equal amount of intermixed quartz and diopside form a band, 15 to 20 feet wide, next to the hanging wall. The pyrrhotite clearly replaces the quartz monzonite, the quartz of which remains. The feldspar and biotite crystals are completely transformed to pyrrhotite and diopside. Farther north on the Empire vein sphalerite occurs with small amounts of pyrite, stibnite, pyrrhotite, and arsenopyrite.

The granite adjacent to the vein is intensely sericitized and locally is greenish gray and has a silky luster. It passes through a zone in which patches of pyrite and sphalerite occur in chloritized and sericitized quartz monzonite into ledge matter made up of sulphide minerals, pyroxene, and quartz, in which the original quartz monzonite is only locally and imperfectly preserved.

The tenor of these veins is not known, but that they contain some gold was proved by panning the specimens collected. In the section on Germania and Washington basins (pp. 244-246) appears additional information concerning them.

SUPERFICIAL DEPOSITS.

Gold placers that occur along the upper valley of Little Smoky Creek have been worked intermittently in a small way for a number of years. They were not examined during the reconnaissance.

MINERALOGY OF THE ORES.

The mineralogy of the ores of the Sawtooth quadrangle is comparatively simple. The more abundant minerals in the lead-silver and silver deposits are argentiferous galena and sphalerite, tetrahedrite, proustite, pyrite, chalcopyrite, and locally arsenopyrite, and pyrrhotite in a quartz-siderite gangue. In the gold-bearing veins the characteristic minerals are pyrrhotite, arsenopyrite, and pyrite, along with a little sphalerite, galena, stibnite, and chalcopyrite in a quartz gangue in which diopside is locally abundant.

Oxidation in few places extends more than 100 feet below the surface, and in most of the deposits primary ore occurs within a depth of 50 feet. The common alteration products are lead carbonate, cerargyrite, iron and manganese oxides, copper carbonates, smithsonite, and calamine.

ALTERATION OF THE WALL ROCK.

Alteration seems to be more pronounced in the igneous than in the sedimentary wall rock. Specimens of granite taken near the ore bodies in the Vienna district are packed with sericite that developed

after the feldspars and locally after the biotite and with chlorite and epidote that developed after the biotite. In Washington Basin much of the vein material is clearly replaced quartz monzonite, it being possible to obtain specimens showing every gradation from material composed principally of quartz, pyrrhotite, sphalerite, and arsenopyrite or quartz, pyrrhotite, and diopside to quartz monzonite containing isolated patches of secondary pyrite and sphalerite in chloritized and sericitized quartz monzonite.

In view of the intense metasomatic replacement and the diopsidization of the quartz monzonite in the deposits of Washington Basin, it is perhaps surprising that no contact metamorphic replacement deposits have been found. All the veins in Washington Basin, however, are within the area of the igneous rock, and it is possible that overlying contact deposits have been swept away by the erosion which formed the basin.

AGE OF THE DEPOSITS.

The deposits of the quadrangle are believed to represent one general epoch of mineralization, which was closely related to that of the intrusion of the Idaho batholith. At Vienna, Sawtooth, and in Washington Basin the ores are inclosed in the igneous mass; elsewhere they are in sedimentary rocks not far removed from the igneous contact. In Boulder Basin and in the vicinity of Carriertown dikes of granite porphyry and diorite porphyry traverse the veins. These dikes are very different in appearance from those that accompanied the Miocene lavas and quite certainly are differentiated from the batholithic magma. The ore solutions therefore are believed to have escaped from the batholithic mass before it had completely solidified. The granite of the batholith is believed to be of late Cretaceous or early Eocene age, and hence the veins belong to the pre-Oligocene deposits recognized elsewhere in the State.¹ The late Tertiary epoch of mineralization is not known to be represented in the quadrangle.

MINING DISTRICTS OF THE SAWTOOTH QUADRANGLE.

ROSETTA DISTRICT.

GENERAL FEATURES.

The Rosetta district, sometimes included in the Little Smoky district, embraces an unorganized area of perhaps 100 square miles in the vicinity of Carriertown in the southern part of the quadrangle. Dollarhide Mountain is the principal landmark in the vicinity, though it is but little higher than many other summits in the region. A wagon road, about half a mile of which was impassable for vehicles

¹ Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, pp. 29, 62, 68, 1913.

in 1912, leads 22 miles east to Ketchum. Except for the Dollarhide summit this road has an easy grade, and it might be put in excellent condition by an expenditure of a few thousand dollars. The highway from Carrietown now in use follows down Carrie Leonard Creek and thence east over Sheep Creek summit and joins the main stage road between Hailey and Soldier. The 4 or 5 miles of this road below Carrietown is along the creek bed and washes badly during the spring freshets.

HISTORY AND PRODUCTION.

The principal mineral locations were made in 1881 and 1882, and for a score or more of years thereafter the Rosetta district was one of the active mining centers in Idaho. Five concentrating mills were in operation part of the time and much of the better grade of ore was packed and later hauled to the smelter at Ketchum. During recent years, however, the district has been comparatively inactive and efforts to recover in depth the veins which were exceptionally productive near the surface have met with indifferent success. None of the mills have been operated for several years and most of them are partly dismantled. The principal activity in 1912 was directed toward locating at a depth of 280 feet the Carrie Leonard veins, which are locally reported to have produced approximately \$500,000 from above the 150-foot level. This work was continued during 1913 and served to indicate that the argentiferous galena gives way to sphalerite, pyrite, and arsenopyrite in depth.

The total production of the district does not appear in official records and can be approximated only from the output of individual mines as reported by residents of the vicinity. The Carrie Leonard, said to have yielded \$500,000, holds the highest record of production. Then follows the King of the West with \$200,000, the Stormy Galore and Tyrannus with \$100,000 each, the Dollarhide and Silver Star with about \$75,000 each, the Margaret with \$30,000, the Isabella with possibly \$20,000, and the Sunday with perhaps \$15,000. In all, the district has produced perhaps \$1,000,000.

TOPOGRAPHY.

The Rosetta district is a high, mountainous area, which ranges in elevation from 5,500 to 9,000 feet. The western part is drained by tributaries of Big and Little Smoky creeks, which flow westward into West Fork of Boise River. The eastern part is drained by Warm Springs Creek, a tributary of Wood River. The area has a wide range in climate. In summer it is a beautiful park, in which a dense forest of fir and pine rises above a fairly open undergrowth, but in winter it is a desolate expanse of snow, traveled by men only on skees and webs. The open season includes the months from May to November.

GEOLOGY.

The rock formations of the district include a small area of Paleozoic sedimentary rocks, bordered on the southeast by Tertiary lavas and on the other sides by the great granite batholith of Idaho, which extends westward and northward for several hundred miles. The sedimentary rocks include limestone, magnesian limestone, slate, and quartzite and dip 20° to 50° E. Dikes of diorite and monzonite porphyry traverse both the granite and the Paleozoic rocks. They are well exposed on the ridge north of Dollarhide Mountain but occur also in several of the mines. (See p. 228.)

Perhaps the most noteworthy feature of the geologic relations of this district is the absence of important contact metamorphism, even in the limestone areas. The microscope reveals a little diopside and a few shreds of wollastonite and termolite, but in no exposures seen were metamorphic minerals visible with a hand lens. This contrasts markedly with the observations of Lindgren on the contacts of the Hailey area to the east¹ but agrees well with the general observation that metamorphic minerals are not uniformly developed around intrusive masses even when in contact with rocks that are similar in composition and structural features.

ORE DEPOSITS.

The ore deposits of the district occur as veins and tabular replacements, containing principally argentiferous galena, tetrahedrite, and sphalerite in a quartz-siderite gangue. Pyrite, chalcopyrite, and a little arsenopyrite are present in many of the ores. Most of the veins occur along crushed zones, and large quantities of fragmental wall rock are included in the gangue. The common strike of the veins is northeast-southwest, with dip either to the northwest or to the southeast, in most places at angles greater than 45°. There is little evidence of hydrothermal alteration, but replacement phenomena are plentifully illustrated. Bunches and stringers of ore protrude into the wall rock in many places, and the veins are markedly different in width within very short distances.

The ores mined were of excellent grade and were valuable chiefly for their silver content, which in different veins ranges from 17 to 400 ounces to the ton, the principal production having been derived from ores averaging 100 to 200 ounces.

Oxidation is confined to a narrow zone near the surface and in none of the deposits is it complete to a depth greater than 50 feet. The outcrops of the ledges are characterized by iron-stained quartz, coarsely honeycombed, with widely spaced cavities of unequal size

¹ Lindgren, Waldemar, The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho: U. S. Geol. Survey, Twentieth Ann. Rept., p. 195, 1900.

and irregular shape. Within a few feet and in places within a few inches of the surface, however, the quartz becomes solid and primary sulphide minerals appear. Galena occurs nearer to the surface than any of the other sulphide minerals, and most specimens of surface ore contain fragments of it. Recent developments on the Dollarhide and Carrie Leonard veins indicate that galena decreases and sphalerite increases markedly in depth.

The age and genesis of the deposits have already been discussed (p. 233); but note may be made here of the dike of diorite porphyry that traverses the vein in the Dollarhide mine. This dike is almost certainly a differentiates from the granite magma. Elsewhere in the vicinity veins traverse the granite. This seems to show that the ore solutions escaped from the magma before its solidification was complete.

MINES AND PRINCIPAL PROSPECTS.

Carrie Leonard mine.—The Carrie Leonard group, comprising eight patented claims, occupies the lower end of the sharp ridge between the two branches of Carrie Leonard Creek at Carrietown. The present working tunnel enters the hill from the northwest at a point near the creek level about 200 yards above the town. Other developments include three tunnels from the north and an equal number from the south. A 40-ton concentrating mill, formerly equipped with wilfleys and jigs but now dismantled, is situated on the south side of the ridge.

Two veins, both inclosed in hard black, locally calcareous quartzite, have been worked and have yielded about \$500,000. One of the veins strikes N. 40° E. and dips 40° SE.; the other strikes N. 55° E. and dips 58° SE. They cross within the claim, and the best ore has been found by following down along their intersection, where the ore is said to have averaged 30 per cent lead, 5 to 6 per cent zinc, and 150 ounces of silver to the ton. This grade of ore extended southward from the intersection for 100 feet along one vein and for about 70 feet along the other, and it continued to a vertical depth of 160 feet, or 650 feet down the line of intersection. Below this point, which is 130 feet above the level of the gulch, little ore has been found. Although the vein here is persistent and the gangue is similar to that above, galena seems to have given way to sphalerite. The bottoms of the old stopes were inaccessible in most places at the time of visit, but in every place observed the ore shoots seemed to pinch out. A strong fault transverse to the course of the vein is exposed in tunnel No. 2, but as it crosses at a point 70 feet beyond the end of the shoot its bearing on the continuation of the ore is of doubtful significance.

Dollarhide mine.—The Dollarhide group comprises 17 claims on the divide between Carrie Leonard and Warm Springs creeks. At

the point where the road crosses this divide it is 8,719 feet above the sea. To the east and to the west the claims extend down the slopes to an elevation of about 8,000 feet, and to the north, near the principal workings, the ridge rises to 9,200 feet. East of the divide is a partly dismantled 40-ton concentrating mill.

The developments include 3,000 feet of work in four tunnels about 100 feet apart. The upper two are no longer accessible and the lowest has not been carried to the vein. Tunnel No. 3 is the principal level and may be entered through either of two portals, which are 535 feet apart. The southern portal is the end of a 120-foot crosscut, which extends westward to the surface from a point on the vein about midway between the north portal and the face of the workings.

The vein, which is inclosed in massive limestone, some of it very siliceous, strikes N. 50° - 60° W. and dips 60° SW. in the eastern part of the mine and 70° NE. in the western part, the dips being opposite on opposite sides of a diorite porphyry dike which crosses tunnel No. 3 about halfway between the two portals. Near the northern adit of tunnel No. 3 it is crossed by a fault which strikes N. 10° E. and dips 28° SE. Ore has not been found west of it. Faults also cross the ore body in the eastern end of the workings, one of them causing an offset of 10 feet to the north on the east side and another an offset of 80 feet in the same direction.

The vein is 3 to 6 feet wide and consists of quartz, through which sphalerite and galena are scattered, and of crushed wall rock in about equal amounts. The better grade of ore occurs as ill-defined lenses that are greatly elongated nearly parallel to the strike of the vein. One of these lenses lies between levels Nos. 2 and 3, but extends down to No. 3 only in a few places.

Isabella mine.—The Isabella, comprising one patented claim, lies between the Carrie Leonard and Dollarhide groups. The developments consist of three short tunnels and a 50-foot shaft, all inaccessible at the time of the examination. The mine was discovered in 1881 and was operated by lessees for a number of years. The ore is said to have been of excellent grade, some of it containing as high as 400 ounces of silver to the ton along with lead and a little zinc. The mine is credited with a production of \$25,000.

Margaret mine.—The Margaret claim, situated east of the Dollarhide group, at an elevation of 8,200 feet, back of the Dollarhide mill, was discovered in 1880 and is the oldest location in the vicinity of Carriertown. It produced \$32,000 from highly argentiferous lead ore. The developments include about 1,500 feet of drifts and tunnels, no longer accessible. The ore body occurred as a horizontal lens in a steeply dipping crushed zone which traverses siliceous limestone beds. Other ore bodies have not been found.

Silver Star mine.—The Silver Star mine is situated about a mile southwest of Carriertown at an elevation of 7,700 feet. It is well

within the area of sedimentary rocks that comprises the productive portion of the district. The mine has not been operated since 1888 and most of the workings are now inaccessible. The property includes 10 to 12 patented claims and a 20-stamp concentrating mill, which after running 20 days was in part dismantled because the amount of silver in the ore fell far below expectations. The ore is said to average 15 or 16 ounces to the ton in silver and about 4 per cent lead with an equal or greater amount of zinc. The developments include an incline 270 feet deep with drifts at vertical depths of 105, 155, and 205 feet below the collar. The lowest level, No. 3, connects with the surface by a crosscut tunnel and a prospect winze follows the ledge to a farther depth of 200 feet. The drifts on the vein aggregate about 2,500 feet in length and explore the ledge for 300 feet west of the shaft on levels Nos. 1 and 3 and for 700 feet east of the shaft on levels Nos. 2 and 3. Very little stoping has been done, the production of \$75,000 and the 15,000 tons of ore now on the dumps being reported to have come from the development work. It is said that breasts of ore up to 12 feet wide occur at many places in the mine and that the principal shoot is 400 feet long.

The ledge, which is inclosed in thin-bedded dark-gray siliceous limestone, strikes almost east and west and dips 40°–45° S. at the outcrop, gradually straightening to nearly vertical at the bottom of the 200-foot winze. The ore as seen on the dump consists of intimately associated tetrahedrite, sphalerite, galena, pyrite, and chalcopyrite in a medium-grained quartz-siderite gangue. The outcrop of the ore body is a honeycombed iron-stained quartz through which galena and anglesite are sparsely distributed.

Silver Crown mine.—The Silver Crown mine, formerly the Climax, is situated near the crest of the ridge one-half mile west of the Silver Star. Two tunnels, one 500 and the other 200 feet long, enter the hill from the north, and a third, 300 feet long, enters from the south. Ore worth \$30,000 is said to have been shipped from the mine during the early period of activity in the district. The ore consists of tetrahedrite, galena, and sphalerite sparsely scattered in a coarse quartz-siderite gangue. The deposit is within the area of siliceous limestone beds.

King of the West mine.—The King of the West mine, situated near the head of King of the West Gulch, at an elevation of 7,300 feet, was located in 1881 and was worked for the next 12 years. The property includes three patented claims and a mill site at the mouth of the gulch, where there is a 50-ton concentrating mill equipped with jigs and trommels. The vein strikes northeast and dips steeply northwest, but none of the 3,000 feet or more of workings, consisting of a 400-foot shaft and a principal tunnel, were accessible at the time of visit. The ore is said to have run 120 ounces of silver to the ton.

The principal minerals, as seen on the dump and about the mill, are galena and tetrahedrite in a quartz-siderite gangue.

Sunday Group mine.—The Sunday group lies about one-half mile west of the King of the West on the north side of the canyon. It comprises two unpatented claims which contain veins reported to have produced \$15,000 or \$20,000 from argentiferous galena ores. Material on one of the four dumps suggests that the ore consisted of galena, pyrite, and chalcopyrite in a gangue composed of quartz and a little siderite mixed with calcareous shale and slate fragments from the inclosing rock.

Stormy Galore mine.—The Stormy Galore group, comprising three unpatented claims, is situated near the head of West Richmond Gulch at an elevation of 7,500 feet. The mine is said to have produced \$100,000 from gray copper ore containing about 400 ounces of silver to the ton, the highest-grade silver ore found in the district. Very little galena accompanies the tetrahedrite. The gangue is a mixture of the magnesian limestone wall rock and coarsely crystallized quartz. Cavities lined with quartz crystals are abundant in many specimens. The principal tunnel extends southward from a point near the creek level, but the one recently worked is 150 feet higher. Above this tunnel are two others, the four aggregating perhaps 2,000 feet of work. The vein, as exposed in next to the lowest tunnel, strikes N. 7° E. and dips 60° E., but both strike and dip vary from place to place. The stopes show it to have been from 2 to 8 feet wide, averaging perhaps 3 feet. The hanging wall is of fine-grained, bluish-gray magnesian limestone and is well defined; the footwall is of similar material but grades back through a zone of crushed and sheeted limestone into the undisturbed country rock. A narrow stringer of ore lies parallel to the vein 20 feet in the hanging wall, and another which strikes north-south and dips steeply west crosses the main vein. The mine has been worked intermittently since its discovery in 1882.

Tyrannus mine.—The Tyrannus group, consisting of five patented claims, is on the north side of West Richmond Gulch near its head, 7,700 feet above sea level and about 2,000 feet southwest of the Stormy Galore mine. A concentrating mill equipped with crusher, trommels, and five jigs is situated on the property. There are four tunnels, representing perhaps 4,000 feet of work in all, but only the lowest was accessible at the time of the writer's visit. In this the old stopes indicate a vein from 18 inches to 8 feet wide, averaging perhaps 3 feet, which strikes N. 60° E. and dips 37° NW. The inclosing rock is calcareous slate with intercalated quartzitic slate and is traversed by dikes of diorite porphyry. The mine is credited by local residents with a production of \$100,000 from argentiferous galena and tetrahedrite ores averaging about 100 ounces of silver to the ton. The gangue minerals are quartz and siderite. The mine

was worked intermittently from its discovery in the fall of 1882 until 1906, at first by the original locators and later by a French company.

Other mines and prospects.—Several other mineral claims are recognized in the district, but none of them were being worked in 1912, and so far as known to the writer none have produced more than a small amount of ore. Most of them are in the vicinity of Worwick hot springs. A large number of claims north of the springs are known as the Rosetta group, and others a few miles to the south as the Five Points group. None of these claims were visited during the reconnaissance.

LITTLE SMOKY DISTRICT.

The Little Smoky district, so named because it includes the area about the headwaters of Little Smoky Creek, lies east of the Rosetta district. Most of the recognized deposits are less than 10 miles southwest of Carrietown. The district embraces a large area of the Tertiary eruptive rocks and a small portion of the area of Paleozoic beds which contain the principal deposits of the Rosetta district. Both lead-silver and gold-silver ores have been exploited in the district, but the total production has been small.

The Hidden Treasure is said to be one of the more promising groups. It comprises four unpatented claims developed by a 40-foot shaft and three short tunnels; in all less than 1,000 feet of work. Considerable ore is said to be blocked out in the mine and to average 15 to 20 per cent lead, 10 ounces silver, and 0.2 ounce gold to the ton. It has produced about \$8,000. Other groups in the district are the Smoky Bullion, Idaho Chief, Prince of India, Gopher, Flynn Consolidated, Stewart, and Stratford. Below these claims, along the valley of Little Smoky Creek, are the Rawley, Hollister, and Rollins placers, each of which has been worked intermittently in a small way for a number of years. The deposits of the district were not examined during the reconnaissance.

WARM SPRINGS DISTRICT.

BOYLE MOUNTAIN.

The deposits near Boyle Mountain lie within the Warm Springs district, which extends into the area from the Hailey quadrangle. Rooks Creek, a small tributary to Warm Springs Creek from the north, drains the eastern slope of Boyle Mountain and flows through an area which has produced nearly \$1,000,000 from lead-silver ores and perhaps \$50,000 from zinc ores. A batholithic mass of dark-gray medium-grained soda granite, locally with a phenocystic development of the feldspars, protrudes through the Paleozoic slates and calcareous sandstones over an area of perhaps 5 square miles. The

principal deposits occur near the northwest border of the granite, in part in the igneous and in part in the sedimentary rocks.

The Old Ontario and Lucky Boy mines, both acquired several years ago by the Boston & Idaho Mining Co., are the principal deposits in the vicinity of Boyle Mountain. The Ontario lies west of the creek and Lucky Boy east of it. In the canyon separating them the Boston & Idaho Co. erected a 100-ton concentrating mill in 1907 but has treated very little ore in it. The period of active production extended from 1881 to 1887, the output during later years being erratic and small.

The Ontario mine is opened by tunnels aggregating several thousand feet of work both in the granite and in the Paleozoic sedimentary rock. Two systems of veins, each offset by numerous normal faults, have been explored. At the time of visit, however, all the tunnels were inaccessible except one, and that one, which is in granite, was caved at a point 500 feet from the portal. Ore on the dump shows the vein to contain fine-grained galena, arsenopyrite, pyrite, and a little sphalerite and chalcopyrite in a quartz gangue. Specimens taken from the dump show that replacement of the granite was involved in the formation of the ore. Pyrite seems to have wandered farthest into the walls, but small patches of all the other minerals are abundant in specimens of the sericitized granite. The ores on this (west) side of the canyon were mined for silver and lead.

The Lucky Boy mine, on the east side of the canyon, was not visited during the hasty reconnaissance. It is operated for zinc ores. Specimens of the ore consist of sphalerite, pyrite, and a little galena and arsenopyrite in a quartz-siderite gangue. The mine is said to have produced 2,600 tons of 45 per cent zinc ores from veins intermittently worked for several years.

BOULDER BASIN.

General features.—The mining claims of Boulder Basin, which lies north of Wood River near the eastern edge of the quadrangle, are recorded in the Warm Springs district, which lies mostly within the Hailey quadrangle. A good wagon road leads from Ketchum up the valley of Wood River and thence up the canyon of Boulder Creek, a total distance of 16 miles. Only the last mile of the road has a steep grade and even over this freighting is done with wagons. The narrow canyon of Boulder Creek opens out near its head into a beautiful amphitheater, which is floored with meadowland dotted with several small lakes and is surrounded on the north, west, and south by precipitous cliffs from 1,000 to 1,600 feet high. Boulder Peak, on the southwest side of the basin, rises 11,100 feet above sea level, being one of the higher peaks along the divide between the drainage basins of Salmon and Big Lost rivers on the north and Wood River on the south. The floor of the basin stands at an elevation of 9,500 feet.

Except for the heavy snows in winter the conditions are excellent for mining. Timber is plentiful, water for domestic use and for power is within easy reach, and the precipitous slopes make development by tunnels particularly advantageous.

Geology.—The rock formations include a thick series of bluish and gray fine-grained quartzites and siliceous slates, which in general strike a little east of north and dip west at high angles. These are traversed by dikes that range in width from a few inches to a few hundred feet. In general the dikes follow the strike of the formations and dip 70°–85° W., many of them following bedding planes and others dipping more steeply than the bedding. They are exceedingly numerous, comprising perhaps one-third of the rock exposed in the sides of Boulder Basin. The study of them was too hurried to afford an adequate idea of their varieties and relations, but collected specimens include granite porphyry, quartz monzonite porphyry, diorite porphyry, and a rare lamprophyre identified as spessartite. The microscopic descriptions of these rocks appear in the section on the dike rocks (pp. 227–228).

Principal claims.—The principal claims in Boulder Basin and vicinity are held by two companies, the Golden Glow Mining Co. and the Boulder Consolidated Mining Co. The former owns 5 patented claims and the latter 23 unpatented claims surrounding the other group and extending southeastward. The principal output, said to be about \$1,000,000, has come from the Golden Glow ground, which was located in 1879, relocated in 1882, and actively exploited during the next 10 years. In recent years small shipments have been made, those in 1911 returning \$15,000 from 125 tons of ore. This ore contained from 43 to 58 per cent of lead, 1 to 2 per cent of copper, and 0.32 to 0.63 ounce of gold and 56 to 92 ounces of silver to the ton.

Golden Glow mine.—The Golden Glow mine is on the west side of the Boulder Basin cirque. Development consists of four tunnels and one shaft. The tunnels, numbered consecutively from the lowest to the highest, represent, respectively, 800, 390, 625, and 90 feet of work; the shaft is above and is 125 feet deep. The levels are about 110 feet apart and are situated nearly one above the other.

The mine contains one principal vein, which strikes in general N. 50° E. but locally turns abruptly east. The general dip is about 70° SE., but locally it is in the opposite direction, as between levels Nos. 2 and 3. The vein material is bordered by well-defined walls, to which the ore adheres firmly in most places. The space between the walls is locally filled in large part with sheeted and crushed wall rock; elsewhere with vein quartz. Three principal ore shoots have been worked. The largest shoot begins 191 feet from portal No. 2 and continues for 100 feet. Sixty-five feet below this level it is 150 feet long, but 60 feet above the level the ends draw in until they are only

5 feet apart. This continues a short distance upward and then the length again increases to 100 feet on level No. 3. Fifteen feet above this level the ore heads squarely against a smooth surface of quartzite. About 300 feet west of this shoot, beyond a dike of granite porphyry, there is another, which, as developed, ranges from 10 to 100 feet in length, averaging perhaps 30 feet. It has been opened to a depth 50 feet below level No. 3 and continues from it to the surface, 125 feet above. Ninety feet west of this shoot is the "Cache shoot," which was worked by shaft to a depth of 125 feet. It contained ore said to have averaged 55 to 60 per cent in lead and 360 ounces in silver and 3 ounces in gold to the ton. The shoot was from 10 inches to 2 feet wide and averaged about 90 feet long. In the other shoots the ore is of much lower grade, and in each the width of the vein is from 6 inches to 6 feet, averaging perhaps 20 to 24 inches.

Oxidation is almost complete down to level No. 3, where the ore is a porous quartz heavily stained with iron and manganese, containing lead carbonate in bunches and pockets. Below, the ore consists of galena and a little sphalerite, pyrite, and chalcopyrite in a quartz gangue, containing a little calcite and siderite. Proustite and stephanite are present locally in very small amounts.

Several of the dikes in these deposits cut across the veins, in places dividing a vein as would a wedge, but elsewhere causing considerable offsets, as in level No. 3, where, on the west side of the dike, the vein is shifted 50 feet to the north. Locally, however, stringers of primary ore cut the dike rocks, suggesting that the injection of the dikes and the formation of the veins were nearly synchronous. The sequence of dike injection is not known, but in tunnel No. 3 granite porphyry traverses the ore, and in tunnel No. 2 ore of the middle shoot shows replacement phenomena against a lamprophyre dike.

Boulder Consolidated mine.—The Boulder Consolidated group comprises 23 claims, which surround the Golden Glow group and extend southeastward across the high elbow in the west rim of Boulder Creek canyon and down to the creek level, nearly a mile distant. Here a long crosscut enters the canyon side at an elevation of 7,950 feet, and so rapidly attains depth that at the present face, 1,000 feet from the portal, it is said to be about 1,500 feet below the surface. At a distance of 4,000 feet, according to the company surveys, the face will be directly below the Golden Glow ore body. The tunnel extends N. 64° W. and traverses, almost at right angles to their strike, steeply dipping quartzite beds which have been intruded by dikes, principally of granite porphyry, so numerous that more than half of the total length of the tunnel is in igneous rock.

Stringers of pyrite accompanied by a little sphalerite and zinc blende occur at several places in the tunnel, but no ore body of minable size had been found at the time of visit. Small prospect tunnels and pits

at several places on the surface show evidence of mineralization, and it is hoped that the crosscut will reveal ore beneath some of these. The main object in driving it, however, is to reach a point beneath the Golden Glow ore body 1,300 feet below the lowest Golden Glow level.

GALENA DISTRICT.

The Galena district has always occupied a subordinate place in the mining activity of the region. A 30-ton capacity smelter was built at the town of Galena, best known as a stage station, in the early eighties, but it ran for only a short time and with indifferent success. The principal mineral locations in the district are the Senate, Gladiator, and Carbonate Hill mines. Their production was small, and during recent years assessment work has not been kept up on most of the claims. The settlement of Galena is well within an area of Tertiary eruptive rocks, although some of the creeks that join Wood River near the station probably head in the older formations. The deposits were not visited. From Galena a trail leads north over the divide to Germania and Washington basins, and from these camps much of the ore for the local smelter is said to have been obtained.

EAST FORK DISTRICT (GERMANIA AND WASHINGTON BASINS).

GENERAL FEATURES.

The deposits of Germania and Washington basins are on the north side of Germania Creek, a tributary to East Fork of Salmon River near its head. They are in the East Fork mining district.

The district is high and mountainous, with summits above 10,000 feet in elevation, which rise abruptly from drainage lines 3,000 to 4,000 feet lower. Steep slopes that are thickly covered with fir and pine make up most of the area, but about the heads of many of the glaciated canyons cliffs rise almost vertically for several hundred feet, and upon these there is no vegetation. Washington Basin comprises the upper end of one of these glaciated canyons and lies just north of Germania Basin, which is shown on the north edge of Sawtooth topographic sheet. Both basins drain to the southeast.

The area is 50 miles by wagon road from Ketchum, the nearest railroad point. The route leads from Ketchum to the head of Wood River, over the Galena summit into the valley of Salmon River and thence up Pole Creek, over a fairly easy summit into Germania Basin and on into Washington Basin. The area also may be reached by trail from Clayton, about 25 miles to the north.

PRINCIPAL CLAIMS.

Lead-silver deposits.—Lead-silver deposits were discovered in Germania Basin in 1880 and were worked for the seven years following. Two principal groups of claims were recognized—the Tyrolease,

comprising two unpatented claims, and the group owned by the Wood Livestock Association, comprising six patented claims. The Tyrolease made only a small production, but the deposits of the other group shipped ore worth more than a quarter of a million dollars. The Parnell claim, separately owned, is said to have produced \$125,000. During this period of seven years two or three other lead-silver veins that crop out in the south wall near the head of Washington basin were also being worked, producing possibly \$50,000.

Gold quartz ledges.—Prior to 1894 no serious attention was given to the large low-grade gold-quartz ledges, five in number, which crop out in a low ridge of igneous rock that divides Washington Basin lengthwise into north and south parts. Since 1894, however, the number of claims in the area on which annual assessment work is done has increased from 2 or 3 to 20 or more. Eleven of these comprise the Empire group, on which the only noteworthy development has been accomplished. A few years ago this group was bonded, but the option was forfeited.

The rock formations in the vicinity comprise a thick series of sedimentary beds invaded by masses of porphyritic quartz monzonite. The sedimentary rocks include fine-grained quartzite overlain by dark-colored massive dolomitic limestone, which grades into a succession of alternating blue and white limestone and next into black slate, comprising in all 1,500 feet or more of beds similar to those exposed in the south side of Washington Basin. The igneous rock consists of orthoclase, plagioclase, quartz, and biotite with interstitial areas packed with micropegmatite.

Last Resort vein.—The Last Resort vein strikes N. 60° E. and dips 40° SE. It may be traced through three claims, except for a gap of about 400 feet, and averages in width about 6 feet, although it is locally as much as 12 feet across. It is developed by a tunnel 112 feet long, which if continued for 1,500 feet would attain a vertical depth of 350 feet. It is also exposed in a dozen or more short tunnels, open cuts, and pits. In all the exposures the vein material is an iron-stained coarse-grained quartz with scattered patches of honeycomb quartz. It is said to carry \$3 to \$5 in gold to the ton.

Empire vein.—The Empire vein or ledge strikes N. 25° E. and dips 55° SE. It is entirely inclosed in the porphyritic granite and crops out at short intervals through four claims. Its average width is about 30 feet, though in one place on the crest of the ridge it is 72 feet across. Development consists of two tunnels, two shallow shafts, and several trenches. The lower tunnel is 450 feet long, the upper one 150 feet. The vein material is coarse-grained bluish quartz and partly replaced quartz monzonite. Near the surface it is intensely oxidized in most places, but at a depth of a few feet primary minerals appear. Arsenopyrite occurs as small patches and

isolated prismatic crystals in the northern part of the vein. In the southern part pyrrhotite, with about an equal amount of intermixed quartz and diopside, forms a band 15 to 20 feet wide next to the hanging wall. Thin sections of this material show clearly that the pyrrhotite replaces quartz monzonite, the quartz of which remains. The feldspar and biotite crystals are completely transformed to pyrrhotite and diopside, the feldspar showing a slight tendency to be in the centers of diopside areas. Much of the diopside also is poikilitic with respect to quartz grains. Near the crest of the ridge the vein incloses a large lenticular mass of quartz monzonite in which considerable sphalerite occurs as isolated patches and stringers, some of which are 3 to 4 inches across. The sphalerite is accompanied by a little galena, pyrite, stibnite, pyrrhotite, and arsenopyrite. The quartz monzonite here is intensely sericitized and locally is greenish gray and of a silky luster. The feldspars are changed to a felted mass of sericite, which incloses grains of the sulphide minerals. Chlorite and a little magnetite occur in areas probably occupied originally by biotite. In one of the thin sections of the sulphide ore the main mass, pyrrhotite, is intricately fractured and traversed by iron-stained quartz of netlike distribution.

The tenor of the Empire ledge matter is not definitely known, but pannings from outcrop material show the presence of gold in many places. Mr. George Z. Blackman, of Clayton, Idaho, the owner, claims that ore from a 30-foot face in the lower tunnel averages \$12 to the ton in gold, although it would seem from the panning of the specimens collected by the writer that this estimate is too high. On the crest of the hill the outcrop is said to contain \$6 to \$7 in gold to the ton.

West Empire vein.—One hundred feet west of the Empire is a parallel ledge 15 feet wide known as the West Empire. It has not been developed.

Vein east of the Empire.—East of the Empire, perhaps 100 feet, another quartz ledge appears at the surface for a considerable distance, but has not been explored.

Reconstruction vein.—The Reconstruction vein lies 400 feet east of the Empire and parallel to it. It is about 20 feet wide and, as exposed at the time of the examination, is an iron and manganese stained honeycombed quartz throughout. Sulphide minerals were not seen in any of the ore, but as the vein corresponds to the Empire in general appearance, it is probable that about the same mineral association characterizes the primary ore. Samples taken across the entire width of the vein are said to show by amalgamation tests a possible recovery of nearly \$10 to the ton in gold. The gold pans readily but is very fine and flaky.

VIENNA DISTRICT.**GENERAL FEATURES.**

The Vienna district embraces an unorganized area in the western part of the quadrangle about the headwaters of Smiley Creek, a tributary of Salmon River, and of Vienna Creek, a tributary of South Fork of Boise River. During the six years following the discovery of mineral in the district in 1879 the camp was an active mining center. The town of Vienna was a flourishing settlement of perhaps 1,000 inhabitants, 200 or more buildings, and a 50-ton capacity stamp and chlorination mill. None of the buildings now stand, however, though great piles of timber mark their positions and clearly bespeak the rapid depreciation of abandoned improvements in this area of heavy snow and long winters. The settlement is completely razed, and is about as desolate a place as one could imagine. Great tiers of cordwood, comprising possibly 20,000 cords in all, piled in the gulch and about the mill, tend to confirm the statement of former residents that activities in the district ceased abruptly. About eight years ago the claims were sold for taxes, and during 1912 three of them were worked under bond and lease from the person who bid them in. Many companies operated in the district during the first two or three years, but the claims were gradually consolidated into two principal groups, the Solace, with 16 patented claims, and the Vienna, with 33 patented claims.

PRODUCTION.

The production of the district can not be stated exactly, but is probably about \$1,000,000. Statements from the reports of the Director of the Mint for 1881 to 1884 afford some scattered and fragmentary information which can not be satisfactorily tabulated. The Vienna mill seems to have been erected soon after the discovery of the Mountain King ledge, in June, 1881, and to have produced \$300,000 during 1883 and about \$200,000 during 1884, all in silver bullion containing some gold. In 1883 the Mountain King, a claim of the Vienna group, is said to have produced \$103,600 from ore containing 20 to 30 ounces of silver to the ton. During this period other claims in the district were producing some ore, but the amount is not a matter of official record. The production after 1884 is not given specifically for this district.

PRINCIPAL MINES.

Development.—The mines are about 2 miles south of the old town of Vienna, near the head of the west branch of Smiley Creek. Development is extensive, possibly aggregating 15,000 or 20,000 feet of work, as estimated from the size of numerous dumps on both sides and around the head of the canyon. The principal workings of the Solace mine are about half a mile south of the Vienna.

Geology.—The deposits of the district occur well within the area of the Idaho granite, which crops out over most of the central part of the State. Here the granite is a light-gray equigranular rock, which along the veins is intensely sericitized, quartz being the only mineral in it which is unaltered. Along the gulch a few miles below the mine a little limestone float was seen, but it is not known to have any relation to the ore deposits and is certainly of small extent within the drainage area of Smiley Creek. About a mile below the old town of Vienna is the southwestern side of a wide belt of Tertiary lavas which extends northward for many miles along the course of Salmon River.

Mountain King mine.—At the time of the writer's visit only the Mountain King workings were accessible. They had recently been cleaned out in part by a group of men who held three claims of the Vienna group under bond and lease, and who were seeking lead-silver ores in the old silver-quartz stopes. This is said to be the only mine in the district which contains important amounts of lead ores, and as lead was not desired in the chlorination mill owned by the old company it was not removed from the mine. The ore occurs along a crushed zone that strikes N. 60° W. and dips 51° NE. in the upper levels and 80° in the lowest or No. 4 level. Development comprises about 6,000 feet of work in four drifts on the vein. As shown by the old stopes the ore body was about 700 feet long and ranged in width from a few inches to 15 feet, probably averaging about 4 feet. It is said that material from these stopes averaged between 20 and 30 ounces of silver to the ton and contained a noteworthy amount of gold. The best lead ore was found on level No. 3 near raise No. 9, where a small vein which strikes N. 40° E. intersects the main lode. The silver-quartz ore occurred as a band 8 to 20 inches wide alongside the galena ore, either next to the hanging wall or next to the footwall. Both sorts of ore show abundant evidences of replacement of crushed granite. Next to the vein, pyrite as isolated cubes and stringers is developed in the granite, and sphalerite and galena replace blocks of wall rock within the fissure. The granite is intensely sericitized adjacent to the fissure, and locally chlorite is abundantly developed. The lead ore is irregularly distributed along the fissure and ranges in width from 1 inch to 6 feet.

Assay records supplied by T. H. Williams, who with two associates held the bond and lease in 1912, are as follows:

Assays of ore from veins of Mountain King mine, Idaho.

Width in inches of vein sampled.	Gold.	Silver.	Lead.	Zinc.	Insoluble.	Sulphur.	Iron.	Copper.
16.....	Ounces. 1.07	Ounces. 26.4	Per cent. 28.0	Per cent. 14.9	Per cent. 4.6	Per cent. 26.1	Per cent. 13.5	Per cent. 0.3
24.....	1.58	11.1	6.8	4.0	27.2	21.6	21.8	.2
20.....	.98	4.9	1.2	12.4	10.4	34.0	25.6	.2
72.....	.58	6.8	11.4	14.2	27.8	22.4	14.3	.2

Three carloads of hand-sorted ore said to average \$50 to the ton were shipped from the mine in 1912. This ore consisted of galena, sphalerite, and pyrite in a coarse-textured quartz gangue.

SAWTOOTH DISTRICT.

The Sawtooth district, which embraces a large area south and southwest of Alturas Lake, was not visited during the reconnaissance. The district was the seat of an important mining industry from about 1880 to 1888. During much of this time about 150 men were employed in the area and ore said to have been worth nearly \$1,000,000 was produced. Detailed records of this early activity are not available, but in the reports of the Director of the Mint for 1881 to 1884, inclusive, brief references to the camp appear in the notes on Alturas County, which then included the area. Deposits were opened on Beaver, Eureka, and Jake gulches, all of which produced high-grade silver ore, some of it containing as much as 4,000 ounces of silver to the ton, but after two or three years the Silver King and Pilgrim mines, both owned by the Columbia & Beaver Co., were the principal producers. A 20-stamp mill erected near the town of Sawtooth made its first run in the fall of 1883, producing \$60,000 worth of bullion in 45 days.

The mode of occurrence of the ore is said to be similar to that at Vienna. All the deposits are veins in granite. The principal ore minerals are proustite, cerargyrite, and silver-bearing sphalerite in a quartz gangue. Galena is notably scarce and in most places is absent. The district is extensively developed, but work was abandoned so long ago that all the tunnels are reported to be caved. The Silver King shaft, 600 feet deep and the most extensive working in the district, is in the flat of Beaver Creek. The workings are entirely flooded. This mine is said by those who worked in its lower levels to contain a 16-inch band of ore which carries 350 to 400 ounces of silver to the ton and a little gold. The silver occurs as proustite and a "fine-grained greasy substance," which the miners called "black metal." The mine was worked from 1881 to 1888 and according to the statement of former residents of the district is reputed to have produced \$700,000, principally during the last two years in which it was operated.

