# Gold-Copper-Lead Deposits of the Yellowjacket District, Lemhi County, Idaho

by ALFRED L. ANDERSON

Pamphlet No. 94

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Gold-Copper-Lead Deposits of the Yellowjacket District, Lemhi County, Idaho

by

Alfred L. Anderson

ABSTRACT

Prospected in the late sixties, extensively developed in the eighties, and currently active since, the Yellowjacket district in western Lemhi County, Idaho, has an estimated early-day gold production of $450,000 and a later (1902-1949) recorded production of 3,855 ounces of gold, 5,608 ounces of silver, 20,792 pounds of copper, and 17,275 pounds of lead. The present investigation is concerned primarily with the possible utilization of the base-metal ores.

The district is underlain by argillaceous and calcareous quartzitic rocks of the Yellowjacket formation and by the Hoodoo quartzite, both of which are members of the Belt series (pre-Cambrian). These rocks are cut by bodies of gabbro of pre-Cambrian (?) age, by intrusives of varied composition of late Cretaceous or early Tertiary age, and by porphyritic dikes of Miocene age. Locally the rocks are covered by a small patch of Challis tuffaceous or Oligocene and by terrace and stream alluvium (Quaternary).

The district is along a zone of marked structural weakness. The Belt strata have been deformed by folding, and complexly fractured during each of several crustal disturbances. The most important of these disturbances facilitated intrusion of various kinds of magmas in late Cretaceous or early Tertiary time and provided access to mineralizing fluids expelled during late stages of the magmatic activity.

The mineral deposits include lodes and placers but the bulk of the production has come from the lodes. Deposits classed as lodes include (1) fissure veins, (2) complex fracture lodes, and (3) fracture-breccia stockworks. The ore occurs chiefly as a filling of fractures, fissures, and breccias, in part augmented by replacement of the altered rock. The ore is mainly gold ore, but some deposits also contain variable amounts of pyrite, chalcopyrite, tetrahedrite, and galena in an abundant quartz-calcite and in places siderite gangue. The ore bodies tend to have a sporadic distribution and ore shoots are commonly discontinuous, but mineralization may be expected over a considerable vertical range. Important base-metal production must depend for the most part on development of large, low-grade ore bodies amenable to fairly large-scale, low-cost mining operations. The gold will contribute very materially to the value of the ore. Some of the deposits are worthy of systematic exploration.

The placer deposits include (1) eluvial (residual or hill-slope), (2) bench, and (3) stream. The eluvial type appears to offer the best opportunity for important financial reward.

INTRODUCTION

PURPOSE AND SCOPE

To assist in the search for possible new sources of supply of the critically short base metals, copper and lead, the Idaho Bureau of Mines and Geology sponsored a study of the old gold camp of Yellowjacket in western Lemhi County in which the ore had long been known to contain some small amounts of base metals. Because of the former low price of copper and lead and the high milling and transportation costs, the base-metal content of the ore had received little attention; but, under the stimulus of the present shortage and consequent high prices, interest has been aroused in the commercial possibilities of the base metals, with many inquiries coming to the Idaho Bureau of Mines and Geology for specific information on the subject.
As so much of the work in the district is old and so many of the underground workings are inaccessible, much of the study had to be confined to surface observations and examination of dump material and old mine records. Detailed studies were carried on wherever mineralization was disclosed and when possible the data were recorded on surface and subsurface maps for permanent reference.

The findings indicate that the copper and lead have a widespread but sporadic distribution and that recovery in many cases may be economically feasible because of the gold content of the ore, which should help very materially to defray mining and milling costs. Some of the deposits possess rather unique structural characteristics and may be classed as fracture-brecia stockworks, which, with certain complex fracture lodes, may, when fully explored, form fairly large, low-grade ore bodies, possibly adaptable to low-cost, moderately large-scale underground mining operations. The studies have also revealed that the igneous geology is more complicated than heretofore realized and that some age reas-
signments are necessary.

FIELDWORK

About two and a half months of the summer of 1951 — mid-June till late August — were spent in the district. Study was slowed because of lack of underground and surface maps suitable for use in geologic mapping. Wherever access was had underground, the workings were mapped by Brunton and tape, with geologic features added in appropriate detail. Unfortunately, the largest and most important mine in the district, the Yellowjacket, was completely closed and most of the first-hand underground information had to come from limited workings on Steen Hill west of the old town of Yellowjacket. However, the writer did have at his disposal a detailed geologic map of the workings in the Yellowjacket mine that were accessible in 1941.

To aid in surface studies a plane table-stadia survey was made of the Continental-Columbia mineral zone extending from the old town of Yellowjacket westward to the Columbia mine at the top of Columbia Hill. This area was mapped on a scale of 1 inch to 400 feet with contours at 50-foot intervals. Later a more detailed map on a scale of 1 inch to 100 feet and with a 10-foot contour interval was made of a part of the mineral zone across Steen Hill. A similar large-scale map was also made of Yellowjacket Hill on which is shown the geology and surface work at the Yellowjacket mine.

As the map scale of the Castro quadrangle in which much of the district occurs was much too small for general geologic mapping, recourse was made to aerial photographs enlarged to about 4 inches to the mile. These photographs were ordered about the middle of June but were not received until about the middle of August. Because of their late arrival, the photos had to be used as a base for geologic sketch reconnaissance instead of detailed mapping as originally planned. The area of this map (Fig. 2) covers about 18 square miles.

Obstacles to geologic study were not restricted to the underground. Surface observations were very much handicapped by deep overburden and dense timber, which effectively concealed bedrock, except where resistant bodies of porphyritic rock steepened and narrowed canyon walls.

ACKNOWLEDGMENTS

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PREVIOUS GEOLOGIC WORK

The district has not received previous detailed geologic study. Earlier work has been chiefly reconnaissance or limited in scope. The principal publications have been by Umpleby (1918) and Ross (1984) with other contributions by Eldridge (1895) and Sheldon (1912). Some information on the district has also been included in the an-
nual volumes of Mineral Resources of the United States issued from 1882 to 1924 by the U.S. Geological Survey and from 1924 to 1951 by the U.S. Bureau of Mines and thereafter by its successor, the Mineral Yearbook.
Fig. 1. Index map showing location of Yellowjacket district and routes of approach (heavy lines).
The principal references are listed below:


GEOGRAPHY

LOCATION AND ACCESSIBILITY

The Yellowjacket district is in the western part of Lemhi County in east-central Idaho about 34 miles by air southwest of Salmon, the county seat, 13 miles southwest of the now celebrated Blackbird district, and 10 miles north of the Meyers Cove district (Fig. 1). It has, however, none of the cobalt mineralization that characterizes the Blackbird district and none of the fluor spar of Meyers Cove. Its own distinctive brand of gold-copper-lead mineralization is restricted to an area of less than 10 square miles centered about the former town of Yellowjacket.

The district is remote but is no longer hard to approach. The old town of Yellowjacket is 60 miles by road from Salmon, 88 miles from Challis, the county seat of Custer County, and 25 miles from the new town and post-office of Cobalt. The 60-mile route from Salmon is over the more than 8,000-foot Williams Creek summit, which is blocked by snow during the winter months. When blocked by snow use must be made of a much longer but less arduous route down the Salmon River to the mouth of Panther Creek (U. S. Highway 93 from Salmon to North Fork) and thence up Panther Creek through Cobalt to the mouth of Porphyry Creek, where connection is made with the road into Yellowjacket.

The best approach to Yellowjacket, however, is from Challis over the newly constructed gravel-surfaced highway (Morgan Creek road) which leaves the main highway U. S. 93 about 3 miles below Challis and extends up Morgan Creek to its head and over the 7578-foot Morgan Creek Summit to the head and thence down Panther Creek to the mouth of Porphyry Creek. This road, built to give access to the Blackbird district and permit year-round movement of cobalt and copper concentrates, is kept open through the winter and is used by stage to deliver mail daily to the post-office at Cobalt.

The 16-mile Yellowjacket road crosses the 7500-foot divide at the head of the south branch of Porphyry Creek and then descends to Yellowjacket Creek by way of Shovel Creek. The road has a good grade and is well maintained as far as the Yellowjacket Ranger Station, 4 miles above the old town of Yellowjacket. From the Ranger Station on the road is narrow and rocky but passable.

SURFACE FEATURES

The district is in the Yellowjacket Mountains, a part of the extensive Salmon River group. The mountains are the dissected plateau and upland type and locally are carved and drained by Yellowjacket Creek and its principal tributaries, Hoodoo and Trail Creeks, and by the smaller tributaries in Columbia and Slaughterhouse Gulches (Fig. 2). Yellowjacket Creek flows to Salmon Creek which in turn joins the Middle Fork of Salmon River (Fig. 1).

The mountains are fairly rugged and have a local relief of about 2,000 feet. Slopes are steep, in places even precipitous, but many divides are relatively broad or gently rounded and retain characteristics of an old erosion surface. Such a surface is well-preserved at and around the head of Columbia Gulch and on the top of Yellowjacket Hill.

Streams have steep gradients, but Yellowjacket Creek meanders as a swiftly flowing stream through a long narrow meadow until within two miles of the old town of Yellowjacket. It then enters a narrow rocky canyon to emerge again in a rather broad, basin-like opening at the old town site. A mile below the town the stream again enters a narrow rocky canyon. Trail Creek also leaves a relatively broad valley to enter a narrow canyon several miles above its junction with Yellowjacket Creek.

Some of the tributaries of Yellowjacket Creek in the northern part of the district head in glacial cirques.

CLIMATE AND VEGETATION

The climate of the district may be described as rigorous. Snow lies deep in
winter and remains on upper slopes well into June. Temperature readings are low through the winter and freezing temperatures are recorded in July and August. The short summer season, however, is delightful, with warm pleasant days and cool, invigorating nights. Much of the summer is characterized by sunshine, but showers are not uncommon. The summer is the dry season.

The vegetation reflects a subhumid climate with kind and density of growth dependent largely on altitude and degree of exposure to the sun. On lower, southward-facing slopes the vegetational cover is chiefly sage brush and grass, but with increasing altitude trees take over so that a whole the area is rather heavily forested. The main forest growth consists of spruce, fir, and lodgepole pine and these provide a supply of timber ample for all mining purposes.

GEOLOGY

FOREWORD

The Yellowjacket district is underlain by sedimentary and igneous rocks and in places by hybrid rocks that represent "granitized" sedimentary materials, which locally are essentially indistinguishable from some of the igneous rocks. The igneous rocks are chiefly intrusive and some of them, because of their relation to mineralization, are of pertinent geologic interest. Most of the rocks are older than the mineral deposits, but there are two minor groups of sedimentary rocks and one group of intrusive igneous rocks which are younger.

The various rocks show rather complicated structural relationships, in part because of folding but more particularly because of faulting and multiple igneous intrusion. Some of the faulting has had marked control on mineralization.

SEDIMENTARY ROCKS

General Statement

The sedimentary rocks consist of two thick members of the Belt series (pre-Cambrian), a small patch of Challis volcanics (Oligocene), and some unconsolidated sands and gravels along stream courses (Quaternary). Although the Challis volcanics are composed largely of extrusive igneous materials—tufts and flows—they are, because of their bedded or layered character, considered with the sedimentary rocks.

Belt Series (Pre-Cambrian)

The Belt rocks are chiefly of quartzitic composition and have been divided locally into the Yellowjacket formation and the Hoodoo quartzite. No attempt has yet been made to correlate them with known members of the Belt series in other parts of the State. These rocks underlie fully two-thirds of the area.

Yellowjacket formation. — The Yellowjacket formation, which receives its name from the old town and district, is the most widespread of all the rocks and is the host for most of the mineral deposits. The formation extends in an east-southeastern direction across the more central and southern parts of the district, and is pierced in the southern part by numerous bodies of igneous rock (Fig. 2). Its contact with the Hoodoo quartzite on the north is sharply defined, but its contact with the hornblende-biotite diorite on the south is in part transitional and marked by metamorphic (granitized) zones which in some places have been mapped with the diorite and in other places with the sedimentary rock.

The formation is thought to be more than 8,000 feet thick, with the base unexposed, and is composed largely of grayish, mostly relatively thin bedded, in part argillaceous and calcareous quartzites and some interfingered thin lenses of limestone. Because of its largely argillaceous character, the quartzitic rock is readily weathered and rarely presents good rock exposures. Its breakdown is facilitated in many places by well-developed fracture cleavage, by rather closely spaced joints, and by abundantly developed fractures and breccias associated with faulting. The rock usually shows some shade of gray (darker on weathered surfaces), occasional ripple marking, more or less well-defined bedding rarely obliterated by fracture cleavage, and local small cross-bedded lenses. The calcareous quartzites weather to a pale buff and in that respect resemble the calcareous beds of the Wallace formation in the Coeur d'Alene district. In places the calcareous beds are distinguished by the presence of larges rounded white or light-gray grains of scapolite.

Near the hornblende-biotite diorite the quartzitic rock becomes more feldsparic and contains considerable quantities of biotite and in some places hornblende. The altered quartzite thus looks very much like

Fig. 2. Geologic sketch map of the Yellowjacket district, Lemhi County, Idaho.
an igneous rock and, were it not that the rock preserves its sedimentary structures, it would certainly be classed as igneous. Rock of this kind caps considerable of the narrow ridge between Trail and Yellowjacket Creeks southeast of the old town of Yellowjacket, but because the cap is so narrow, the altered quartzite was not differentiated from the hornblende-biotite diorite in mapping. Similarly altered rock in which sedimentary structures are preserved was mapped as a part of the Yellowjacket formation at the Tin Cup mine west of lower Yellowjacket Creek and on the higher ridge southwest of the mine (Fig. 2). There boundaries between the diorite and Yellowjacket formation are purely arbitrary and in places much hybrid rock is mapped as diorite.

The calcareous members on Yellowjacket Hill north of the old town have altered to dark-banded hornfels and to whittish, rather coarsely crystalline marble, which generally contains scattered grains and granular masses of silicates. Minerals formed in the calcareous rock include variable amounts of biotite, chlorite, scapolite, hornblende, actinolite, plagioclase, apatite, and some other minor accessories. Some of the rock shows rather conspicuous banding with dark minerals in layers, and on casual inspection resembles sheared gabbroic rock.

Hoodoo quartzite.—The Hoodoo quartzite, which receives its name from Hoodoo Creek along which it is conspicuously exposed, extends across the northern part of the district as an ever-expanding band from northwest to southeast (Fig. 2). It is almost as widespread as the Yellowjacket formation, but it is the host for mineral deposits on only two of the mining properties and has been cut by only a few intrusive bodies. The quartzite overlies the Yellowjacket formation, but within the district the two formations appear to be separated by faults.

The more than 3,000-foot thick Hoodoo quartzite is composed of nearly white, originally massive, intricately jointed quartzite with mostly indistinct bedding. It is more resistant to weathering than the Yellowjacket formation and thus tends to form better and more conspicuous outcrops. Because of its lighter color and superior resistance to erosion, its presence is generally indicated in the topography and is readily revealed in aerial photographs.

According to Ross the representative rock

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is composed of 70 to 80 percent of quartz, up to 10 percent feldspar (microcline and albite), and sericitic mica and chlorite. The quartz is reported to occur in interlocking grains measuring about 0.2 mm. in average diameter, and the feldspar as clear unaltered grains about 0.5 mm. long.

**Challis volcanics (Oligocene)**

The Challis volcanics are confined to a small area on and near the crest and west slope of Columbia Hill (Fig. 2). The volcanics are actually in place on and just below the crest of the ridge, but landslides have carried broken masses of the rocks far down the slope toward Hoo doo Creek. The landslide material has not been differentiated from the rock in place and the whole has been mapped as Challis.

The volcanics are poorly exposed and their thickness is indeterminate. The rocks consist locally of light-colored tuffs and intercalated dacitic and andesitic flows. These flows crop out for a short distance along the top of the ridge, apparently above intrusive granophyre. The dacite resembles some of the granophyre on Columbia Hill, but contains more phenocrysts, particularly biotite. The phenocrysts also include fairly numerous crystals of andesine and a few of quartz in a pinkish, largely glassy ground-mass with tiny feldspar microlites. The andesite is nearly black and contains phenocrysts of andesine and augite or hornblende in a moliblitic ground-mass with some glass. The tuff is apparently composed of material of intermediate composition.

**Quaternary deposits**

The Quaternary deposits include terrace and stream alluvium, the first of Pleistocene and the second of Recent age. These two have not been differentiated on the geologic map of the district (Fig. 2), but they are shown separately on the larger-scale map of the Continental-Columbia mineral belt (Fig. 3).

**Terrace alluvium (Pleistocene).** — The older alluvium, is most conspicuous and seems to be most extensive in the open, basin-like valley of Yellowjacket Creek at and around the old town of Yellowjacket (Fig. 3). The surface that carries the older alluvium is somewhat uneven but rises abruptly above the present relatively flat valley floor of Yellowjacket Creek, especially on the north and west sides of the creek. The alluvial accumulation appears
to represent the intermingled remains of two separate terraces, one about 50 feet above the present stream and the other at 100 feet or higher. In places the terraces are obscured by wash from the higher slopes and smaller gulches. The material composing the alluvium consists largely of gravel with a coarse bouldery admixture made up in considerable part of granitic and porphyritic rock. The gravels are in part auriferous but the only work on the gravel has been on small terrace remnants below the town.

Recent alluvium.—The Recent alluvium is confined to the floor of the long narrow meadow several miles above the old town of Yellowjacket, to the widened part of the valley at the old town site and to the meadow several miles up Trail Creek (Fig. 2). The material, especially at and below the old town, is coarse gravelly and bouldery and is made up largely of quartzite and porphyritic igneous rock. The gravel at and below Yellowjacket is gold-bearing and some of the gravel has been washed. Large boulders interfere somewhat with placer operations.

IGNEOUS ROCK

General statement

The igneous rocks here considered are intrusive and belong to three clearly defined groups, apparently representing as many epochs or cycles of igneous activity. The earliest group is possibly late pre-Cambrian; the second, late Cretaceous or early Tertiary and the latest, mid-Tertiary. The late Cretaceous or early Tertiary intrusives were not recognized by Ross, but some of the members here so considered were regarded by him as pre-Cambrian (?) and others as mid-Tertiary. Several of the late Cretaceous or early Tertiary intrusives show some resemblance to the pre-Cambrian (?) rock but there is no similarity whatsoever between them and the mid-Tertiary rocks. They also show no resemblance to the rock of the Idaho batholith (late Mesozoic).

Pre-Cambrian (?) intrusives

The pre-Cambrian (?) intrusives appear to be composed entirely of one kind of rock —gabbro—which is alike in all of its occurrences. The pre-Cambrian (?) rock was classed by Ross as diabase, but as the rock shows no well-defined diabasic texture, it seems more appropriate to refer to it as gab-
Fig. 3. Topographic geologic map of Continental-Columbia mineral zone.
cores within the hornblende, is largely altered to epidote. No biotite is revealed in thin section, but it is possible that some of the patches of chlorite may be its altered equivalent. Some of the plagioclase is incompletely saussuritized and retains remnants of original labradorite. The fine intergrowths of quartz and orthoclase appear to be characteristic of the rock, but neither quartz nor orthoclase comprise more than 5 percent of the rock.

Late Cretaceous or early Tertiary intrusives

The intrusives of late Cretaceous or early Tertiary age show a wide range in composition and are represented by such rocks as diabase, olivine gabbro, augite-hornblende-biotite diorite, hornblende-biotite diorite, biotite diorite, aenigmatite, pulaskite, pegmatite, and several kinds of lamprophyre. Most of these varieties are not widely distributed and some of them are limited to a single body. The hornblende-biotite diorite comprises the largest body of igneous rock in the district.

The various intrusives show such structural and mineralogic features as to indicate that they are genetically related and are products of a single magmatic cycle. Ross apparently mistook the diabase for the older pre-Cambrian (?) rock and the hornblende-biotite diorite for an associate of the Miocene pink granite, failing to note that the diorite was cut by lodes which he has related genetically to the Idaho batholith (Mesozoic). He makes no mention of the other rock varieties. As these intrusives are cut by Miocene dikes they have to be older and are very likely products of the igneous activity that took place during the late or closing stages of the Laramide orogeny in late Cretaceous or early Tertiary time.

Except for the lamprophyres, these intrusives are all pre-mineral and are cut by ore or altered by the mineralizing fluids. The lamprophyric dikes were apparently intruded at the close of mineralization.

Diabase—The bodies of diabase are small and cannot be shown on the surface maps. They are fairly numerous, but generally are most readily recognized as dikes in underground workings. Fresh rock collected on the dump of the No. 3 North adit of the Yellowjacket mine is probably typical of the diabase.

The rock is more coarsely grained and more darkly colored than the pre-Cambrian (?) rock and contains about twice as much dark mineral, chiefly augite. Thin sections reveal that the rock has an ophitic or diabasic texture with large grains of augite wrapped around and engulfing the calcic plagioclase (labradorite) crystals. Magnetite appears to be the only other primary mineral. With the augite is a little uraltite, bluish-tinted amphibole.

Basic rock collected or observed elsewhere was too weathered or too altered for correlation with the diabase or showed greater resemblance to some of the finer-grained dioritic or gabbroic rocks.

Olivine gabbro—The olivine gabbro is exposed on Yellowjacket Hill a short distance south of the No. 3 North adit (Figs. 2 and 4). Although mapped as olivine gabbro, the body may be composite and made up in considerable part of pre-Cambrian (?) gabbro into which the olivine gabbro was intruded.

The fresh rock is dark gray, medium-grained, and contains readily discernible plagioclase grains, but the dark minerals, which compose at least two-thirds of the rock, are not individually distinguishable. The minerals actually include abundant olivine, lesser augite and labradorite, and a very little pale brownish hornblende and magnetite, the latter as inclusions in the olivine. The texture bears some resemblance to that of the diabase.

Augite-hornblende-biotite diorite—The augite-hornblende-biotite diorite is a minor rock type but forms a mappable body on Yellowjacket Hill partly concealed by the big dump at the head of the old tram (Fig. 4). It may also be represented by several small, highly altered bodies exposed underground at the Columbia and Black Eagle mines.

This dioritic or possibly gabbroic rock exposed on Yellowjacket Hill is moderately dark gray, medium-grained, and is distinguished in the hand specimen by a liberal sprinkling of fairly conspicuous grains of biotite. Other abundant or conspicuous minerals are augite, hornblende, and zoned plagioclase. The rock also contains a little quartz and orthoclase, the accessories apatite, sirenite, and magnetite, and minor amounts of the secondary minerals chlorite, epidote, and calcite. The zoned plagioclase contains cores of labradorite, but average composition is apparently within the range.
of calcic andesine. The augite shows some mantling by hornblende, but hornblende also occurs as independent brownish crystals. The quartz composes about 5 percent of the rock and occurs as medium-sized grains and as very fine microscopic intergrowths with orthoclase.

This rock shows a very marked resemblance to the hypersthene-augite hornblende-biotite diorite that intrudes the Idaho batholith at Horseshoe Bend and Boise Basin and the Paleozoic rocks near Hailey, Idaho. The only difference is the lack of hypersthene, but this lack may be more apparent than real as only one thin section of the local rock was examined. Hypersthene could certainly be present in other parts of the body.

The dikes in the long adit at the Columbia mine and at the Black Eagle are much smaller than the one at the Yellowjacket, and they are composed of a darker and more finely grained rock. They are also in and close to mineralized ground and are in part sheared and altered. In thin section the rocks show evidence of rather complete reconstitution.

The rock at the Columbia mine is now composed largely of untwinned oligoclase (derived from a more calcic plagioclase) and bleached and partly uralized hornblende along with some augite and considerable greenish biotite and magnetite. The shapes of the original plagioclase laths have been largely destroyed and the spaces taken by smaller crystals of oligoclase. There are also indications that the original rock contained considerable brown hornblende and biotite and that the rock in general was more coarsely grained than it is now.

The rock at the Black Eagle has been highly sheared and has a prominent foliation. The original plagioclase shows extensive granulation with destruction of twinning lines and change from a calcic to a more sodic composition. Much biotite is contained in the rock, but the original brownish hornblende and any augite that might have been present have been almost completely altered to bluish uralite. The rock contains considerable magnetite and pyrite and locally has much zoisite and some epidote. In places the sheared dike contains quartz and gold and is said to constitute ore.

**Hornblende-biotite diorite** — The hornblende-biotite diorite is the one which Rose has called a quartz-hornblende diorite and has grouped with the mid-Tertiary intrusives. It is exposed over much of the southeastern and southwestern part of the district (Fig. 2) and for some distance beyond the margin of the district. It has a real exposure of somewhat less than 8 square miles. The body reaches under part of the old town of Yellowjacket and a short distance up Yellowjacket Hill, with a small dike like outlier still higher on the slope. As the diorite is pre-ore, it cannot be correlated with the post-ore Miocene intrusives.

The rock is somewhat variable in composition and general appearance, but most of it is moderately coarse-grained, light to moderately dark, and commonly spangled with numerous black grains of hornblende and biotite, which together may comprise from 20 to 50 percent of the rock constituents. The two minerals are about equally divided, and with the plagioclase, a highly twinned andesine, make up the main mass of the rock. Other minerals include a little microcline, considerable accessory apatite, sparse amounts of magnetite, zircon, allanite, and sphene, and minor amounts of such alteration products as epidote, chlorite, sericite, and calcite. Quartz was not observed in the rocks that were studied, but Rose points out that quartz is present in some of the rock in amounts generally less than 5 percent and in the less siliceous facies in amounts much less than 1 percent. He also mentions that in a few places the quartz exceeds 20 percent. Through the Yellowjacket district the rock appears to be largely, if not wholly free of quartz and therefore should be classed as a hornblende-biotite diorite rather than as a quartz-hornblende diorite.

**Biotite diorite** — The biotite diorite was observed as a small (unmapped) body at the Tin Cup mine on the west side of Yellowjacket Creek about a mile below the old town. It occurs in a pendant of highly metamorphosed Yellowjacket formation and may actually be a product of igneous metamorphism rather than of igneous intrusion.

The rock is almost black, finely crystalline, and has a distinctive micaceous appearance. It is composed of about half biotite.
tite with the remainder mainly twinned oligo-
goclase along with some accessory apatite,
magnetite, and secondary calcite. The olig-
gooclase grains tend to be somewhat larger
than the grains of biotite. Although rich in
biotite, the rock does not possess lam-
prophyric characteristics. It does not ap-
pear typically “igneous” in character but
could be and probably is a “granitized” sedi-
mentary rock.

Syenite — The syenite appears to be a
local border facies of the hornblende-bio-
tite diorite and was not differentiated from
the diorite in mapping. It is known to oc-
cur at the Hisey and Tin Cup mines (Fig.
2) and near the Bryan. Further study may
reveal that it has a fairly widespread dis-
tribution. The rock collected at the Hisey
mine came from a point several hundred
yards within the dioritic body and seems to
be typical of the rock to the contact.

The Hisey rock is appreciably weather-
ed and shows considerable granular disin-
tegration. The firm rock is moderately
coarse-grained and tends toward a trachy-
toid and coarse porphyritic development
with large tabular feldspar crystals in pa-
rallel and subparallel arrangement. Dark
minerals, apparently chloritized hornblende,
are rather scanty and the rock in conse-
quence has a light-gray to flesh color. In
the hand specimen and outcrop, the rock
shows a marked resemblance to some of the
syenitic rock in the Coeur d’Alene district.

The thin section reveals that the rock
is highly feldspathic and that it is composed
largely of coarse crystals of microcline, in
part rimmed and in places largely replaced
by albite. Some of the crystals of micro-
cline are highly perthitic and some show local
zones of pseudomorphology where finely
crystalline aggregates of albite have replac-
ed the microcline along fractures. The thin
sections also reveal scattered remnants of
granular and mosaic quartzite, in part con-
taining heavy concentrations of magnetite
grains. The sections also reveal a little
bleached biotite and some chloritic material,
but other original ferro-magnesian minerals
are not recognizable.

The syenite is apparently a feldspathized
quartzite and because of the abundance of
pottash feldspar is classifiable as syenite.
The textures and structures are very simi-
lar to those of the syenite associated with
the Gem stock in the Coeur d’Alene dis-
trict12; but the local rock is a “syenitized”
quartzite instead of a “syenitized” diorite
and it contains no plagioclase, except the
considerable amounts of albite, and no
quartz, except the scattered remnant patch-
es of the inherited quartzite.

The syenite at the Tin Cup mine shows
a resemblance to that at the Hisey but is
medium rather than coarse-grained and is
composed largely of albite rather than mi-
croline. Mostly remnants remain of what
were once large grains of microcline and in
place of the microline are much smaller
grains of albite. The rock is rather lightly
colored but contains up to 10 percent of dark
minerals, which include hornblende and bio-
tite in various stages of alteration to chlor-
ite. There is also a liberal sprinkling of
course sericite or muscovite and considerable
accessory sphenite, magnetite, and zircon.
Alteration products include epidote, chlorite,
and sericite. The microscope also reveals
some traces of quartzite, and the rock, which
may appropriately be called an albite syen-
ite, is essentially a completely albitized
quartzite.

Albite pulaskite — A small body of rock
which may be classed as albite pulaskite cuts
across the body of pre-Cambrian (?) gabbro
a short distance east of the tram head on
Yellowjack Hill (Fig. 4). The rock has a
light pinkish-gray color and contains a
sprinkling of altered ferromagnesian min-
erals. It has a somewhat aplitic appearance
and is composed chiefly of feldspar grains
about 1 mm. in long dimension.

The thin section reveals that the rock is
composed almost entirely of twinned albite
crystals with a subparallel or trachytoid de-
velopment and contains only very very few
amounts of orthoclase, some accessory
quartz, a scattering of hematite grains, and
a little apatite, magnetite, and sericite.

Pegmatite — Pegmatite was not observ-
ed in place, but fragments were found on
Yellowjack Hill in the huge dump at the
head of the old tram below the portal of the
No. 2 adit (Fig. 4). The fragments appar-
ently came from bodies at least a foot or two
wide somewhere in the workings tapped by
the No. 2 adit. These fragments are com-
posed of large crystals of pinkish feldspar,
with quartz and some mica. Some of the rock
has a graphic texture but most of it is
coarsely granular.

Lamprophyre — Lamprophyric dikes are
fairly numerous, especially in the mineral-
ized areas, but are rarely seen on the sur-
face, except as dark patches of soil. The
dikes are usually no more than a few feet
wide and are generally too small to be shown on any except a large-scale, detailed map. One dike larger than most is exposed near the portal of the No. 2 adit on the Continental Divide. The body is shown in Figure 7. These dikes are fairly conspicuous features underground, generally in or near the ore. They, like the ore, appear to be localized along zones of greatest structural weakness and were intruded during closing stages of mineralization or shortly after.

These dikes are composed of a dark-gray, fine-grained, inconspicuously porphyritic rock with the phenocrysts about the same color as the matrix and therefore not easily distinguished, except in thin section. Some of the dikes have scattered phenocrysts of serpentinized olivine, along with augite, and hornblende; some have just olivine and augite; and some only augite and biotite. The phenocrysts occur in fine-grained groundmasses composed of oligoclase-andesine, hornblende, and generally biotite, accompanied exceptionally by a little interstiti al quartz and orthoclase and always by consider able calcite, epidote, chlorite, and magnetite. In some dikes the biotite is more abundant than the other dark minerals and the rock may be classed as kersantite, but in most dikes augite or hornblende predominate and the rock is more appropriately classified as diorite lamprophyre (spessartite).

**Miocene intrusive rocks**

**Occurrence and distribution** — The Miocene intrusive rocks are mostly concentrated on and near the top of Columbia Hill and in a northeast-trending belt about 3 miles long beginning near Yellowjacket Creek south of the old town and continuing to near the east edge of the map-area (Fig. 2). The bodies are dike-like, but those on Columbia Hill are so closely spaced that they are mapped as a single body more than half a mile long and about half as wide. Those along the Yellowjacket belt are also crowded, especially in the lower valleys and gulches, and, where especially numerous and closely spaced in valleys and gulches, are also mapped collectively as single bodies. They are less numerous and more widely spaced across the ridges, apparently because most of them were not intruded as high as the present ridge levels. Most of them thus appear to extend through or under the ridges.

Most of the dikes have been intruded into the Yellowjacket formation but those at the far northeast end of the Yellowjacket belt enter the Hoodoo quartzite and those at and near the southwest end invade the hornblende-biotite diorite. The bodies at and near the top of Columbia Hill come in contact with the Chalpis volcanics.

These Miocene intrusives are of three kinds—granophyre, granite porphyry, and vitrophyre. The granophyric bodies are the most numerous and widespread and are shown on the map (Fig. 2) as single or individual dikes, where not too closely spaced, and as larger stocklike masses, where mapped collectively. The dikes range downward in size to those which are too small to be shown on the map. The granophyre is the oldest of the Miocene intrusives and is cut by both the granite porphyry and the vitrophyre. The bodies of granite porphyry are relatively large and those shown on the map (Fig. 2) are individual dikes. The vitrophyric dikes are too small to show on the maps.

**Granophyre** — The appearance of the granophyre is much the same throughout the district and variations mainly reflect size of body and rate of cooling. Most of the granophyric rock is epidote- and the scattered quartz and orthoclase phenocrysts, which normally make up about 10 percent of the rock, are contained in pinkish-gray, fine-grained or aphanitic groundmasses composed largely of quartz and orthoclase in micrographic intergrowths. The quartz phenocrysts average about 1 mm. in diameter and, in this section, appear to be more numerous than the larger orthoclase phenocrysts, which measure up to 6 mm. long. Thin sections also reveal scattered grains of biotite, mostly altered to reddish-brown secondary products. The rock generally contains considerable magnetite and locally may contain zircon and allanite.

Several dikes were noted, however, which are more conspicuously porphyritic and which contain up to 30 percent of phenocrysts, chiefly quartz, orthoclase, and oligoclase plus a little hornblende and biotite, all embedded in pinkish-gray, fine-grained groundmasses composed of granular as well as micrographic quartz and orthoclase. Phenocrysts are mostly less than 4 mm. in longest dimension. In one of the rocks examined in thin section the phenocrysts have spherulitic rims. Accessory minerals, as in the other granophyres, include magnetite, allanite, and zircon. The rocks also contain a little sericite, chlorite, and epidote.

The smaller, more isolated dikes show the effects of more rapid cooling and the phenocrysts are contained in groundmasses which are largely microspherulitic. The micro-
spherulites are commonly of large size and tend to occur as halos surrounding the phenocrysts with intervening areas of fine microgranular quartz and orthoclase. In some granophyric dikes the microspherulitic intergrowths merge with the micrographic. The phenocrysts and the accessory minerals are like those in the other granophyres. Quartz phenocrysts are always more numerous than those of feldspar and other minerals.

Granite porphyry—The granite porphyry is the rock which Ross\(^{13}\) has called a coarse granophyre. As the rock locally is not generally granophytic, the term granophyre hardly seems appropriate and the name granite porphyry is assigned instead.

The most striking feature of the granite porphyry is its marked porphyritic character. The rock is distinguished by the presence of large and very conspicuous feldspar phenocrysts which in part measure up to 4 centimeters (about 2 inches) long and comprise fully a third of the rock. Other phenocrysts include numerous but smaller crystals of quartz, which measure up to 5 mm. long and compose 5 to 10 percent of the rock, and less numerous phenocrysts of chloritized biotite and hornblende. Many of the feldspar phenocrysts are pale pinkish or flesh-colored but some are white or light gray. Most of them and particularly those of largest size and of pinkish color are composed of potash feldspar. These comprise about three-fourths of the feldspar phenocrysts; the others are oligoclase. All crystals are remarkably well-shaped.

The phenocrysts are embedded in grayish, fine-grained, microgranular groundmass composed of quartz and orthoclase, accompanied locally by a little oligoclase. The rocks also contain scattered grains of magnetite, apatite, zircon, and exceptionally allanite.

One dike in lower Columbia Gulch mapped as granite porphyry has some of the features characteristic of the pink granophyre. It is not quite so conspicuously porphyritic as the more typical granite porphyry and its groundmass contains some micrographic quartz and orthoclase, especially in areas surrounding phenocrysts. These micrographic areas merge with microgranular quartz and orthoclase.

Vitrophyre—Vitrophyric dikes are widespread through the porphyry belt but generally in bodies only a few feet wide. The largest is about 15 feet wide and several hundred feet long.

The dikes are composed of a dark gray to black obsidian-like rock which in places shows a perlitic structure. The rock contains fairly conspicuous phenocrysts of quartz and feldspars (orthoclase and analcite) in a dark glassy groundmass which in thin section shows narrow envelopes of polarizing, ill-defined microspherulites about the phenocrysts and a liberal sprinkling of trichites and some longulites in the intervening glassy base. The quartz phenocrysts are more numerous than those of the feldspar, but glass forms the bulk of the rock.

**STRUCTURE**

**General Statement**

The Yellowjacket district is along a zone of marked structural weakness, a zone in which the older bedded rocks have apparently been subjected to repeated deformation beginning in late pre-Cambrian time and continuing intermittently to the present. As a result these rocks have been complexly folded and fractured and made especially vulnerable to the invasion of magma during late pre-Cambrian (?) late Cretaceous or early Tertiary, and mid-Tertiary times and also to movement of ore-bearing fluids that occurred during closing stages of igneous activity in late Cretaceous or early Tertiary time.

Data on the folding are incomplete but much information has been assembled on the faulting, deduced in part from the structural relations of the intruded dikes and the mineralized fractures.

**Folds**

The folding in the district is complicated and, because of extensive rock fracturing, few satisfactory rock exposures, and limited time for study, could not be entirely deciphered. Through most of the district the Belt strata strike N.30°-60°W. and dip moderately to steeply southwest, but there are some local departures of both strike and dip, particularly in the vicinity of faults. According to Ross\(^{14}\) the dip of the beds between Yellowjacket and Hoodoo Creeks indicates an anticlinal structure, marked in place by close folding and disturbed locally by igneous intrusion. There is much steepening and flattening of dip and local overturning within short distan-

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\(^{13}\) U.S. Geol. Survey Bull. 804, op. cit. pp. 64-65.

ces. Such rapid changes in dip might well have had some role in the formation of breccia zones observed underground in some of the mines, particularly along the Conti-
tinental trend. There has been no proof or disproof of any such relationship must await additional data.

The time of folding is not precisely known, although the folding is older than most of the faulting. Ross 3 presents some evidence of structural movements accom-
pnied by overthrusting in pre-Mesozoic time, presumably in the late pre-Cambrian. It is likely that some folding may have taken place then and in fact the pre-Cam-
bian folding was accentuated by orogenic movements of late Mesozoic and later times.

Faults

For more systematic treatment the faults have been differentiated on the basis of their relation to igneous intrusives and mineralization and to other factors which in part make age separation possible. The faults are thus grouped as dike faults, mineralized faults and fracture zones, post-
mineral faults, and regional faults.

Dike faults — The faults that directed intrusives are of as many ages as the magmas, but they can be resolved into three general age groups corresponding to the three epochs of igneous activity. Whatever facts are deduced concerning these faults have come largely from the structural relationships of the dikes, their trends and patterns.

As the late pre-Cambrian (?) intrusives generally show elongation in west-north-
west and northeast directions (Figs. 3 and 4), it is presumed that the guiding frac-
tures had a similar alignment; and, as the two directions are at right angles, that they are complimentary sets of frac-
tures formed in response to regional deforma-
tive forces. The trends of these bodies do not conform with the trend of the in-
vaded Belt rocks and seem uninfluenced by the folding. Because room was provided for entry of magma, the faults were pre-
sumably formed by tensional forces and may therefore have been normal faults. The faults apparently were of no great magnitude, for the strata bordering the dikes show little apparent displacement.

The dikes of late Cretaceous or early Tertiary age are also elongated in north-
east and northwest directions, but the de-

parture from north is generally greater in the case of the dikes of northeast trend as compared with the late pre-Cambrian (?) dikes and less in the case of the northwest-
trending dikes (Fig. 2). Consequently, pre-
vailing trends are more east-northeast and north-northwest and the directing fractures therefore appear to be unrelated to those which influenced intrusion of the late pre-
Cambrian (?) magma. These younger fractures also appear to have had some control of the emplacement of the hornblende biotite diorite stock whose boundaries show tendencies to extend in northeast and north-
west directions. As in the case of the pre-
Cambrian (?) fractures, it is presumed that the directing fractures were tensional and the faults therefore normal.

The mid-Tertiary dikes show a decided preference for a northeast alignment but a few bodies are pointed in a north-northwest direction (Fig. 2). Although most of the dikes tend to point in the long direction of the porphyry belt, they rarely parallel the belt but mostly extend somewhat obliquely across, in either a more northerly or more easterly direction. The more prevalent trends are about N.60°-70°E. and N.10°-30°
E. These are also the trends favored by the members of the composite body on Columbia Hill. The bodies of granite porphyry are less prone to accord with these directions than the granophyres and in part trend about due north, but the dikes swerve to either side. The general structural pattern of these Tertiary dikes thus differs somewhat and appears to be largely independent of or un-
related to the earlier fracture systems.

Mineralized faults and fracture zones —

Most of the mineralized fractures are con-
centrated into two zones or belts, one ex-
tending in an east-northeasterly direction across Yellowjacket Hill and the other in a west-northwesterly direction from the turn of Yellowjacket Creek at the old town to the top of Columbia Hill. This second and much longer belt is referred to as the Con-
tinental-Columbia mineral belt, named from the two properties with the most extensive workings. Mineralized fractures are not re-
stricted entirely to these zones, but some are scattered over other parts of the dis-
trict as widely separated and independent structural features.

Both zones are characterized by complex-
ly fractured rock with the principal frac-
tures striking about N.60°E. and the lesser ones, N.15°-25°W. There are also frac-
tures of other trend, for the mineralized fracture zones not only contain the frac-
tures that just preceded and prepared the way for the mineralizing fluids but also the fractures of earlier date that formed in advance of intrusion and were not utilized by the magmas. Individual fractures are generally short and discontinuous and at the most cannot be traced for more than a few hundred feet. Those of northeast trend dominate and control the general direction of the mineralized zone on Yellowjacket Hill, but fractures of northwest trend are locally prominent and have been important factors in localizing ore. The northeast fractures generally dip northwest at angles of 35° to 80°. Those of northwest trend commonly dip steeply southwest. The northeast fractures are also the most prominent along the Continental-Columbia belt but have had no influence on the trend of the belt itself. The fractures of northwest trend, though numerous in places, are generally inconspicuous and of not much consequence. The fracturing along the Continental-Columbia belt is not continuous along the belt but is largely concentrated in local areas which are sporadically deployed, in part as staggered or en echelon groupings. These component fracture areas also contain earlier inherited as well as superimposed fractures and also local breccias, perhaps in part more or less directly related to folding.

The Yellowjacket and Continental-Columbia zones are entirely separate and are not components of a single zone of structural weakness cut and offset by faulting. They were probably developed as complimentary shears.

Some of the mineralized fractures outside these two zones have the same trends as those within, but there are also some that do not conform and, like the Heisey, strike about N.70° W., or, like the Copper Glance, strike in a more north-northeastly direction. Dips of these fractures, like those along the main fracture zones, are generally steeply southwest or northwest, but there are local exceptions.

Although the mineralization apparently took place during the closing stages of the late Cretaceous or early Tertiary igneous activity, the fractures that contain the ore commonly cut all but the lamprophyric dikes. Recurrent faulting during the closing stages of igneous activity apparently prepared the setting for the ore.

**Post-mineral faults** — Numerous faults of rather small magnitude and of post-mineral age also occur along the mineralized fracture zones. Some of these directed the intrusion of the lamprophyric dikes and thus are closely associated with the closing stages of mineralization. Most of the post-ore faults, however, trend in north-northwest and northeast directions and thus accord with the trend of the Miocene dikes. Some of them actually contain Miocene dikes.

Some faults of appreciable magnitude are known. One exposed by the surface work and expressed locally in the topography on Yellowjacket Hill cuts N.20° W. across the mineralized fracture zone and dips about 30° SW. This fault may have caused considerable vertical displacement of the mineralized zone with downthrow on the southwest side. Two faults of N.40° W. strike and southwest dip are also reported underground at the Yellowjacket mine. Maps of some of the underground workings actually show numerous faults, some of considerable magnitude and some of marked curvature.

**Regional faults** — Two faults of major magnitude also cross or extend into the district. One, not so sharply defined as the other, extends across in a northwesternly direction (Fig. 2) and has apparently brought beds of the Hoodoo quartzite on the northeast against the beds of the Yellowjacket formation on the southwest. This fault has been offset in several places, with the greatest offset along a regional fault of northeast trend which passes just west and north of the Yellowjacket mine. In places the contact between the Hoodoo and Yellowjacket beds along the northwesternly trending fault is bordered by an abruptly steepened slope or escarpment. This is particularly true north and east of Slaughterhouse Gulch. The fault continues northwest of the district an unknown distance and then extends along the east side of the district, apparently beyond the head of Meadow Creek several miles southeast of Yellowjacket Creek. The fault is normal with downthrow on the northeast. The amount of displacement was not determined but probably exceeds a few hundred feet.

The other fault may be traced from the old town of Yellowjacket to the head of the gulch north of the Yellowjacket mine and thence through the low saddle at the head of Slaughterhouse Gulch and for some distance northeast of the saddle, holding to an average N.25° E. course (Fig. 2). This fault is plainly marked by saddles and aligned valleys and as pointed out by Ross it may be readily traced by brecciated and slicken-sided rock even where the rock on both sides...
belongs to the Yellowjacket formation. The fault dips steeply northwest. The offset of more than 3,000 feet shown by the Hoodoo quartzite might suggest that the fault has a marked horizontal component of movement, but the fault is apparently normal and the apparent horizontal offset is just what it should be along a fault of vertical movement that cuts another with a north-easterly dip. The vertical displacement may be several thousand feet.

These two regional faults differ in age. The northwest fault is cut by and is therefore older than the Miocene intrusives (Fig. 2). The northeast fault is not known to occur in contact with these younger intrusives. As the fault of northeast trend cuts the other it is younger, but whether it is as young as the Miocene faults is not definitely known. It loses its identity as it reaches the body of hornblende-biotite diorite, but whether it has been cut off by the stock or continues into it was not determined. Ross suggests that both faults can probably be correlated with the strong system of faults that cut the Challis volcanics elsewhere in the region. It is possible that the northeast fault is younger than the volcanics, but the writer is inclined to believe that the northwest fault is considerably older. Ross also points out that the small block of Challis volcanics near the top of Columbia Hill has probably gained its position as a result of normal faulting.

Historic summary

The geologic record within the Yellowjacket district is fragmentary and must be augmented by data from the surrounding region. The decipherable record begins with extensive accumulation of sediment in vast shallow seas in Algonkian (late pre-Cambrian) time when more than 8,000 feet of impure sandy and limy materials were deposited on the slowly sinking floor of the sea, followed by more than 3,000 feet of relatively clean sand. Subsequently these sediments were converted to the impure quartzitic and limy rocks of the Yellowjacket formation and to the white beds of the overlying Hoodoo quartzite. The sedimentation terminated at the close of the Algonkian with disappearance of the seas and the emergence of land. This emergence was probably associated with a crustal disturbance of some magnitude. During the disturbance the strata were probably somewhat folded and faulted and then locally invaded by small masses of gabbroic magma.

There is a long break in the local record after late pre-Cambrian time, but the Paleozoic seas which have left a record of extensive sedimentation in eastern Lemhi County and parts of Custer County also probably covered the Yellowjacket district and left a considerable accumulation of quartzitic and limy strata, since removed by erosion. The Casto volcanics (Permian?) which are exposed but a short distance to the south and west also probably extended across the district, but these rocks too have been removed.

Little is known of what happened in the lower part of the Mesozoic, even in the surrounding region. Perhaps land conditions prevailed, but the district must have been subjected to severe deformation during the Sierra Nevada orogeny which preceded the emplacement of the Idaho batholith in late Jurassic and early Cretaceous time. Much of the folding and some of the faulting may have occurred during this orogeny and most of the Paleozoic rocks may have been removed then and during the considerable period of erosion which followed the emplacement of the batholith. It is probable that the batholith, which is exposed no more than 10 miles to the north, may extend beneath the Yellowjacket district at some depth.

Events that occurred at the close of the Mesozoic, however, have left their mark in the district, for it was then that forces associated with the Laramide orogeny produced the host of fractures that facilitated intrusion of magma and movement of ore-bearing fluids at or shortly after the close of Cretaceous time. Structural and petrologic relations suggest that the magma had its source in the basic subcrust below the granitic crustal shell and that the gabbroic and diabasic magma first injected came from this deep magma reservoir as probable injections of the parental magma. The less calcic magmas that followed are probably products of this original basic magma which had undergone more or less progressive differentiation at its deep source. The mineralizing fluids were probably expelled from the same deep source during the closing stages of igneous activity, just in advance of the lamprophyres.

Erosion during and after the late Cretaceous or early Tertiary disturbance removed
much rock from the district, including any Paleozoic rock that may have escaped earlier erosion, and may also have exposed some of the newly emplaced igneous bodies and mineral deposits. Erosion was soon halted, however, by extrusavation of the Challis volcanics in Oligocene time as the whole region came beneath the mantle of lava flows and tuffs. The volcanic outpourings apparently ceased in lower Miocene time, but crustal unrest followed and the volcanic blanket was warped into a broad arch, broken locally by faults, and then invaded by magmas of intermediate and silicic composition. In the Yellowjacket district the faulting and intrusion were localized along the earlier zone of structural weakness, with the granophyric and porphyritic intrusives especially concentrated on Columbia Hill and in a belt just south and east of the old town of Yellowjacket.

Since the mid-Tertiary crustal disturbance there has been long continued erosion which continues today. Except for one small infaulted mass, the blanket of Challis volcanics was stripped from the district and many of the Miocene intrusives laid bare. During pliocene time the region was apparently reduced to an old erosion surface with deep accumulation of soil or disintegrated and decomposed rock, which still mantles the upper slopes and ridge crests.

At the close of the Pliocene there came another crustal disturbance which was reflected locally by intermittent uplift, with the land surface raised to its present level. This uplift inaugurated a new cycle of erosion and the development of the present canyons which have cut deeply in the district and have exposed more of the Miocene intrusives and older rocks. Paused during the uplift in late Pliocene and Pleistocene time are reflected today by rock-cut terraces on the canyon walls and by still-remainina old-valley floors along upper Yellowjacket and Trail Creeks.

During Pleistocene time the valleys in the north part of the district, which drain northeast to Yellowjacket Creek, and the upper valley of Yellowjacket Creek itself were occupied by glaciers which supplied outwash debris that filled the lower valley and canyon bottoms with bouldery sand and gravel. Since disappearance of the glaciers, the streams have removed much of this fill but have left some remnants as terraces at and below the old town of Yellowjacket. The streams are now lowering their floors, except where the more resistant porphyries have retarded progress and have induced local accumulations of flood-plain materials.

ORE DEPOSITS

HISTORY

The Yellowjacket district came into existence with the discovery of the Yellowjacket lode in September of 1888, which according to Umpleby \(^1\) was among the earliest, if not the earliest lode deposit recognized in Lemhi County. The lode was worked by arrastres and a 5-stamp mill during the early seventies but there was no extensive development until the eighties and no considerable production until the years from 1885 to 1887. The Yellowjacket mine was equipped with a 10-stamp mill in 1882, but this was replaced by one of 30-stamps in 1894 and then gradually increased to 60 stamps, composed of 12 batteries of 5 stamps each. The mill still stands, but some of the stamps have disappeared and a part of the mill now houses a small grinding and concentrating plant. From the start the mill was operated by power from Pelton water wheels, fed by flume from Yellowjacket Creek. At first the ore was hauled from the hill to the mill, but wagon haulage was replaced by aerial tram in 1892.

The late nineties marked the end of the most productive era of the camp's history. Work at the Yellowjacket mine was suspended in 1897 but continued until 1905 at the Columbia, the then second most important mine in the district. The Columbia had been located in 1892 and its ore treated at the Yellowjacket mill until its own mill, located a short distance below the Yellowjacket, was ready in the late nineties. Most of the other mines and prospects had been located prior to the nineties and most of them too were idle at the turn of the century. As the lode mines closed, more attention was given the placers along Yellowjacket Creek immediately below the town, but despite evidence of considerable work, the results were apparently disappointing, for the years 1906, 1907, and 1914 recorded only a small production. Some work continued at the Black Eagle on Hoodoo Creek after the turn of the century and a 5-stamp mill was completed in 1908, but there was no recorded production from the mine until 1922.

The district experienced some renewed

\(^1\) U.S. Geol. Survey Bull. 528, op. cit. p. 165.
activity in 1910 when the Mandarin Mines Corporation acquired control of the Yellowjacket mine and started operations, with a change in the milling process to include cyanidation. Work continued for several years with a small production recorded from 1911 to 1914. Then there was little activity until the early twenties when the Black Eagle made a shipment of gold ore in 1922 and the Columbia followed with a small lot of copper-gold ore in 1923. The year 1923 also witnessed renewed activity at the Yellowjacket mine when the New York - Idaho Exploration Company started extensive improvements, including an ambitious housing program of which the large hotel today remains as a lasting monument; but the work was suspended early in 1924 before much work was done underground and before any ore was found.

The late twenties ushered in another period of activity, initiated this time by an extensive development program on the Continental group. During 1929 a gas-driven compressor and complete mining equipment were installed at the Continental, and work was pushed underground with resultant discovery of a broad zone of mineralization from which high-grade ore was mined. Development work continued at the Continental through most of the thirties, mainly in extending the main adit along which ore had been found in 1929, and in erecting a small flotation plant which was completed in 1936 or 1937.

The ore discovery at the Continental in 1929 attracted considerable attention and before the year was over many of the other properties in the district were receiving the attention of investigators and promoters. Work at the Yellowjacket mine was resumed by the United Mace Smelters, Inc., under lease and option, but the attention was directed mainly to the Yellowjacket placer at the top of the hill. This work continued through 1933. Then in 1935 the mine was taken over by the Buckhorn Gold Corporation which repaired the power plant and mill and increased the capacity of the mill to 125 tons by the addition of a ball mill. Work by the Buckhorn Gold Corporation continued into 1937, though not on as large a scale as in 1936. In early 1938 the mine was turned over to the Treasure Gold Mining Company in exchange for stock in that company. The new company did some 4,300 feet of work before the end of the year and then in 1939 transferred the operations to the Condor Gold Mining Company, which continued the work.

The Condor Gold Mining Company carried on exploration until late 1940 when it withdrew from the district. The mine was closed and remained so during the war.

During the late thirties the Bryan mine was also worked and produced some gold from 1935 to 1941.

The district remained dormant through the war years, but after the war men returned to prospect and work their claims. The Yellowjacket mine was sold and the new owners, Messrs. Edwin F. and Heber S. Steen, made ready to work the residual placer material that blankets the top of Yellowjacket Hill. The Yellowjacket mill was rehabilitated to treat the gold-bearing debris, trucked from the screening plant on Yellowjacket Hill. The mill operated for a short time during the summer of 1949, but the weather conditions were unfavorable for screening and milling and the production was small. The outbreak of the Korean war in 1950 disrupted the work at the mine and the plant was idle in 1951. Work continued elsewhere in the district and during 1951 small mills were installed at two of the smaller properties, the Tin Cup and Hisey, and plans were underway for a third at the Parks. A small mill was also brought into operation for a short time on ore from the Yellowjacket mine. Placer miners were also active along Yellowjacket Creek below the old camp. The biggest work, however, was at the Continental, where a bulldozer was used to make exploratory cuts and build service roads.

**PRODUCTION**

The total production of the Yellowjacket district is not known, for there is no authentic record of production prior to 1939. Since then the production is known to have exceeded $250,000. Up to 1910 Umpleby estimated the total production, which was largely that of the Yellowjacket mine, at about $450,000. If correct, this would indicate a large unrecorded production, particularly prior to 1939, for Ross, who compiled the production at the Yellowjacket mine from company records for the years 1920 to 1957, the most productive period in the history of the district, came out with a total of $121,761.56 for those years. To this should probably be added something from the Columbia and possibly from several other of the early-day operators.

The production since 1902 is a matter of record and figures from 1902 to 1949...
were kindly provided by the Statistics Branch of the U.S. Bureau of Mines at Albany, Oregon. The statistics include the recoverable metals produced—gold, silver, copper, and lead—at each of the mines at which ore was treated or shipped. The grand total for the 48-year period was 9,390 tons of ore sold or treated, with a content of 3,855 ounces of gold, 5,608 ounces of silver, 20,792 pounds of copper, and 17,275 pounds of lead.

The production from individual properties in terms of recoverable metals is shown in the following table:

<table>
<thead>
<tr>
<th>Years</th>
<th>Ore sold or treated</th>
<th>Gold (fine ozs.)</th>
<th>Silver (fine ozs.)</th>
<th>Copper (pounds)</th>
<th>Lead (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellowjacket mine: 1902-49</td>
<td>8,547</td>
<td>3,003</td>
<td>3,397</td>
<td>3,285</td>
<td>3,050</td>
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<tr>
<td>Bryan mine: 1935-41</td>
<td>460</td>
<td>372</td>
<td>137</td>
<td>3,551</td>
<td>1,541</td>
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<tr>
<td>Steen Group mine: 1929-39</td>
<td>180</td>
<td>66</td>
<td>179</td>
<td>5,829</td>
<td></td>
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<tr>
<td>Lead Star mine: 1946-48</td>
<td>21</td>
<td>3</td>
<td>802</td>
<td>500</td>
<td>10,100</td>
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<tr>
<td>Copper Glance mine: 1929-41</td>
<td>9</td>
<td>6</td>
<td>344</td>
<td>3,516</td>
<td>1,171</td>
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<tr>
<td>Silver Moon mine: 1936-37</td>
<td>10</td>
<td>3</td>
<td>133</td>
<td>139</td>
<td>1,413</td>
</tr>
<tr>
<td>Tin Cup mine: 1934-49</td>
<td>26</td>
<td>48</td>
<td>23</td>
<td>417</td>
<td></td>
</tr>
<tr>
<td>Black Eagle mine: 1922</td>
<td>22</td>
<td>43</td>
<td>87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Bar placer: 1933-37</td>
<td>32</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>North Star mine: 1941-42</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Columbia mine: 1923</td>
<td>4</td>
<td>1</td>
<td>367</td>
<td>641</td>
<td></td>
</tr>
<tr>
<td>Gold Chain placer: 1924</td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Slaughterhouse pl. 1932</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Grubstake mine: 1935</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mayfield mine: 1938-39</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diamond Queen mine: 1908</td>
<td>30</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Merrit mine: 1934</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Production from all mines in Yellowjacket District, Lemhi County, Idaho in terms of recoverable metals

<table>
<thead>
<tr>
<th>Years</th>
<th>Ore sold or treated</th>
<th>Gold (fine ozs.)</th>
<th>Silver (fine ozs.)</th>
<th>Copper (pounds)</th>
<th>Lead (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1902-49</td>
<td>9,390</td>
<td>3,855</td>
<td>5,608</td>
<td>20,792</td>
<td>17,275</td>
</tr>
</tbody>
</table>

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CHARACTER OF THE DEPOSITS

As indicated in the production statistics, the district has produced gold, silver, copper, and lead, recovered for the most part from lodes but with some minor gold recovery from placers. The district is known primarily as a gold district, but many of the deposits may be appropriately classed as gold-base-metal deposits, some as silver-copper deposits, and one at least as a silver-lead deposit. In general the deposits contain only sporadic amounts of the base metals, copper and lead, and if the two are present in the same deposit, they show a tendency to occur apart from each other. The main source of the silver is in the mineral tetrahedrite (gray copper) which may be present in either the copper or lead ores but most commonly and abundantly in the lead ore. Zinc appears to be mysteriously absent in these base-metal ores.

Except for the placers, the deposits are primarily fissure, fracture, and breccia fillings, accompanied in places by some replacement of the bordering rock. Most of these deposits are structurally complex, but they may be classed for convenience as (1) veins, (2) lodes, and (3) stockworks. The lodes are mineralized fracture-fissure zones with numerous veins and stringers, and the stockworks are mineralized fracture-breccia zones. The two have provided most of the production to date.

The placers are also varied as to kind and include (1) eluvial or hill-slope deposits, (2) stream deposits, and (3) bench or terrace deposits. Most of the placer production has come from the stream deposits, but the placer of greatest potential worth appears to be the eluvial.

GEOGRAPHIC DISTRIBUTION

Most of the lode deposits are near the old town of Yellowjacket but a few are scattered over other parts of the district (Fig. 2). Those near the old town are confined to the fracture zone on upper Yellowjacket Hill and to the structural zone that extends west-northwest of the town to Columbia Hill. The zone across Yellowjacket Hill contains the Yellowjacket lode; and the other, which has been designated herein as the Continental-Columbia, contains a number of complex fracture-breccia stockworks and lodes, including the Bryan, Continental, Lincoln, Liberty, Columbia, and others (Fig. 3).

The deposits not in the vicinity of Yellowjacket are rather widely scattered. These include several deposits of the lode type near the mouth of Slaughterhouse Gulch (Lead Star) and on the ridge between Yellowjacket and Trail Creeks (Copper Glance and Gold Bug). They also include several deposits of the vein type; the Tin Cup, a short distance below the old town, and the Hisey, Black Eagle, and Parks in the Hoodoo Creek drainage.

The placer deposits are also close to Yellowjacket. The eluvial (hill slope) type is confined to Yellowjacket Hill as a mantle over the Yellowjacket lode and the slope below. The stream type is restricted to the valley bottom for a mile or more below the old town of Yellowjacket and to the upper part of Slaughterhouse Gulch just north of Yellowjacket Hill. The bench deposits are under and below the town of Yellowjacket, but the only work has been on the east side of the creek about a mile below the town.

GEOLOGIC DISTRIBUTION

The distribution of the veins, lodes and stockworks is structural rather than stratigraphic and the deposits therefore are restricted to favorable structural zones rather than to any particular formation. The Yellowjacket formation, however, has been in the path of the most intense deformation and it has consequently become the host of most of the lode deposits. A few of the deposits (Black Eagle and Parks) are in the Hoodoo quartzite and several others (Hisey, White Rabbit, and Tin Cup) are in the hornblende-biotite diorite or its syenitic facies. Some of the late pre-Cambrian (?) and late Cretaceous or early Tertiary intrusives are also cut by the veins and lodes. As the Miocene intrusives are younger than the mineralization, they contain no ore deposits, but some of them cut the deposits.

The placer deposits are confined to the youngest sedimentary rocks. The eluvial placer probably contains material liberated by weathering as far back as the early part of the Pliocene. The bench placers are restricted to the Pleistocene terrace gravels and the stream placers, to the recent stream deposits.

STRUCTURAL RELATIONS

The structural relations of the mineralized fractures or fracture zones have already been given considerable attention. As
mentioned earlier, the Yellowjacket zone has an east-northeast elongation, which is the direction of the principal fractures, but it also contains numerous, somewhat less prominent fractures of northwest trend. In contrast, the Continental-Columbia zone trends west-northwest, but like the Yellowjacket zone is dominated by fractures that strike northeast. These two sets of fractures have exerted a marked control on the location of ore throughout much of the deposits themselves.

The few strictly vein deposits are along well-defined fissures, in part developed along broad zones of fracturing. The veins show a tendency to conform with the original fissure openings and therefore are usually no more than a few inches wide, with local swells and pinches, nor more than a few hundred feet long. Only the Hisey vein is larger, up to 8 feet wide, but its greater size may have resulted from replacement of the bordering rock. The veins apparently show no preference for either the northeast or northwest directions for, whereas the Black Eagle is along a fissure of northeast trend, the Hisey is along one of west-northwest trend, and the Tin Cup along one of north-northwest trend.

The lode deposits are more structurally complex and involve much broader zones of intricately fractured rock. Ross* has described the Yellowjacket lode as a great shatter zone containing numerous veins and stringers in more or less extensively altered quartzite. The same may be said for most of the other lodes, but on a smaller scale. The Yellowjacket apparently has many veins, none of them very persistent but some of them up to 40 feet or more wide and more than 100 feet long. There are also many local zones of more intensely fractured rock occupied by more or less closely spaced stringers that make bodies of ore of considerable size, also zones with just bunches of quartz. The veins and stringers may trend in either the northeast or northwest directions, in fact some of the largest ore bodies at the Yellowjacket mine strike northwest across the trend of the main fracture zone. Elsewhere the smaller lodes may contain small veins and stringers and here and there irregular breccia fillings and replacements.

The stockwork deposits have much in common with the larger lodes but generally lack the well-defined veins and consist instead of stringers and cemented and part-

ly replaced breccias. As these bodies of fractured and brecciated rock are more rounded or oval than tabular, they may quite appropriately be called fracture-breccia stockworks rather than lodes. Most of the deposits along the Continental-Columbia belt are of this character. Some of them are rather small and consist of small veins and stringers and replaced rock along fracture-breccia zones; but some, such as the Continental and Lincoln, are several hundred feet in diameter and locally contain as much fractured rock as brecciated rock. The more prominent mineralization is along the northeast fractures, generally as ill-defined veins or stringers. The individual veins are not very long and are generally discontinuous on both strike and dip. The distribution of the stockworks along the Continental-Columbia belt is unpredictable but the presence of a body is generally marked by quartz showings or slight topographic swells on the surface.

These various bodies of mineralized rock seem to dip or plunge consistently in a westerly direction. Except at the Tin Cup, the veins dip northwest or northeast depending on the direction of strike. According to report the great shatter zone that comprises the Yellowjacket lode dips northwest. The stockwork deposits on Columbia Hill are reported to plunge northwest. This also appears to be the direction of plunge of ore bodies on the Continental and Lincoln ground. This factor of plunge has apparently been overlooked by those who have driven long crosscuts to tap the ore at depth.

MINERALOGY

The deposits possess no unusual mineralogic features but are composed of rather ordinary ore and gangue minerals. This applies not only to the originally deposited minerals, the primary minerals, but also to those minerals resulting from weathering processes, the secondary or supergene sulfides and the oxidized ore minerals.

Primary Minerals

The primary minerals include calcite, quartz, siderite, and barite among the gangue, and pyrite, sphalerite, chalcopyrite, tetrahedrite, galena, and gold among the ore or metallic minerals. As the ore is moderately coarse-grained, the minerals, except the gold, are readily discernible to the unaided eye.

Gangue minerals — Calcite is widely distributed and is particularly abundant at the

margins or fringes of the ore zones, mostly as a filling of fractures and breccias. It is not closely associated with the ore mineralization and its presence alone is taken as an indication of a barren zone or as a possible approach to an ore zone. It was introduced ahead of the quartz and ore minerals and has been largely eliminated from the ore zone through replacement by the quartz and ore minerals.

Quartz is not only the most abundant of the gangue minerals, but, because of its close association with the ore minerals, it is the most important of the group. It forms the main filling of the veins and stringers and the main cement of the breccias within the ore zones. In fringe areas it may form a coating on calcite but generally its stringers and irregular masses penetrate through and replace the calcite and in places, the country rock. The quartz is white and requires close scrutiny under ground to be distinguished from the white calcite.

Siderite occurs as a minor gangue mineral in a few places and is present in noteworthy amounts at only the Tin Cup and Copper Glance mines. It tends to have a rather even distribution and occurs as scattered small bunches and small lenticular masses along the main fissures, usually accompanied by quartz and ore minerals. The siderite has a pale buff color on fresh fracture but becomes blackish on exposure to the atmosphere. This darkening results from a thin coating of black manganese oxide. The bunches and masses of siderite are commonly cut and in part replaced by the quartz and ore minerals. Its relation to the calcite was not observed, but its distribution suggests that it has a closer association with the base-metal mineralization than with the calcite.

Barite has a very sparse distribution and was observed only in several small chunks of ore on the shaft dump at the Columbia mine. The chunks reveal that quartz preceded and the sulfides followed barite deposition.

Ore minerals—Pyrite is contained in all deposits, in some as rather sparse disseminations in the quartz, in others as more closely spaced grains or small grain aggregates. Although more widely distributed than any other ore mineral, it is nowhere particularly abundant and forms no massive bodies of appreciable size. It occurs with or without the other sulfides, but is less conspicuous in ore that contains the base metal sulfides than where it occurs alone. If it occurs with other sulfides it may in part be contained in them as corroded, irregular remnant grains. It is more abundant in areas of intense rather than weak mineralization and its presence in the quartz is generally regarded with favor as an indication of gold metallization.

Specularite (specular hematite) has been observed as fracture coatings in some of the fractured rock at the Lead Star and as coarse platy crystals in quartz at one place along the Yellowjacket lode. It appears to be a mineral of very limited and scanty distribution. The quartz that contains it at the Yellowjacket mine has very little, if any gold, and its appearance in the ore is taken as a sign of declining gold values.

Sphalerite has been reported in some of the deposits but zinc is not indicated in smelter returns and sphalerite was not found in any of the ore that was examined. As some of the ore has been on the dump for a number of years, it is, of course, possible that the zinc has been leached. If present at all, it would have to be in very sparse amounts.

Chalcopyrite is the chief source of copper in the district. It normally has a spotty or bunchy distribution and commonly forms small discontinuous seams and irregular masses, usually accompanied by pyrite and exceptionally by tetrachalcite. It is generally present but is not abundant in the lead ores. Chalcopyrite seems to prefer its own company or that of pyrite.

Tetrachalcite is relatively abundant in some of the ores and is probably the source of much of the silver in the base-metal deposits. It is generally associated with galena and shows a marked preference for the lead ores. It does occur with chalcopyrite at the Copper Glance, accompanied, however, by a little galena. The tetrachalcite commonly forms small granules or irregular masses in the ore, partly included or surrounded by galena and chalcopyrite.

Galena is an important though generally not an abundant mineral. Except for its minor oxidized products, it is the sole source of the lead. It occurs rather sparingly in many deposits as more or less widely separated grains or small masses, but it is relatively abundant in some and forms small shoots composed of irregular stringers and masses or small discontinuous lenses, generally in quartz. The galena is moderately coarse-grained, cubic, and is usually ac-
companied by variable amounts of the other sulfides.

Gold, the most important ore mineral in the district, is rarely visible to the eye; but its presence in the quartz and in the pyrite and other sulfides is revealed by assay. Its distribution is somewhat spotty and the amount rather variable. The only gold seen was in some pieces of high-grade at the Tin Cup Mine where it occurred in small grains closely associated with quartz and sulfides. The gold has a pronounced yellow color and apparently contains only minor amounts of silver. It seems to be a late introduction into fractures in the quartz and sulfides.

Secondary minerals

The secondary or supergene sulfides and oxidized minerals are conspicuous enough to attract some attention, but as weathering has not extended deeply the minerals are not present in large quantity. They have nevertheless added something to the value of the near-surface ore.

Secondary sulfides — The secondary sulfides include chalcocite, covellite, and probably argentite. These have been formed near the surface by action of downward percolating meteoric waters containing dissolved copper and probably silver from the weathered ore. As these waters came in contact with the primary ore they gave up their dissolved copper and silver by reaction with the primary sulfides, forming the secondary sulfides, covellite, chalcocite, and probably argentite. The chalcocite is the most abundant of these secondary sulfides and is conspicuous in some of the ore mined at shallow depths, chiefly as a replacement of the chalcopyrite. The chalcocite is generally accompanied by covellite, but covellite is more common as microscopic grains and veinlets in partly oxidized galena. Although no actual search was made for the secondary silver sulfide, argentite, its presence is likely in the partly oxidized silver-rich ore. The addition of these minerals to the primary ore has locally increased the richness of the ore, but this enriched ore has a limited distribution and is not a very important factor in production.

Oxidized minerals — The oxidized minerals that were recognized include cuprite, tenorite, chrysocolla, malachite and azurite as the oxidized copper minerals, cerussite and anglesite as the oxidized lead minerals, and limonite and pyrolusite as the oxidized iron and manganese minerals. A little native copper has been reported.

The most abundant copper minerals are the chrysocolla (hydrous copper silicate), malachite (green copper carbonate), and azurite (blue copper carbonate); and these occur as patches on the partly oxidized copper ores and as lumps and small masses in the deeply weathered lode material. In the lump-like masses the minerals may be accompanied by considerable amounts of tennantite (black copper oxide) and by brownish mixtures of limonite and in places by cuprite (red copper oxide). Lumps of the brownish mixtures, encrusted in part by chrysocolla and malachite, are scattered through the loose material in and along the Yellowjacket lode. Azurite is mostly restricted to the oxidized ore that contains tetrahedrite and its presence in the outcrop is almost a certain indication that tetrahedrite occurs in the primary ore below. Chalcopyrite seems to yield only the greenish carbonate, malachite.

The cerussite (lead carbonate) and anglesite (lead sulfate) occur rather sparingly through the district and only at or close to the surface in or enclosing partly oxidized galena. These minerals locally have little commercial interest.

Oxidation of pyrite and chalcopyrite and locally of siderite has generally produced conspicuous amounts of limonite in the outcrop and through the upper part of the oxidized zone. The oxidation of the siderite has also produced some manganese oxide, (pyrolusite), which tends to give the gossan a blackish color.

Paragenesis

Study of structural and textural relationships of the ore and gangue minerals indicates that general mineralization was initiated by deposition of calcite, locally siderite, and that, after a minor structural interruption, was followed by deposition of quartz and sulfides. There was also a slight structural break between the deposition of quartz and the sulfides, for the sulfides apparently were introduced into areas where the quartz had been fractured. Barite preceded the sulfides locally. The sulfides were not formed simultaneously, but, as deduced from fracture and replacement relationships, were deposited more or less successively as pyrite, tetrahedrite, chalcopyrite, and galena. The gold was apparently added after the sulfides.

The formation of the secondary miner-
als (the supergene sulfides and oxidized ore minerals) came much later and only after the deposits had been bared by erosion and the primary minerals exposed to attack of atmospheric agencies. The supergene sulfides were formed when the metals dissolved at or near the surface came in contact with the primary sulfides below at or near the bottom of the oxidized zone. The oxidized minerals were formed nearer the surface. No attempt was made to determine the order in which the various oxidized minerals were formed.

**DISTRIBUTION OF THE ORE**

The distribution of the ore within the lodes and stockworks is generally quite erratic, but not so much so as in the veins. In the laver the ore is usually the quartz filling and the distribution of ore depends chiefly on the distribution of quartz, which in turn depends on the spacing of the original openings along the fissure. As the ore bodies thus swell where the fissure walls separate and pinch where they come together, the distribution of ore is largely controlled by structure. The metal content of the ore, however, is variable and lean zones intervene between zones of richer ore. Sulfides are generally not conspicuous in most veins and, if present, occur as sparsely scattered grains or as small local concentrations. The usual sulfide is pyrite, but scattered bunches of chalcopyrite occur with the pyrite at the Tin Cup. In general the ore of the veins appears to extend over a considerable vertical range, with local interruptions by pinching.

In the lodes and stockworks the distribution of ore is controlled by fractures and breccias and the ore occurs as stringers, irregular bunches and masses, and in some of the lodes also as relatively short discontinuous veins. The loci of ore deposition appears to be the areas of most extensively fractured and fissured rock, with the most pronounced mineralization along local fissures. The veins and other masses of ore in these deposits, however, appear to lack continuity and the ore may be cut off sharply above and below as well as along the strike. This feature is particularly well exemplified at the Yellowjacket mine where large bodies of ore on upper levels fail to appear on lower levels and those on lower levels fail to match those above. The same lack of continuity is also manifested in the stockworks where the ore is in zones of complexity fractured and brecciated rock without well-defined veins of any size and contained instead in local breccias and irregular stringers and masses which lack continuity on strike and dip. This erratic type of ore distribution and lack of upward and downward persistence of individual bodies apparently reflects the discontinuities of the pre-mineral fractures and fissures.

The rather abrupt termination of individual ore bodies does not signify the end of mineralization. The Yellowjacket lode has been opened over a vertical distance of 460 feet without exposing a bottom of mineralization, although there is some suggestion of a change in the character of the ore from gold-quartz above to quartz-base metal ore below. Along the Continental-Columbia belt the erratic bodies of ore occur over a vertical range of 1,000 feet with no apparent change in the character of the mineralization and with the bottom of mineralization still out of sight.

**TENOR OF THE ORE**

Few data are available on which to estimate the tenor or worth of the ore that remains in the mines. According to Umpleby the ore mined at the Yellowjacket mine, mostly prior to the turn of the century, averaged about $8 a ton (the equivalent of about 0.387 ounce of gold per ton). This value is only a little above the 0.351 ounce per ton which has been the average since 1902 and still not much above the assay value of the sampled ore on and below the No. 2 level when that part of the mine was open in 1940. Sample widths of 10 to 12 feet on one ore zone on the No. 2 level showed 0.25 to 0.34 ounce of gold and up to 0.05 ounce of silver per ton, and as much as 0.82 percent copper. Another ore zone 10 to 15 feet wide contained from 0.17 to 0.28 ounce of gold and 0.1 to 0.3 ounce of silver per ton, and 0.36 to 1.86 percent copper. A third zone on a lower level assayed 0.25 to 1.2 ounces of gold and 0.3 to 0.8 ounce of silver per ton and 0.3 to 1.6 percent copper. This zone was 4 to 8 feet wide. A fourth zone with sample widths of 5 to 12 feet showed 0.15 to 1.9 ounces of gold and 0.10 to 0.6 ounce of silver per ton and 0.16 to 0.8 percent copper. Little gold ore had been exposed along the No. 3 level but some lead ore was found.

As much of the ore shipped from the other mines in the district in later years has been rather carefully selected material,
the production statistics are not truly representative of typical ore. The figures may have some significance, nevertheless. Ore shipped from the Columbia mine in 1923 contained 0.25 ounce of gold and 92 ounces of silver per ton and 8 percent copper. According to earlier reports the average ore was supposed to be worth $30 a ton, even as high as $150 a ton. Shipments from the Copper Clance from 1929 to 1941 averaged 0.66 ounce of gold and 33 ounces of silver per ton, 19 percent copper, and 8 percent lead, but the ore was carefully sorted before shipment. The ore shipped from the Lead Star was also sorted and it contained 0.14 ounce of gold and 38 ounces of silver per ton, 1.2 percent copper, and 24 percent lead. This ore came from a small compact vein or lens of essentially massive galena. At the Bryan the ore averaged 0.81 ounce of gold and 0.3 ounce of silver per ton, 0.38 percent copper, and 0.16 percent lead. At the Tim Cup the gold content was 1.85 ounces per ton, the silver 0.9 ounce per ton, and the copper 0.79 percent. Ore sold or treated at the Continental averaged 0.36 ounce of gold and 1 ounce of silver per ton and 1.7 percent copper. Sampling that has been done underground at the Continental indicates the presence of ore that contains from 0.10 to 0.30 ounce of gold per ton and 1.0 to 1.6 percent copper.

The tenor of the ore is such as to encourage search for bodies large enough to sustain low-cost, large-scale operations.

Oxidation and Enrichment

The depth to which oxidation and enrichment extends varies from place to place and is known only approximately. The deepest oxidation appears to have been at the Yellowjacket mine, for the ore that was mined in the early days has been reported as free-milling, thoroughly oxidized gold ore. Such ore extended to the No. 2 level as much as 260 feet below the highest cuts; but the ore exposed on the No. 3 level about 200 feet below the No. 2 is largely, if not entirely, unoxidized and consists mostly of sulfides in quartz.

Oxidation elsewhere in the district is much shallower. The ore worked near the surface at the Columbia mine in the early days was more or less extensively oxidized and free-milling, but the oxidation there as elsewhere does not appear to have penetrated to any considerable depth and even near the surface was incomplete. Except at the Yellowjacket mine, oxidation nowhere appears to have been of any consequence at depths of 40 to 50 feet below the surface and in some places the depth is considerably less.

As oxidation doubtless raised the ratio of gold in the ore near the surface, it is probable that the ore bodies at depth will have a lower gold content. The copper and the silver content may also be somewhat less beneath the oxidized zone, unless there has been a material improvement in base-metal metallization with increasing depth.

Origin of the Deposits

Because of their close association with igneous activity, these deposits like most ore deposits are supposedly of magmatic origin and probably formed by ascending ore-bearing fluids that originated in a deep magmatic source. The relations and associations of the deposits indicate that they were formed after intrusion of diabase, gabbro, hornblende-biotite diorite, and syenite in late Cretaceous or early Tertiary time and just before the introduction of the lamprophyres which brought the cycle of igneous activity to a close. The deposits thus belong to the early Tertiary epoch of metallization, and, like the accompanying intrusives, had their source in magma that formed in the basic subcrustal material beneath the granitic shell. Recurrent fracturing which penetrated to the magma source apparently permitted periodic withdrawal of fractions of the magma undergoing compositional changes through differentiation processes and eventual expulsion of the ore fluids and the lamprophyres.

As the ore-bearing fluids reached the zones of complexly fractured, fissured, and brecciated rock relatively near the surface, they gave up their load of metals and other mineral constituents which filled openings and locally replaced bordering rock forming veins, lodes, and stockworks, depending on local fracture conditions. The nature of the minerals and their associations indicates that the ore fluids possessed only a moderate amount of heat when they gave up their metals; and the extensive fracturing and brecciation suggest that deposition took place at moderate depths, perhaps within a mile or two of the then existing surface. Coming in contact with so much cool, fractured rock may have speeded cooling and caused some dumping of the mineral load, but the evidence is not wholly conclusive. The ore fluids tended to re-

linquish the base metals ahead of the gold and there is some suggestion that the gold was in part carried to higher levels than the base metals.

The ore fluids had a somewhat variable composition. Although in the main they carried calcium, silica, gold, iron, copper, lead, sulfur, and a little antimony, they did not deposit these constituents uniformly. Some fracture zones or parts of some fracture zones received fluids considerably richer in copper or in lead than others and some of the fluids enriched in lead were also locally well-supplied with silver and antimony, both of which had a marked attachment for any copper that was present. This variation in the composition of the metallizing fluids probably accounts for the differences in metal content of the deposits. The variations may be the result of subtraction of certain of the constituents from the fluids before the present observable depositional sites were reached. As the movement of fluids was not continuous but depended on more or less recurrent fracturing, the fluids may have been shunted from one channelway to another just in time to leave appreciable amounts of one metal at one place and a second at another.

Local redistribution of the metals has come about since the deposits were uncovered by erosion and subjected to the attack of atmospheric agencies. Some deposits had their gold ratio increased near the surface through oxidation of sulfides and removal of the metals combined through oxidation of sulfides and removal of the metals combined with the sulfur. Base-metal deposits were also somewhat enriched in copper, released by weathering and deposited lower down as oxidized and secondary sulfide minerals.

Weathering also brought about disintegration of the lodes with liberation of the gold, which was then free to migrate down the slopes and into the streams to become concentrated in the gravels as placer gold. Some of the gold, however, lingered behind over the outcrops and slopes below and thus became concentrated in eluvial or hill-slope placers. Topographic conditions on Yellowjacket Hill were especially conducive to the formation of eluvial placer ground.

OUTLOOK

The Yellowjacket district appears to have a reasonably bright outlook as a producer of base and precious metals. Appreciable amounts of gold apparently remain unmined underground and in the eluvial placer on Yellowjacket Hill. The future of the district as a producer of base metals will depend on the development of large bodies of low-grade ore amenable to economic mining methods. The gold and silver in the base-metal ore should carry a considerable part of the operational costs and thus permit recovery of the base metals which otherwise would be uneconomical.

Sizable bodies of low-grade ore are most likely to be found in the large lodes and stockworks. These bodies are not adequately exposed at the present time but the showings as they are are warrant systematic exploration. In any exploration program it should be remembered that the ore has a rather spotty distribution and that individual bodies may terminate abruptly because of local changes in the controlling structures. The mineralization may be expected to extend over a vertical range that is known to exceed 1,000 feet and the downward termination of a given body therefore need not mean the bottom of mineralization. These peculiarities of the mineralization make it necessary to explore the entire ore zone with the expectation that the better pockets of ore may bring much of the mineralized zone up to the grade of mineable ore. It should also be kept in mind that the lodes and stockworks do not extend vertically downward, a factor apparently little considered in former years when downward extension of bodies were sought in deep adits and crosscuts. Further work in the district entails a considerable amount of speculative risk, but in view of the growing scarcity of base metals the risk appears to be justified. The district is worthy of attention.

MINES AND PROSPECTS

YELLOWJACKET MINE

Location and accessibility

The Yellowjacket mine, the oldest and most productive in the district, is near the top of Yellowjacket Hill about three-fourths of a mile northeast of the old town of Yellowjacket (Fig. 2). It is reached from town by a good but narrow road which ascends the steep slope of the hill with the assistance of several switchbacks. The road is entirely adequate for trucking and general use and is the only route from mine to mill since the aerial tramway, which formerly connected the mine with the mill at the base of the hill, was allowed to go to ruin.

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Fig. 5. Map of the underground workings at the Yellowjacket Mine (from U. S. Geol. Surv. Bull. 834, Plate 6).
Property and development

When the mine was last worked underground in 1940, the property comprised 7 patented and 43 unpatented claims and several mill sites. Since then the property has changed hands (now owned by Messrs. Edwin F. and Heber S. Steen), but the number of claims probably remains the same. The development is extensive and includes a number of open cuts (Fig. 4), many of which are enlarged—by stopes from below, and more than 5,000 feet of underground workings on four main and several intermediate levels (Fig. 5). As the underground work was completely inaccessible in 1950, the map of the underground workings (Fig. 5) is reproduced from the one compiled by Ross and published as Plate 6 in U.S. Geol. Survey Bull. 854, p. 106. There have been some changes since the map was published but these changes are minor and were made mainly when the mine was reopened in the late thirties. Some of this work is shown in figure 6 which has been adapted from a late company map. This map shows the geology on parts of the No. 2 and 3 levels.

The writer with the assistance of Mr. McGreevy also prepared a topographic-geologic map of the surface on which is shown the location of all the cuts, caved stopes, and glory holes; the position of the portals of each of the adits; and the exposed bodies of intrusive igneous rock (Fig. 4). Because it was impossible to get underground, the writer has had to draw heavily on the data assembled by Ross and others.

History and production

The history of the Yellowjacket mine has been fully treated elsewhere in the report and the details need not be repeated. Most of the $450,000 production reported by Umpaugh and the $121,761,000 production obtained by Ross* from company records came from the Yellowjacket mine. The records of the U.S. Bureau of Mines show that the ore sold or treated from the Yellowjacket mine since 1902 through 1949 totalled 8,547 tons and contained 3,003 ounces of gold; 5,397 ounces of silver; 8,286 pounds of copper; and 3,252 pounds of lead. How much of this production should be credited to placer operations is not known.

Geology

The mine is contained in the grayish quartzitic and in part calcareous beds of the Yellowjacket formation which locally has been much broken by faults and joints and cut by many dikes and small masses of igneous rock of pre-Cambrian (?), late Cretaceous or early Tertiary, and Miocene age (Fig. 4). The beds show marked changes in attitude from place to place but in general they strike in a northwesterly direction and dip northeast. Just to the west and north of the mine the formation has been cut by a regional fault of northeasterly trend and northwesterly dip. This fault is one that was described in some detail in an earlier part of the report and nothing more need be said about it as it has had no bearing on the local mineralization. There are, however, many smaller faults which appear in or near the Yellowjacket lode which are of pertinent geologic interest, as some of them have influenced mineralization and others have produced offsets in the ore bodies. Some of these faults trend in a northeasterly direction and dip northwest, others trend about N.30°W, and dip almost vertically, and a few strike northwest at wide angles and dip southwest at relatively low angles, apparently causing some offsets in the mineralized zone.

The intrusive rocks exposed and mapped on the surface (Fig. 4) include irregular bodies of the pre-Cambrian (?) gabbro, one body each of olivine gabbro, diorite, and pulaskite of late Cretaceous or early Tertiary age, and one body of Miocene granophyre. Small bodies of these and other rocks are numerous in underground workings, with lamprophyres and various other basic intrusive rocks reported to be especially abundant.

Where not stripped away or covered over, the lode and the rock below are beneath a cover of soil and disintegrated rock which is appreciably rich in detrital gold released by weathering of the lode and concentrated over the outcrop and on the slope below.

Structural relations of the lode

As stated earlier the Yellowjacket lode is along a broad zone of complexly shattered or fractured rock which trends about N.70° E. and dips steeply northwest. This zone appears to be up to several hundred feet wide, fully 1,200 feet long, and contains numerous veins and stringers separated by more or less extensively altered rock. These veins and stringers appear to strike in two preferred directions, one about N.65°-70° E., the other about N.30° W.

The alignment of the caved stopes and
glory holes suggests an important offset of the fracture zone about midway of its length. This interruption of alignment may confirm the statement made by Umpleby8 that two faults encountered underground, both of which strike N.40°W. and dip southwest, have caused notable offsets. The more westerly of these faults is reported to throw the vein about 175 feet on the east side and the more easterly one, a further displacement to the west of 90 feet. These faults may in part account for the considerable spacing between the stopes above the No. 1 and No. 2 levels (Fig. 5) and perhaps also for the failure to find downward extensions of the No. 2 ore bodies on the No. 3 level, 200 feet below the No. 2. Rose9, however, expresses doubt on the cutting off of ore shoots by notable faults and considers the possibility that the lack of downward persistence of the ore bodies may be due to original discontinuities of pre-mineral fissures and to consequent or independent irregularities in both hypogene and supergene mineralization. He further points out that the ore shoots mined in the upper workings may have pitched west-northwest at small angles and may represent only uneroded remnants of much larger shoots and that, if something of this sort is true, it is possible that ore shoots as large as those already mined may exist in the lode at some place not yet penetrated by mine workings. The writer is in no position to make any statement one way or another.

The map of the No. 2 and 3 levels (Fig. 6) shows that the lode contains almost innumerable faults of varying degrees of magnitude and of varying attitude and trend. Some of the bodies of ore apparently abut against faults; but there are suggestions, too, that terminations of ore also result from discontinuities of the pre-mineral fissures.

Character and distribution of ore

The surface exposures have little to offer on the character and distribution of the ore, although the caved stopes and the glory holes (Fig. 4) do provide some information on the location and size of ore bodies mined in the early days. According to Sheldon,10 the ore body mined on the top of the ridge, now marked by the uppermost cut and glory hole, was from 200 to 300 feet long, 40 to 50 feet wide, and 150 feet deep. Some 600 to 800 feet southwest down the ridge was another body 40 to 50 feet wide. Some stringers and bunches of quartz still remain in the sides of the cuts and reveal that the ore mined was free-milling, thoroughly oxidized gold ore which originally contained some pyrite and in places minor amounts of chalcopyrite. The quartz now remaining is iron-stained and in places contains rusty cubical cavities and here and there small copper stains. As mentioned elsewhere the ore mined averaged $8 a ton, mainly in gold (the equivalent of 0.387 ounce per ton). Base-metal ores are reported to have been encountered in various parts of the workings and the presence of lumps of oxidized copper minerals in the dump material tends to confirm these reports.

The ore apparently had a sporadic and erratic distribution and was contained in many bodies, most or all of which lacked continuity either because of faulting or more probably because of original discontinuity of the directing fissures. The map of the No. 2 and No. 3 levels (Fig. 6) shows several fairly closely spaced ore zones on and below the No. 2 level, some of northwest and some of northeast trend. These measure from 0 to 40 feet across, apparently have not been fully explored along their strikes.

There apparently has been a material change in the character of the mineralization with depth, for the ore exposed on the No. 3 level contains considerable amounts of base metals, including a sizable body of quartz-galena in essentially the downward projection of the ore bodies mined on and for some distance below the No. 2 level. The quartz-galena body on the No. 3 level (Fig. 6) trends in a northwesterly direction. It has been exposed for a length of more than 80 feet and for part of the distance has a width of at least 25 feet. The writer did not have access to assay or sample records, but according to unconfirmed report the body averages about 0.2 ounce of gold per ton, 5 to 10 percent lead, and about 3 percent copper. The body seems to be worthy of more attention than it has received. The map (Fig. 6) shows that it is cut off in the south end of the cross-cut by a fault occupied by a fine-grained intrusive. Another fault is reported to cut the body above the level.

Placer deposit

The eluvial placer that caps the lode and the slope below should be a valuable
asset to the mine. As the ridge is relatively broad and the lode closely follows the crestal slope (Fig. 4), topographic conditions have been favorable for retention of the gold released by weathering and disintegration of the lode material.

The placer starts near the head of the uppermost glory hole and extends southwest down the ridge along the full length of the lode for a known distance of not less than 1,500 feet. The placer appears to range up to 500 or possibly 600 feet across with an average width of about 300 feet. The average thickness of the placer is probably about 20 feet, but the thickness over the flattened, terrace-like part of the slope may be considerably more.

The owners report that the loose debris averages about $3 in gold per cubic yard and that the amount of this material exceeds 1,000,000 cubic yards. At the upper end of the placer, the material in and around the uppermost big cut and glory hole is reported to sample better than $4 a cubic yard. On the steeper slope below, the samples are reported to run about $2 a cubic yard; but in the flatter part of the ridge below the second glory hole, to the pond of the old Midway adit, the debris samples about $2.50 a yard, and from there to and below the No. 2 adit, about $3.25 a yard. The owners report that the fines obtained by screening the debris carry $6 a ton in gold.

During the late forties a 150-ton dry screening plant was installed at the large glory hole at the base of the steep slope, from which up to 80 tons of fines passing 3 mesh were trucked from the hill to the mill. Fragments of vein quartz and lumps of oxidized copper ore were picked from the oversize reject and saved for future milling or shipment.

Outlook

Although the present study of the Yellowjacket mine had to be confined entirely to surface observations, the data obtained from this study and from older reports and maps indicate commercial possibilities. In addition to the placer material there is apparently considerable mineable gold ore still underground; but until the mine is reopened and the underground more thoroughly explored, no statement can be made as to where the ore is to be found and in what quantity. Some element of doubt still exists as to the cause of the downward discontinuity of the ore bodies and as to the direction and angle of pitch of the ore shoots. So far as can be learned, there has been little exploratory work beneath the ore bodies mined from the No. 1 adit and not too much work beneath the No. 2. Apparently, some bodies of ore remain below the No. 2, which have not been uncovered on the No. 3 level and these invite attention.

Not to be overlooked and at present more strategically important are the base-metal ores which appear to become more and more abundant with increasing depth. The disclosures along the No. 3 level suggest a considerable change in the character of the mineralization from gold-quartz in the upper levels to quartz-base metals on the lower levels of the mine, with primarily lead-copper ores at and below the present lowest level. That the base-metal ore may continue to considerable depth below the present No. 3 level is indicated by the presence of a small, discontinuous body of lead ore on the slope a short distance above the mill and about 1,000 feet lower than the highest point on the Yellowjacket lode. The body of quartz-lead ore now known on the No. 3 level should be more fully explored, especially below the level. From present knowledge the area below the present workings appears to constitute good hunting ground.

STEEN PROPERTIES

The Steen family owns a number of properties along the slope immediately west of the old town of Yellowjacket, mainly along the Continental-Columbia mineral belt. These properties include the Continental, Lincoln, Broken Hill, Liberty, and Daniel along the mineral belt (Fig. 3), and the White Rabbit some distance south of the mineral belt (Fig. 2). Most of these properties have been known since 1891 or before, but the production has been small. The most extensive work has been on the Continental and Lincoln, with considerable work also on the Liberty. Most of the properties take heir names from the claims on which they are located.

Continental

Location and development — The Continental is in a steep shallow gulch about midway up the east slope of Steen Hill (Fig. 3) at an altitude of about 6,400 feet. A steep road which branches from one in Columbia Gulch leads to the mine.

The Continental is developed by two
adits; the No. 2, with about 70 feet of work, and the No. 3, with approximately 1,300 feet of work, including an 850-foot crosscut which extends under the Lincoln property on zone top of the hill (Figs. 7, 8, and 9). Another adit, the No. 4, is at the turn of the road on the Red Bird claim below the Continental, but this short adit is caved and is not directed toward the No. 3 (Fig.7). The 180 tons of ore mined between 1929 and 1939 apparently came from the No. 5 adit. The production from the development during those years totalled 66 ounces of gold, 179 ounces of silver, and 5,829 pounds of copper.

Geology — The mine is in the quartzitic and slightly calcareous beds of the Yellowjacket formation. These beds trend northwest and dip southwest at small to moderate angles. In places the formation has been extensively fractured, locally brecciated, and the fracture-breccia zones more or less extensively mineralized and cut locally by lamprophyric and granophyric dikes (Fig. 8).

Occurrence and distribution of ore — The ore bodies are of the fracture-breccia stockwork type and are confined to the more prominent zones of the northeast fracture. The largest stockwork is centered about 150 feet from the portal of the No. 3 adit (Fig.8). The body has been exposed for at least 120 feet in a northeast direction and possibly 200 feet or more in a westerly direction. Several smaller ore zones are exposed beyond, but the most distant one is on Lincoln ground. Local details of the occurrences are shown in figures 8 and 9.

Although a large body of quartz is exposed on the surface (Fig.7), there are no well-defined veins of any size in the underground workings at Inland. The ore as exposed on the No. 3 level is composed of irregular quartz-calcite veinlets along fractures and quartz-calcite cemented breccias. Sulfides are not conspicuous and in general are irregularly scattered rather sparsely through the quartz. The only sulfides observed were pyrite and in places chalcopyrite but minor amounts of tetrahedrite and galena are reported. Except near the portal, there is little evidence of oxidation along the No.3 level. Oxidized copper minerals are, however, conspicuous at the portal of the No.2 adit.

The ore is not uniformly distributed through the stockworks, and, because of this irregularity, it has been difficult to sample and to evaluate. From study of past sampling records, it appears that the body may average between 0.10 and 0.20 ounce of gold per ton and 1 to 2 percent copper. There are places, however, where the gold content may reach an ounce or more and the copper 2 or 3 percent.

Several small veins were uncovered by bulldozing operations in 1951. One vein about 42 feet northeast of the No. 3 portal strikes N.70°E. and dips 20° NW. It contains large bunches of quartz. Another lightly mineralized fracture zone about 120 feet northeast of the portal apparently marks the outer boundary of the fracture-breccia zone.

Suggestions — The main stockwork has not been adequately explored and may be larger than the work now indicates. Further exploration will have to be carried on mostly below the No. 3 adit level for any work upward is limited by the surface 20 to 200 feet above (Fig.9). In any exploration program it must be kept in mind that the ore is bumpy or pockety, that ore shoots are discontinuous and individually may bottom rather abruptly, and that the search should be for large bodies of low-grade ore that may be mined by low-cost methods. The ore zone as a whole should continue downward for hundreds of feet, probably pitching in a westerly direction. Because of the close proximity of the No.3 level to the surface, drilling of the big stockwork whether by diamond or churn drill should be carried on from the surface rather than from within the workings. The supply of water from the No.3 adit is adequate for all drilling purposes.

Lincoln

Location and development — The Lincoln is on the top of Steen Hill above the Continental and may be reached from the Continental (Fig.7) or from Columbia Gulch via the Liberty property (Fig.3). The Lincoln has been opened by a now caved vertical shaft 90 feet deep on the top of the ridge, which is connected with the No.1 adit and its approximately 310 feet of workings driven into the east slope about 370 feet vertically above the No. 3 adit on the Continental (Figs.7, 8, and 9). The No.3 Continental has been terminated almost directly under the Lincoln shaft and thus in part explores some of the Lincoln ground. There are also a number of cuts and several short adits along the crest of the ridge and on the upper northwest slope. The property has produced some ore, mostly in
Fig. 7. Topographic-geologic map of Steen Hill.
Fig. 8. Geologic map of underground workings at Continental.
Fig. 9. Longitudinal section along No. 3 Continental adit.

Note: Country Rock unless otherwise noted is Yellowjacket formation.
the early days, but the total amount has been small.

Geology — Like the other properties along the Continental Columbia mineral zone, the Lincoln is in the quartzite and in part calcareous beds of the Yellowjacket formation and these beds, as elsewhere, are extensively fractured and brecciated and locally mineralized and invaded by lamprophyric dikes. The beds have a general northerly trend and northeasterly and southwesterly dip. The more prominent fractures strike northeast but there are also some which strike northwest and north. The more important fractures observed underground are shown in figure 8, but most of the smaller fractures and the breccias were omitted.

Occurrence and distribution of ore — The Lincoln has a fracture-breccia stockwork deposit that is perhaps larger than the one on the Continental, if all the exposed bodies of quartz and otherwise mineralized fractures and breccias along the ridge are included. The underground workings explore only a part of this broadly mineralized area. Shattered and brecciated rock cemented by quartz and calcite is exposed almost continuously along the ridge in a N. 60°—65°E. direction. Along the ridge are also some short, well-defined veins of diverse trend which measure from a foot or less up to several feet wide.

One small zone of mineralized fractures has been exposed in a short adit and cut about 100 feet northeast of the shaft, and a quartz vein about 1 foot wide has been uncovered 150 to 200 feet northeast of the shaft. This second vein strikes about N. 20°E., dips 55°SE., and has been explored by two open cuts. Another vein measuring 1 foot wide and striking about N.60°E. is exposed still farther to the northeast just below the turn of the road. On the northwestern slope of the ridge just west of the shaft is another vein (Q vein) which appears to strike N.40°W. and which may be traced down the slope for more than 100 feet. This vein has been exposed in cuts and explored by short, now caved adits. In the uppermost cut it forms a body of massive quartz from 4 to 10 feet wide. This vein appears to be one of the longest on the hill, although in places it vertically disappears by plunging. The most conspicuous surface showing, however, is a ledge of massive, somewhat iron-stained quartz about 30 feet across and traceable down the slope for 150 feet not far north of the No. 1 adit. These various vein and quartz exposures are shown in Figures 3 and 7.

The underground characteristics of a part of this extensive stockwork are depicted in Figure 8 where the zone has been explored by the workings in the No. 1 adit. This map shows the distribution of the main fractures and breccias and indicates the nature of the mineralization. Galena is exposed along the drift to the shaft, but elsewhere the ore is chiefly gold and oxidized copper minerals contained in bunches and veins of quartz and calcite. The gold content of the ore appears to be about the same and the copper content only a little lower than in the Continental stockwork. On the shaft dump is a small pile of very rusty quartz containing malachite, azurite, chrysocolla, cuprite, and some rather coarsely crystalline galena. The ore is reported to have contained 0.5 to 0.7 ounce of gold per ton.

Suggestions — The stockwork has not been adequately explored. The body apparently plunges northwest, for the face of the No. 3 adit, which is almost directly under the shaft, is in barren ground. Extension of the adit in a more northwesterly direction ought to pick up the downward extension of the fracture-breccia zone; however, the ground should be probed in advance by the diamond drill from the present face of the No. 3 adit. Drilling to the north and northwest and obliquely upward and downward should suffice in a preliminary exploratory program. As at the Continental, the objective of a development program should be the blocking out of a body of low-grade ore sufficiently large for a fairly large-scale, low-cost mining operation. The No. 3 adit should provide ample basin for some time should the stockwork deposit prove large and rich enough to be worked economically. There is, of course, always the possibility that shoots of rich ore adapted to selective mining may be found.

Broken Hill

The Broken Hill is southwest and about 400 feet vertically above the No. 3 portal of the Continental or about 700 feet due south and at the same level as the Lincoln No. 1 adit (Fig. 7). The road which passes in front of the Lincoln No. 1 adit ends at the Broken Hill. The discovery adit, which originally was about 25 feet long, has been covered or destroyed by the bulldozing operations. The work now consists of a large cut about 150 feet long and up to 20 feet high (Fig. 7).

The bulldozed cut extends diagonally across a zone 40 to 50 feet wide of com-
plexy fractured calcareous, quartzitic beds of the Yellowjacket formation. In one place the beds of the disturbed zone strike N. 26°E. and dip 40°NW. and in another place strike N. 40°E. and dip vertically. In most places the bedding has been largely obliterated by the fracturing. The more intense deformation is within a 10 to 15 feet wide where the shearing has produced a rather prominent sheeted structure. The general strike of the fracture zone is about N.60°-70°E. and the dip, 70°NW.; but where mineralized the strike changes to about N.30°E.

The actual mineralized zone as revealed in the cut is 6 to 8 feet wide and contains, in addition to scattered quartz and calcite stringers, a quartz vein 2 to 4 inches wide, which on the bank above the cut is 2 to 3 feet wide. The mineralized zone is exposed for about 50 feet along the strike. In places the quartz is somewhat iron-stained and locally contains small patches of mala- chite, azurite, and chrysocolla. The copper staining also extends into the fractured quartzite above and below the vein and bordering zone of stringers. The mineralized zone contains a little galena and some cerussite and anglesite. A 5-ton smelter shipment is reported to have contained 0.045 ounces of gold and 14.9 ounces of silver ton, 0.8 percent copper, and 17.2 percent lead. As suggested by the presence of azurite among the oxidation products, the primary ore probably also contains tetrahedrite in addition to chalcopyrite.

Other properties on Steen Hill

Among the other showings on Steen Hill is an outcrop of partly iron-stained quartz known as the B vein. This vein is cut by the zig-zag road about midway between the Continental and Lincoln workings (Fig. 7). The body of quartz had been opened by a short adit, but the bulldozing operations have almost destroyed evidence of the adit.

The quartzitic beds of the Yellowjacket formation strike northwesterly and dip about 65°SW, but as usual the beds locally have been extensively fractured and the bedding largely obliterated. The main zone of fracturing strikes about N. 60°-70°E. and apparently dips steeply northwest. Contained in the fracture zone is a body of quartz up to 5 or 6 feet wide which has been exposed for 20 feet on the two sides of the old adit for a total distance of 40 feet. The quartz is honey-combed, rather heavily iron-stained, and apparently contained considerable pyrite before oxidation.

Other veins and cemented breccias occur northwest of the B vein and have in part been explored by adits driven into the north or Columbia Gulch side of the ridge (Fig. 7). The adit to the H vein is now caved but on the dump is a considerable pile of coarsely crystalline massive quartz composed in part of chunks 2 feet thick. Some of the quartz is honey-combed, but there is no copper staining.

No attempt is made to describe all the showings on Steen Hill.

Liberty

Location and development — The Liberty is along the gulch just west of the Lincoln, (Fig. 8 and 7), in what is known locally as Liberty Gulch, a tributary of Columbia Gulch. It is reached by the road to the Columbia mine and the branch that circles back to the Lincoln (Fig. 3). The property has half a dozen adits on about as many bodies of mineralized rock and these are deployed along the west side of the gulch for some hundreds of feet (Figs. 7 and 10). All but one of these are caved. Five of the adits are shown in figure 10, the open workings by solid lines, the blockaded workings, corroded from an old map, by broken lines. These have been numbered from 1 to 5, beginning with the one lowest in the gulch. The most important disclosures revealed today are in the uppermost or No. 5 adit.

Production from the Liberty was not learned but apparently has not been large. A small amount of ore was stoned in the No. 5 adit by lessees and may have been marketed as from the Silver Moon mine. If this is so, the production (1926-1927) amounted to 10 tons and totalled 3 ounces of gold, 133 ounces of silver, 159 pounds of copper, and 1,413 pounds of lead.

Geologic relations — The deposits are in the Yellowjacket formation, which, because of deep overburden, is rarely exposed on the surface. Underground observations disclose that locally the formation has been extensively fractured and brecciated and material on the dumps of caved adits shows that the formation has been intruded locally by bodies of hornblende diorite, lamprophyre, and granophyre. The surface reveals little of the structural relationships; but some of the zones of mineralized rock are more resistant to erosion than the more
Fig. 10. Map of Liberty workings (inaccessible workings shown by dash line).
readily weathered calcareous members of the Yellowjacket formation and are reflected as small, more or less oval-like swells in the topography.

Most of the workings are apparently on separate zones of fractured and mineralized rock and the position of these and those reflected as low surface swells suggests an echelon arrangement with the individual zones elongated in a northeasterly direction. The swarm as a whole has a more northerly trend. These mineralized fracture zones are individually rather short and the ore bodies in them probably mainly less than 30 feet long. The one penetrated by the No. 5 adit, however, may be more extensive than the others and may constitute a fracture-brecia stockwork at least 75 feet in diameter. There are zone less extensively developed deposits higher on the slope which are not shown on the map.

**Mineralogic features**—These deposits contain appreciable amounts of base metals and individual deposits seem to differ in their preference for the different metals. Each of them contains the usual quartz-calcite gangue as breccia cements and replacements and as irregular veinlets and bunches, but those lower in the gulch contain chalcopyrite as their principal base-metal mineral and those in the upper part of the gulch contain chiefly galena and tetrahedrite. Each carries some gold and those with galena and tetrahedrite also contain appreciable amounts of silver.

**Description of deposits**—The principal deposit is apparently the one exposed in the No. 5 adit. The distribution and structural relation of the principal mineralized fractures as shown in figure 10 and their spacing and characteristics suggest they form a part of a fracture-brecia stockwork not fully explored by the underground work. The most pronounced mineralization is at the face of the south branch of the adit along a zone of N. 60°E. strike and 70°SE. dip. In this zone are grains and irregular masses and veinlets of galena and tetrahedrite. The mineralized body measures up to 3 feet wide and occurs above a well-defined footwall. The hanging wall, however, merges with a breccia that extends outward for 20 feet. This hanging wall breccia is cemented by quartz and contains bunches of quartz as much as 2 feet in diameter. The ore has been stope 15 feet above the level and about 15 feet along the strike, with irregular veinlets and pockets of galena still showing in the northeasterly face of the stope. The ore zone is short, for it does not reach the north branch of the adit. (Fig. 10). The other branch passes through a mineralized zone about 2 feet wide of N. 62°W. strike and 85° NE. dip, and then continues along a weakly mineralized fracture that strikes N. 17°E. and dips 85°SE.

Before reaching the main ore zone in the south branch, the adit is along a fracture-brecia zone up to 2 feet wide that strikes N. 74°E. and dips 40°SE. This zone contains quartz and calcite and some small scattered bunches of sulfides. Several non-mineralized slips of northwest and northeast strike also show up underground.

Between the No. 5 and No. 4 adits the road has uncovered a broad rubble or breccia zone with rock fragments cemented and in part replaced by calcite and quartz. The more recently developed breccia zone, some 20 or 30 feet wide, trends in a northeasterly direction. It forms a low, oval-shaped knoll above the road bank and is but one of several such knolls in that area.

Adit No. 4 appears to be on a separate zone of mineralized rock. The southwest branch of this short adit and the main adit itself (Fig. 10) contain sporadically distributed bunches of chalcopyrite in coarse rubble breccias and in fractures. Some of the chalcopyrite occurs in pods up to an inch thick and 12 inches long, but most of it is in the form of irregular bunches. The other branch of the adit is along a N. 50°W. slip.

Adit No. 3 explores still another mineralized body. The adit is tightly lagged for a short distance in from the portal and then enters a breccia zone in which the rock fragments are cemented by coarse-grained quartz, which locally occurs in unusually large bunches. The adit is blocked short of the main ore zone, but material piled on the dump indicates that the ore contains some coarsely crystalline siderite and some chalcopyrite, in part coated by malachite.

Adit No. 2 lies above and to one side of adit No. 3 and apparently explores the same ore body. It has been driven just under the road, and caved slopes from it and workings below have caused a notable sag in the road bed. The adit is not accessible but the dump has a considerable amount of coarse calcite-brecia and a small pile of chalcopyrite showing various stages of alteration to chalcocite and malachite. Some of the irregular masses of chalcopyrite measure up to 2 inches in diameter.

The lowest adit, adit No. 1, is driven
about S. 20°W, and apparently undercuts the workings in adits 2 and 3. Some of the dump material includes hornblende diorite impregnated with ore minerals and fragments of lamprophyric rock. On the dump are also considerable amounts of quartz and ferriferous calcite, mostly in breccias, and appreciable quantities of massive chalcopyrite, in part altered to chalcopyrite and coated with patches of malachite. The chalcopyrite evidently occurred as irregular masses and small discontinuous seams in the ore, replacing quartz, calcite, and altered rock.

Directly across from the No. 2 and No. 3 adits on the east side of the gulch (Fig. 3) is another caved adit, which may not be on Liberty ground. This adit was driven about 30°E. toward workings on the Lincoln, and the dump reveals that it passed through a body of granophyre of considerable size and then entered quartzite and breccia material. Somewhere underground it also cut hornblende diorite. A small amount of iron-stained, coarsely crystalline quartz in chunks up to 18 inches in diameter has been piled to one side of the dump.

Suggestions — Although the metallization on the Liberty is somewhat spotty and the individual ore bodies rather small, their considerable number would seem to justify more exploratory work than has been done. Base metals, particularly copper, seem more abundant here than elsewhere. It is presumed that the ore carries appreciable values in gold.

Daniel

The Daniel, a formerly unpatented and open claim of the Columbia group was located by the Steens in June, 1961. The Daniel lies south and somewhat above the Columbia patented claims and about due west of the No. 5 adit on the Liberty (Fig. 3). From the present condition of the workings it is evident that the original location was made a long time ago. The development consists of a series of rather closely spaced shallow cuts and short adits aligned in a S. 50°E. direction up the slope. These are all caved and the only clue that the workings are on a vein or ledge is the quartz which appears in large chunks on most of the dumps.

The quartz body apparently strikes N. 50°-60°W, and has an explored length of not less than 100 feet and a probable length of some hundreds of feet. Judging from the size of some of the bunches of quartz, the body cannot be less than 2 feet wide. The quartz is somewhat iron-stained and shows casts after pyrite. Large chunks of calcite also occur on one of the dumps. The body is regarded to yield gold values but assay returns were not seen.

Between the Daniel and Liberty and probably on the Elizabeth claim is another quartz vein about 2 feet wide which appears to strike N. 65° W. The quartz is rather heavily coated with iron oxides.

White Rabbit

The White Rabbit is outside the Continental-Columbia zone in a gulch some distance west and above Yellowjacket Creek and about a mile in air line southwest of the old town of Yellowjacket (Fig. 2). The White Rabbit has not been worked for many years and the road from town is now overgrown with brush and trees. It was worked in the early days by George Steen, but all but one of the four or five adits are now caved. Above this open adit are some caved stopes and open cuts, mostly on the outcrop. The writer has no information as to production.

Unlike the other properties, this one is in hornblende diorite and small pendants of highly altered Yellowjacket formation. The lower workings appear to be entirely in diorite, the upper workings in diorite and highly altered quartzite.

The work apparently has been directed along a narrow, perhaps discontinuous vein, which in the open work along the outcrop strikes N. 30°W. and dips 65° SW. The chunks of quartz on the dumps indicate that the vein is as much as 12 inches thick, and the work on it, that it is at least 60 feet long. It is composed entirely of quartz which in places contains coarse cubes of limonite pseudomorphous after pyrite.

No quartz appears on the dump of the lowest and longest adit which is probably less than 100 feet vertically below the upper work.

Columbia

Location and development

The Columbia mine is near the head of Columbia Gulch about a mile west of the old town of Yellowjacket (Figs. 2 and 3). The road to the mine was suitable for wagons in the early days but is too steep for the modern car and truck unless geared for mountain grades.
Fig. 13. Longitudinal section of shaft of No. 1, Columbia, Wash.
The property comprises several patented claims owned by Rigby and Taylor of Idaho Falls. The work has been fairly extensive and spreads over a considerable area. Except for the 1587-foot crosscut driven to explore the property at depth, the workings are almost entirely caved. Those that were open or partly open were mapped (solid lines) and together with added extensions of the blocked workings taken from an old map of the property (broken lines) are shown in Figure 11. In addition to these workings there are two caved shafts and a number of old cuts. Altogether there are more than 2,000 feet of underground workings.

**History and production**

The mine was located in 1892 and was active until about 1908. At first the ore was treated at the Yellowjacket mill but later went to its own mill erected a short distance below the Yellowjacket mill. The last important work ended in 1903, when the long adit driven to explore the downward extension of the ore bodies failed to disclose ore. Since then the mine has been idle most of the time but some work was carried on in the early twenties and again in 1936.

Although the Columbia has been regarded as next to the Yellowjacket in importance its production has been small. The early day production of the mine was not learned, but the 1923 production is recorded as 4 tons of ore, containing 1 ounce of gold, 367 ounces of silver, and 641 pounds of copper.

**Geology**

The geologic conditions at the Columbia are not much different from those along other parts of the Continental-Columbia zone. The principal rock is the intricately fractured and otherwise deformed quartzitic beds of the Yellowjacket formation which has locally been intruded by late pre-Cambrian (?) and late Cretaceous or early Tertiary gabbroic dikes and by a composite body of granophyre and granite porphyry (Miocene) boldly exposed on the top of Columbia Hill (Fig. 2). This composite body of intrusive rocks and the patch of Challis volcanics just beyond mark the end of the Continental-Columbia mineral belt.

Except in the steep sides of Columbia Gulch, the Yellowjacket formation and the rocks that intrude it are poorly exposed and mostly concealed beneath a deep overburden. The abundance of igneous material on mine dumps, however, gives testimony of the actual presence of the intrusive rocks. The variable dip of the quartzitic beds in the gulch and in the long adit driven into the ridge from the lower gulch suggests complicated folding. As elsewhere the formation has been extensively fractured. The northeast fractures are the most prominent, but those with northwest trend appear to be most numerous.

**Structural relations of the ore bodies**

Because caved workings prevented examination of most of the ore bodies, much of the information concerning them has had to come from surface observations. The data contained in other reports, particularly one by Eldridge, the ore bodies comprise a number of mineralized fracture-brecchia zones which range from a few feet up to 50 feet wide. Most of these trend about N. 60° E. and dip 30°-70° NW., but a second, subordinate set of the mineralized zones strike N. 15°-25°W. The lamprophyric dikes reported as numerous underground favor the northeast zone of fractures.

The ore bodies within the zones of fractured rock are individually short with stope lengths of a few tens of feet. The ore bodies are apparently discontinuous and the ore appears to be more or less generously distributed in bunches or pockets. Dump material indicates that some of the ore was contained in coarse brecia.

**Ore**

The ore is reported to consist of breciated quartzite cemented by calcite and quartz, with sulfides irregularly distributed in the quartz and fragments of quartzite. The sulfides include chalcopyrite, pyrite, tetrahedrite, and galena which are reported to be more abundant here than at most of the other properties. Barite occurs locally as a minor gangue mineral.

The ore near the surface was partly oxidized and some of the ore on the dump today consists of malachite, azurite, and chrysocolla.

Eldridge reports that the average ore in the early days was worth $30 a ton and that some ore went as high as $150 a ton. A considerable part of the value was reported as gold.

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Descriptive features

At the No. 2 adit, as at most of the other adits, the dump material provides about the only clue as to what is underground. The 70 feet of the No. 2 adit that is open (Figs. 3 and 11) exposes nothing of pertinent geologic interest. Material on the dump indicates that the workings do cut a body of gabbro and also enter coarsely brecciated quartzite cemented by calcite and quartz. The old mine map shows stope areas 25 to 30 feet long, apparently the length of individual ore shoots. Except for thin films of malachite, the only ore substance on the dump is quartz. Quartz probably from the same body, is exposed on the dump of a caved adit and cut about 100 feet to the east (unmapped).

Adit No. 3 (Fig. 11) is open to the face, but an underhand stop blocks the adit short of the face. Some bunches of quartz appear near the small stope but no ore remains there or on the dump.

Farther to the south and above the old camp buildings are several caved adits (No. 5) and a shaft, but the only visible evidence of mineralization is restricted to some bunches of coarsely crystalline quartz.

The most productive work apparently was in adit No. 4 (Fig. 11) well up on the ridge. This adit is open for about 115 feet and in that distance discloses several prominent slips, one of which was explored by a 15-foot drift. This slip, which appears to be unmineralized, strikes about N. 65° E. and dips 25° NW. Beyond the drift the adit is driven along a prominent slip of N. 22° W. strike and 70° NE. dip; but the only feature of note is that the slip splits with one branch striking N. 5° E. and the other, N. 30° E. The adit is caved just beyond, but irregular bunches and stringers of calcite appear near the cave and probably denote the approach to an ore zone. Several small stopes are shown on the mine map beyond the cave, one apparently on a fracture zone of N. 20° W. trend, another on a zone of northeasterly-trending fractures. Most of the production probably came from these stopes. Scattered fragments of ore on the dump contain small grains and masses of galena and tetrahedrite, in part coated by malachite and azurite.

The shaft on the summit of the ridge probably connects with the No. 4 adit. The last work was apparently carried on at the shaft, which is now open to a depth of about 15 feet. A small vein or mineralized fracture of N. 30° E. strike and 70° NW. dip is exposed in the sides of the shaft. Other fractures, some of them rather prominent, are also visible. The dump has some fragments of quartz and barite, with a little galena and tetrahedrite. Present also are malachite, azurite, and limonitic iron oxides.

Between the shaft and the portal of the No. 4 adit are several cuts. One of these uncovers a quartz vein, the others expose quartz float.

A second shaft on the ridge some distance to the south (Fig. 3) is surrounded by a half dozen piles of white, in part rusty quartz, some of which retains a little cubic pyrite. The quartz is from a body 5 to 6 feet wide and at least 30 feet long. A slip surface on the quartz strikes N. 80° E. and dips 60° NW., which may be about the strike of the quartz body itself. A second quartz vein occurs a short distance to the north. This one seems to be parallel to the first. It shows no sign of metallization.

Adit No. 1 was driven to undercut all of the workings on the ridge (Fig. 3), and explore the downward extension of the ore bodies mined on the upper levels (Fig. 12). This adit (Fig. 11) reveals numerous fractures, all but two of which strike northwest. Most of the northwest fractures strike about N. 20° W., and dip 70°-80° SW., a few dip 65°-85° NE. These are unmineralized or show only slight evidence of mineralization. The adit also penetrates considerable brecciated rock, but the breccias are not so coarse as those in the upper workings and contain more calcite. Some stringers and bunches of quartz do occur in the more central parts of the breccia zone and in places the quartz contains a little pyrite. A crosscut driven northwest from the adit well south of the area of the shaft encounters no mineralization of note. The adit exposes two bodies of gabbro, both of which appear to belong to the late Cretaceous or early Tertiary group.

Comments

Ore of commercial grade was not found in the long adit and this failure to find ore prompted the early closing of the mine. The adit apparently was aimed to pass under the shaft without regard to the fact that the ore bodies plunge northwest and thus with depth are carried away from the shaft and hence some distance northwest of the adit. The single exploratory cross-
cut was not located in the proper place to probe for any downward extensions of the ore zones exposed in the upper workings (Fig. 12). More exploratory work should have been carried on in this long adit before the project was abandoned. This work should have been near the shaft and out under the No. 4 adit. The calcite zones encountered in the No. 1 adit suggest fringe areas of mineralization.

**BROUGH PROPERTY**

The Brough property, owned chiefly by Fred Brough of Salmon, Idaho, is at the eastern end of the Continental-Columbia mineral zone and extends from Yellowjacket Creek at the lower end of the old town to the Continental group, (Fig. 3). The property comprises two patented claims, one a placer claim, the Snowstorm, the other, a lode claim, the Bryan.

Much of the work on the property was apparently done in the early days but there has been some work since. The early-day production is not known but that of late years is a matter of record and credited to the Bryan.

**Snowstorm Development**—The Snowstorm placer covers 16 acres, but all the work has been confined to a lode near the base of the slope at the edge of town. The development consists of a 429-foot adit with a 45-foot crosscut about 150 feet from the portal and some stopes near the portal which extend to the surface. A big cut has been made at the portal but the adit is blocked and all the underground workings are inaccessible.

**Geologic relations**—The country rock is composed largely of impure quartzitic and limy beds of the Yellowjacket formation. In a cut above the adit these beds strike N. 40° W. and dip 50° SW., but elsewhere the formation has been so extensively fractured that strikes and dips are indeterminable. Underground the fractured rock is cut by a vitrophyric dike, chunks of which are scattered on the dump.

The cut at the portal of the adit exposes a broad zone of fractured rock in which the more prominent fractures trend about N. 20°-30° W., with less prominent ones of more westerly and northeasterly trends. These fractures are rather short and appear to be components of a broad fracture-breccia stockwork, which, to judge from the distribution of quartz float on the slope above the adit, must be as much as 100 feet wide. This zone of fractured and mineralized rock appears to extend up the slope in a general west-northwesterly direction. Slopes break through to the surface along the more highly mineralized parts of the zone.

**Character and distribution of ore**—The stockwork appears to be without well-defined veins but contains irregular bunches, stringers, and seams of quartz which extend along and across the fracture zone. Some of the quartz seams strike N. 20° W. and dip 40° SW., but the general dip of the stockwork appears to be northeast.

The ore consists largely of coarsely crystalline white quartz which cements breccias, fills fractures, and locally replaces quartzite. It contains generally sparse amounts of chalcopyrite, pyrite, and exceptionally galena. The sulfides are reported to have a sporadic but rather persistent distribution. According to the owners, bunches of chalcopyrite weighing from 1 to 20 pounds have been found and occasionally a chunk of galena has been uncovered. Secondary copper minerals, chiefly malachite, subordinately chrysocolla, are locally conspicuous in the quartz and in fractures in the quartzite. The most important metal, is the gold, which is reported to run $6 to $7 to the ton, exceptionally more.

**Bryan Development and production**—The workings on the Bryan are on the ridge some 500 to 450 feet above the Snowstorm adit (Fig. 3). The main development is at the sharp turn of the road between the No. 4 and No. 3 adits on the Continental (Fig. 7). The workings include a number of old cuts and short adits with the most recent work in a large cut at the road turn. This cut was made by dragline in the late thirties or early forties. All the old adits, which extend for some distance along the ridge, are caved.

The production recorded for the years 1935-41 totalled 460 tons of ore containing 372 ounces of gold, 137 ounces of silver, 5,561 pounds of copper, and 1,541 pounds of lead.

**Geologic relations**—The complexly fractured Yellowjacket formation has been intruded by a tongue of hornblende-biotite diorite or its syenitic facies and by a dike of Mioecne granophyre, which lies along a part of the ore zone. The quartzitic rock has lo-
cally been somewhat "granitized" and alteration shows up particularly in the lowest cut and adit. The "granitized" rock is somewhat more resistant to erosion than the other rocks and forms a rather prominent ledge about 70 feet long which trends N. 40°E.

The fracture zone along which mineralization occurs is fairly broad and trends in a general west-northwesterly direction. It appears to be more or less independent of the one in the Snowwork, but may be a center of more intense fracturing along the same zone. Important fractures strike N. 80°W. and N. 20°E., but there are also fractures of other strike. Those that strike N. 20°-30°W. are the more prominent and have been most instrumental in directing the general trend of the fracture zone. Individual fractures are rather very long with the general character of the fracturing may be likened to that of a stockwork.

Character and distribution of ore — This zone of fractured rock contains some small but well-defined veins. One exposed in the cuts below the road turn is up to 16 inches thick, strikes N. 80°W., dips steeply north-east, and occurs beneath a hanging wall of post-ore granophyre. The vein is composed of quartz and is bordered by stringers in the underlying fractured quartzite. Appreciable amounts of copper minerals, including chalcopyrite and chalcocite and their oxidized products occur locally.

The large open cut at the road turn in which most of the work has been done has exposed a broad zone of mineralized rock in which short adits formerly had been driven along narrow veins of diverse trend. One quite persistent vein just in front of the cut measures about 16 inches wide and strikes N. 80°W., about parallel to the road. It dips steeply north and is accompanied by stringers of quartz in the bordering walls. Another vein exposed in the cut strikes N. 30°E. and measures 2 to 14 inches thick. It, too, is bordered by stringers. The veins of northwest trend appear to be larger and longer than those which strike northeast and individually have been traced for a hundred feet or more along the strike. Much of the ore mined in the large cut apparently came from stringers and small veins which locally comprise a small stockwork. The ore apparently contained little base metal for that mined averaged 0.81 ounce of gold and 0.3 ounce of silver per ton, 0.38 percent copper, and 0.16 percent lead.

Comment — Bodies of rather low-grade ore of fairly large size might be developed, perhaps of such size as to sustain moderately sized operations for some time. Small bodies of high grade ore may occur locally.

TIN CUP

Location and development

The Tin Cup mine is on the west side of Yellowjacket Creek less than a mile below the old town of Yellowjacket (Fig. 2). The workings are several hundred feet above the creek and mill and are reached by trail which leaves the creek road at the mill. The property comprises two claims owned by Hugo A. Simi and acquired by him from H. T. Stewart in 1937. The development consists of several old cuts along the outcrop and a 170-foot adit with 130 feet of drift which are connected by inclining and driving a 90-foot drift about 50 feet below the adit level (Fig. 13). Some ore was stoped and shipped in 1934 and intermittently then to 1949, except during the war years when the mine was closed. When Mr. Simi acquired the property the development consisted of the adit then in 105 feet to the vein, and about 50 feet of drifts northward along the vein. All work since then has been by Mr. Simi, who in 1951 was at work on a small mill. The record production from 1934 to 1949 is 26 tons of ore containing 43 ounces of gold, 23 ounces of silver, and 417 pounds of copper.

Geologic relations

The mine is in a mass of highly altered Yellowjacket formation which has been invaded by hornblende-biotite diorite, lamprophyre, and granophyre, and locally converted in part to albite aenite. The bedding of the considerably "granitized" rock has been in part preserved and the beds locally strike northeast and dip steeply southeast. The rock has been rather extensively fractured and contains numerous minor slips of northeast and northwest trend and steep northeast and southeast dip. The rock has also been cut by faults of considerable magnitude including one of northeast strike and 50°NW. dip. This fault apparently cuts off the vein near the north end of the adit drift. It is bordered on the hanging wall by a broad zone of soft, highly shattered rock.

The mineralization is confined to a fissure which strikes about N. 15°W. and dips about 55°SW. This fissure contains a vein measuring from a few inches to 18 inches thick, averaging perhaps about 12 inches (Fig. 13). The vein is mostly igneous rock and appears to have a basic type of
Fig. 13. Plan and sections of Tin Cup Mine.
rock on one and in places on both walls. The vein has been cut by a fault of about the same strike as the vein and displaced about 10 feet vertically (Fig. 13, cross section A-A'). The vein displays a marked tendency to pinch and swell and to show minor variations in direction of trend, indicated by variable degrees of curvature. Ore shoots may have a northerly plunge.

Character of the ore

The vein filling consists of quartz with sporadically distributed bunches of siderite and with small but variable amounts of pyrite, chalcopyrite, and exceptionally a little galena. The ore is rather thoroughly oxidized above the adit level but only partly so along the wins and on the lower level. The ore in places is notably rich in gold and that shipped has averaged 1.85 ounces per ton. The chalcopyrite is fairly abundant in some parts of the vein, but the copper content of the ore shipped has averaged only 0.8 percent copper, probably because most of the copper had been leached from the oxidized gold ore.

HINTZ

The Hintz property is about 4 miles below Yellowjacket on the steep slope north and about 800 feet above Yellowjacket Creek. The location was made and the property abandoned more than 50 years ago and then was rediscovered and relocated by Harry Hintz in 1939. The ownership passed to Lloyd McMann in 1947. The development comprises an adit about 35 feet long.

The mineralization is confined to a vein in hornblende-biotite diorite. The vein may be traced along the canyon wall in an easterly direction for about 65 feet. It dips steeply north to vertical, is as much as 6 feet wide, and is composed largely of quartz with a sprinkling of small grains of chalcopyrite. The vein is reported to contain appreciable amounts of silver but little gold.

HISEY (Ohio)

Location and development

The Ohio, owned and operated by Jack Hisey, is about three-fourths of a mile southwest of the Columbia on the steep south slope of a gulch tributary to and less than half a mile above Hoodoo Creek (Fig. 2). The property consists of several unpatented claims with present activity centered on the Ohio and on a mill site and camp on Hoodoo Creek.

The development comprises two short adits, one about 22 feet vertically above the other. These, as shown in figure 14, contain about 125 feet of workings. During 1951 a small dam was completed on Hoodoo Creek and a 5-ton mill installed to operate by water power.

Geologic features

The property is one of the few that is in the hornblende-biotite diorite, but it is near the margin of the diorite body and locally in the syenitic facies. The syenitic rock has been broken by faults of both pre- and post-ore age. The older faults strike N. 60° W. and N. 30° W. and dip 55° SW. and 60° SW. The younger faults strike N. 30° E. and dip 75° NW. There are also a few slips of N. 50° E. strike and 75° SE. dip, but these slips have no appreciable offsets.

The deposit is the vein type and is located along a fault of N. 60° W. strike and 55° SW. dip. The vein, partly filling and partly replacement, is 4 to 8 feet wide and may be traced in the upper adit and along the surface for about 70 feet (Fig. 14). It appears to split off or break up near the face of the upper adit, with bunches of quartz directed along minor fractures. The vein has a 4-foot offset, made by a fault that strikes N. 30° E. and dips 75° SW. (Fig. 14.)

The lower adit passes through the vein a short distance from the portal and then continues out in the hanging wall for some distance before it swings back to the vein. For some distance in the hanging wall the adit is along a fault of N. 30° W. strike and 60° SW. dip. The vein measures 7 feet across in the present face (Fig. 14).

The vein is composed of white, massive, coarse-grained quartz, locally stained by iron oxides. The gold is reported to have a somewhat spotty distribution but the owner hopes to maintain heads of 0.4 to 0.5 ounce of gold per ton.

BLACK EAGLE

Location and development

The Black Eagle mine is on the east fork of Hoodoo Creek in the northwest corner of the district (Fig. 2), more specifically on the slope west and a short distance above creek level at an altitude of about 7,450 feet. It is about 2½ miles air line and perhaps about 4 miles by road from the old town of Yellowjacket. Much of the road has grades too steep for cars without special low gear ratios.

The property comprises three patented claims and the development includes five
short and one rather long adit and several open cuts. All the adits except the lowest and longest are caved. The latter is dangerously accessible for about 100 feet.

History and production

The mine was located in the late nineties but little work was done until about 1905. A 5-stamp mill was erected at that time but was destroyed by fire in the mid-thirties. Work since 1908 has been carried on intermittently with perhaps the greatest activity in the early twenties. Twenty two tons of ore were shipped in 1922. This ore yielded 48 ounces of gold and 57 ounces of silver.

Geologic relations

The Black Eagle is in the Hoodoo quartzite and is along a broad zone of complexly fractured and sheeted rock. This zone trends about N. 65°E., directly across the strike of the quartzitic beds. The bedding of the quartzite has been almost completely obliterated along the fault zone, and the pronounced sheeting which accompanied the faulting has assumed the appearance of bedding. The beds actually strike N. 30°W. and locally dip 85°NE. The fracturing and sheeting also extends through a diabasic or gabbroic sill or dike (late Cretaceous or early Tertiary). The intrusive is exposed on the surface as well as underground, and may be traced up the slope in a northwesterly direction for several hundred feet.

The complexly fractured and sheeted zone is occupied by a narrow quartz vein which near the portal of the lower adit dips about 50°NW. The vein may be traced for some hundreds of feet by the line of cuts and caved adits, but is actually visible at the portal of the lower adit and in one of those farther along on the slope. Vein quartz on the dumps of the caved adits suggests its continuity below the surface. The vein is about 8 inches wide at the portal of the lower adit and about 24 inches wide at the other exposure. According to Umpleby14 the vein ranges from a mere stringer to 5 feet with an average width of about 6 inches.

Character of the ore

The vein filling is the white quartz characteristic of the district. Some of the quartz exposed on the dumps has scattered small limonitic cubes pseudomorphous after pyrite; but the siderite, pyrite, specularite, and calcite reported by Ross15 in the sheared and altered gabbro and the sparse and irregularly scattered grains of chalcopyrite and sphalerite reported by Umpleby16 were not observed in the material now remaining on the dumps. The ore is valued chiefly for its gold. The ore treated in the early twenties contained about 2 ounces of gold and 4 ounces of silver per ton. No lead and copper are reported.

PARKS

The property of Ernie Parks is in a steep-sided gulch directly across from the Black Eagle (Fig. 2). The property comprises several unpatented claims and a well-kept cabin occupied by the owner. The development includes a short adit on the steep northward-facing slope of the gulch and a large cut and some caved adits across on the other side. These workings are probably less than 200 yards from Hoodoo Creek.

As at the Black Eagle the country rock is the Hoodoo quartzite which has been broken by a few small faults of generally northwesterly trend. The beds have about the same strike and dip as those on the neighboring property.

The latest work has been confined to a short adit on the south side of the gulch. This adit has been driven along a bedding fault bordered by 4 inches of gouge and finely brecciated, somewhat iron-stained quartzite. This fault is joined by a second of N. 50°W. strike and 57°SW. dip. This ore contains about 6 inches of crushed rock. The objective of the adit appears to be a quartz vein 1 to 2 inches wide on the rocky slope about 20 feet above the portal. This narrow vein strikes N. 80°E., dips 55°NW., and may be traced about 10 feet before it pinches out. It is composed of more or less extensively honey-combed quartz from which pyrite has been leached.

The large cut across the gulch exposes a fairly prominent fault of apparent N. 80°W. strike and 45°NE. dip. The rock along the fault has been somewhat enriched in biotite, now largely altered to chlorite. Vein quartz was not observed in place but chunks of coarsely crystalline quartz up to 12 inches thick are piled on the dump and suggest the presence of bunches or lenses of quartz somewhere along the zone of fractured rock.

RED JACKET

The old Red Jacket mine is on and just

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Fig. 14. Plan and section of workings at Hissey Mine. Quartz vein (stippled) enclosed in Syenite.
Fig. 15. Geologic sketch map, underground workings at Copper Glance Mine.
below the crest of the high ridge that forms the local drainage divide between Yellowjack and Hoodoo Creeks about 1 1/4 miles northwest of the old town of Yellowjacket (Fig. 2). It is supposed to have been discovered about the same time as the Yellowjack but little work was done on it until the nineties and apparently little, if any, work has been done since. The property straddles the divide but the principal work has been on the southeast slope. The development comprises several caved adits and a number of cuts, particularly along and on the north side of the ridge. Judging from the size of the dumps, two of the adits must have been driven inward for several hundred feet.

The Red Jacket is in the Yellowjacket formation not far from the fault contact with the Hoodoo quartzite. The distribution of the adits and cuts suggests a northeast-erly-trending fracture zone. Some quartz and weathered sulfides remain on the dumps of the two lower adits and the size of some of the pieces of quartz suggest that the ore material came from bodies up to a foot or more thick. The sulfides are not plentiful and consist largely of chalcopyrite, in considerable part altered to chalcocite and copper-pitch ore. A little galena is also present. The pyrite and sphalerite reported by Unpleby 17 were not seen, but the long exposure to the weather may have brought about their removal. Secondary minerals also include malchite, formed apparently since the ore was mined.

LEAD STAR

Location and development

The Lead Star, which may now be known as the Ridge, is on the Yellowjacket slope a short distance north of the mouth of Slaughterhouse Gulch (Fig. 2). It is several hundred feet above the edge of the meadow occupied by Yellowjacket Creek and is reached by a road of good grade from the ranch at the lower end of the meadow.

The development comprises a lower adit at least 110 feet long with drifts of unknown lengths driven northwest 40 and 110 feet from the portal. These lower workings are connected with a glory hole at least 40 feet in diameter exposed higher on the slope. Above the glory hole are several caved adits, one directly over the other and generally no more than 10 feet apart vertically. Much of the work is old but some work has been car-

ried on in the lower adit since the end of World War 2 and some 21 tons of ore were shipped from 1946 to 1948. This shipment contained 3 ounces of gold, 802 ounces of silver, 500 pounds of copper, and 10,100 pounds of lead. The mine is now owned or operated by Frank Blades and Roy Fitz.

Geologic features

The Lead Star is along the southeastern edge of the Miocene porphyry belt. A granite-porphyry dike of considerable size cuts and a narrow vitrophyric dike lies along the zone of complexly fractured, finely micaceous quartzite beds of the Yellowjacket formation along which the mineralization has taken place. Where not too greatly disturbed by the fracturing, the beds of quartzite strike about N. 55° W. and dip 45° SW. The fracture zone cuts obliquely across the beds in a N. 70° W. direction and appears to dip about 70° NE. The direction and dip of the fracture zone also appears to be the direction and dip of the principal fractures.

The complexity of the fracturing is shown to good advantage in the glory hole. The zone of severely fractured rock is there more than 40 feet wide and the position of the adits on one side of the glory hole suggests that the fracturing may exceed 60 feet feet of the fractures dip southwest at angles of about 60°.

The black vitrophyric dike is also exposed in the glory hole. This dike is 3 to 4 feet wide, strikes in the direction of the fracture zone, and dips 60° SW. The granophyric dike is on the slope below the glory hole. It is exposed in the lower adit as well as on the surface. It is about 30 feet wide and apparently has been introduced in a N. 40°-50° W. direction across the ore zone. A drift 40 feet from the portal has been driven N. 60° W. along the footwall of the dike in highly altered and altered and somewhat mineralized quartzite. The drift is caved at 25 feet and prevents inspection of small stopes which seem to lie ahead. The main mineralization, however, appears to be in the hanging wall of the dike, where at 70 feet from the portal, a drift has also been driven northwest. The drift and stopes were so badly caved that they could not be entered. This work apparently connects with the glory hole. It is likely that the glory hole has developed largely by movement of the greatly shattered rock into the openings below where it was removed to the dump.

Character and occurrence of ore

The ore apparently has a spotty distribu-

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tion along the fracture zone, but much of the production is reported to have come from a short lenticular vein of massive sulfides about 8 inches wide in the hanging wall of the granophyric dike. Ore is also reported to occur as stringers and small irregular bunches in other parts of the fracture zone.

The ore lens was composed largely of galena, but material scattered on the dump shows a little chalcopyrite and patches of azurite and malachite, which probably denoted the occurrence of tetrahedrite. The presence of appreciable chalcopyrite and tetrahedrite is also suggested from the production figures, for the ore shipped contained 38 ounces of silver per ton, 1.2 percent copper, and 24 percent lead. The ore also carried 0.14 ounce of gold per ton. The only other mineral observed in addition to those already mentioned was a little specularite as thin seams in fractures in the quartzite bordering the glory hole.

COPPER GLANCE

The Copper Glance (Idaho) is near the head of Anderson Gulch almost on the divide separating Yellowjacket Creek from Trail Creek (Fig. 2). The only approach to the property is by trail from Anderson Gulch which joins Yellowjacket Creek directly across from the mouth of Slaughterhouse Gulch.

The property was founded in 1901 and for many years was owned and operated by J. E. and C. C. Anderson. It is now owned by H. J. Kurry and F. A. McCall. With change of owners the name of the property has apparently been changed to the Idaho.

The property has not been extensively developed and the work has been largely confined to two short drifts and several raises and stopes in a 305-foot adit (Fig. 15). Shipments of ore in 1929 and 1941 totalled 9 tons and contained 6 ounces of gold, 344 ounces of silver, 3,516 pounds of copper, and 1,171 pounds of lead.

The country rock is the Yellowjacket formation, which as shown in the adit (Fig. 15), is intruded by lamprophyric dikes. The quartzite rocks exposed in the mine workings are considerably fractured and the fractures appear to be components of a broad zone of disturbance whose trend, to judge from the claim boundaries, must have a general east-west direction. The fractures exposed underground are numerous but most of them are so small that individually they cannot be mapped. The more prominent fractures trend northeast. The lamprophyric dikes and the mineralized fractures also favor this direction (Fig. 15).

The body of mineralized rock exposed in the first drift strikes N. 55°E. and dips 70°NW. The one in the second drift strikes N. 5°E. and dips east at a low angle. The bodies range up to several feet wide but are apparently less than 30 feet long. The ore has a somewhat spotty distribution with much of it in scattered irregular masses and discontinuous lenses and stringers.

The ore occurs as a filling of fractures and as a replacement of the altered quartzite. It is composed largely of chalcopyrite accompanied by lesser amounts of tetrahedrite, pyrite, and galena. These are associated with and replace a quartz-siderite gangue. Some of the ore in the drifts is partly altered to chalcocite and copperpitch ore and that on the dump shows patches and films of malachite, azurite, and chrysocolla. The ore that was shipped contained 0.66 ounce of gold and 33.0 ounces of silver per ton, 19 percent copper, and 8 percent lead, all from carefully hand-sorted material.

A breccia zone near the face of the adit contains large bunches of quartz accompanied in places by a little siderite and chalcopyrite.

GOLD BUG

The Gold Bug is along the north side of Trail Creek across the ridge from the Copper Glance (Fig. 2). The most convenient approach is by trail from the mouth of Trail Creek. The property lies a short distance up the slope and has been developed by a series of short adits and one small shaft above the highest adit, but all adits are now caved. The property was located in 1902 by J. E. and C. C. Anderson but is now owned by Wayne Shull of Challis, Idaho.

This property is also located along a prominent fracture zone in the Yellowjacket formation. The zone is reported to be about 150 feet wide, and, if the aligned adits are an indication of trend, extends up the slope in a N. 5°E. direction. The zone cuts obliquely across the beds of the Yellowjacket formation, which near the portal of the lowest adit strike N. 8°W. and dip vertically. A young granophyric dike, elongated in a northeasterly direction (Fig. 2), cuts across the fracture zone.

The structural relationships appear to be quite complicated and in part rather obscure. Ross reports that in the lower adit

the closely spaced fractures trend in the direction of the zone and dip steeply west. At the shaft the most prominent fracture strikes N. 30°W. and dips 65°NE. This fracture has been offset by nearly flat slips.

The closely spaced fractures in the lower adit are reported filled with narrow veinlets of quartz and partly oxidized siderite and pyrite and to average about 0.4 ounce of gold per ton. Little is known of the mineralization at the shaft. The main fracture has a band of gossan 3 to 4 feet wide, probably formed by oxidation of siderite. Fragments of white quartz and numerous chunks of limonitic oxides are piled on the dump.

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Fig. 11. Plan of workings at Columbia Mine. (Closed workings shown by broken lines.)
Fig. 6. Geologic map parts of No. 2 and 3 level - Yellowjacket Mine. (Adapted from company map.)