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Geology of Upper Bear Gulch and Dry Boulder Creek Area Madison County, Montana

Norman King

GEOLOGY OF
UPPER BEAR GULCH AND DRY BOULDER CREEK AREA
MADISON COUNTY, MONTANA

by
NORMAN KING

A Thesis
Submitted to the Department of Geology
in partial fulfillment of the
Requirements for the degree of
Bachelor of Science in Geological Engineering

MONTANA SCHOOL OF MINES
BUTTE, MONTANA
April, 1948

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GEOLOGY OF

UPPER BEAR GULCH AND DRY BOULDER CREEK AREA

MADISON COUNTY, MONTANA

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INTRODUCTION

Potential gold mines lie high among the rugged peaks of the Tobacco Root Mountains of southwestern Montana. This is a region where little geologic work has been done, though extensive mine operations have been carried on, and valuable ore has been shipped. Practically nothing concerning the details of the geology of this region can be found in published reports. An area at the heads of Bear Gulch and Dry Boulder creek was chosen by the writer for study, and this report on the area is presented as a thesis for the Department of Geology at Montana School of Mines.

A total of 26 days were spent in the field mapping the area and the Bielenberg and Higgons mine. Work was completed in July 1947 because of favorable weather during that month, however, much time was lost because of flash showers and persisting snow drifts. Due to impassable roads, the region was inaccessible by truck, and the equipment and supplies were packed in for the last two miles.

Although the area, which is a part of the Tidal Wave Mining District, has never been mapped in detail, work of a reconnaissance nature was done by Tansley, Schafer, and Hart; and a general description of the geology and mines of the area is given in their publication, "A Geological Reconnaissance of the Tobacco Root Mountains, Madison County, Montana," Montana Bureau of Mines and Geology, Memoir No. 9, 1933.

Location and Accessibility

The Upper Bear Gulch and Dry Boulder Creek area lies on the west slope of the Tobacco Root Mountains in Madison County, Montana, 33 miles southeast of Butte, and 16 miles south of Whitehall. Hellroaring Canyon lies to the north, and Dry Gulch lies to the south. The area is 6,000 feet wide and 7,000 feet long, covering nearly two square miles. The general location is shown on the index map on Plate VII.

The old Vigilante Trail, now U. S. Highway No. 41, lies about nine miles to the west of the area and passes through the towns of Silver Star and Twin Bridges. Dry Boulder Creek may be reached by a secondary dirt road branching from Highway No. 41 at Silver Star. However, since 1941 there has been little activity in the area, and the road is in very poor condition. Bear Gulch is readily accessible by a county road branching off of the Vigilante Trail at Twin Bridges.

The Alder branch of the Northern Pacific Railroad parallels Highway No. 41, and passes through both Silver Star and Twin Bridges. In the past practically all of the ore shipped from the Tidal Wave Mining District for refining or concentration passed over this line. About fifteen miles to the north, the Chicago, Milwaukee, St. Paul, and Pacific Railroad and the Northern Pacific Railroad pass through Jefferson Valley.

Acknowledgments

The author wishes to express appreciation to Dr. E. S. Perry, head of the Geology Department of the Montana School of Mines, for his valuable assistance in outlining details of field mapping, map construction, and thesis form. Also the author wishes to thank his two brothers, Edward and George King, who gave generously of their time and efforts in assisting with the field work.

RELIEF AND DRAINAGE

The area is characterized by extreme relief with elevations ranging from 8,000 to over 10,000 feet. Upper Bear Gulch valley has a total fall of 2,000 feet in 3 miles or nearly 700 feet to the mile. Steep ridges and cliffs have been formed at the heads of the canyons by valley glaciers and swift cataracting streams. Erosion is greatest in the spring when large volumes of water are supplied by melting snow and ice. All of the streams from this area flow westward to Jefferson River which joins with Madison and Gallatin Rivers at Three Forks to form Missouri River. In turn Missouri River flows into Mississippi River and finally to the

PLATE I

PHOTOGRAPHS OF DRY BOULDER CREEK
AREA

A. Ridge between Dry Boulder Creek and Upper Bear Gulch. This ridge forms the west wall of the cirque in the Dry boulder Creek area, and is about 1,000 feet high. Faulted segments of veins may be seen on the mountain side. Picture taken in July, 1947.

B. Ridge to the east of Dry Boulder Creek forming the east wall of the cirque. This ridge is over 1,000 feet high and is somewhat steeper than that shown in A. Picture taken in June, 1947.

C. Head of the cirque. This picture was taken looking south over Lower Boulder Lake. Photographed in July, 1947.

PLATE I

A

B

C

PHOTOGRAPHS OF DRY BOULDER CREEK AREA

PLATE II

PHOTOGRAPHS OF UPPER BEAR GULCH

A. Upper Bear Gulch, looking east from Smelter Hill. The 250 ton flotation mill and B & H group of claims lies in the center. Note cirque in background. (Reprinted from Geology of the Tidal Wave Mining District, by M. L. Reyner).

B. Bielenberg and Higgons mine at the head of the cirque shown in A. Talus near the mine is gneiss and monzonite. Note small mine cars standing on the dump near the adit entrance.

C. Closeup view of timber along the valley floor. Trees average about 10 inches in diameter and are 30 to 40 feet high. They form excellent material for building cabins and for mine timber.

PLATE II

A

B

C

PHOTOGRAPHS OF UPPER BEAR GULCH

Gulf of Mexico.

Though the district is classified as semi-arid with annual precipitation averaging about 20 inches, patches of snow remain in shaded areas until late July because of high elevations. Temperatures range from a maximum of about 90°F to a minimum of about minus 45°F. The valley floors and lower slopes are covered with a thick secondary growth of Lodge Pole pine containing minor amounts of Douglas fir, spruce, and cedar. The high slopes are covered only with sagebrush and bunch grass and the timber line is at an elevation of about 10,000 feet. Very little of the area is suitable for grazing cattle and cultivation is not possible. Timber suitable for all mine operations is present in the lower slopes of the mountain, and some timber in this general area has been sawed into boards and hauled to the main valley.

HISTORY OF MINING

The Tobacco Root Mountains were invaded by numerous prospectors spreading out from California in the early sixties. At this time ores were valued for their free gold content only, yet several rich strikes were made in this district as early as 1864. These were followed by the development of several small mines giving only a small total production. Activity boomed in the twenty year period from 1880 to 1900, and prospectors were present in every canyon.

Since 1900 lode mining has been intermittant, and carried on only by owners or lessees on a small scale. The only commercial ores mined in this area came from the Pete and Joe claims, the Pollinger claims, and the Bielenberg and Higgins claims. Ores from the first two properties were shipped to smelters for concentration; ores of the latter were concentrated at the mine in the B & H mill which was constructed in 1916. Operation of the mill was discontinued in 1918, but intermittent operations were carried on in the interval between 1934 to 1942 when the government closed all gold properties.

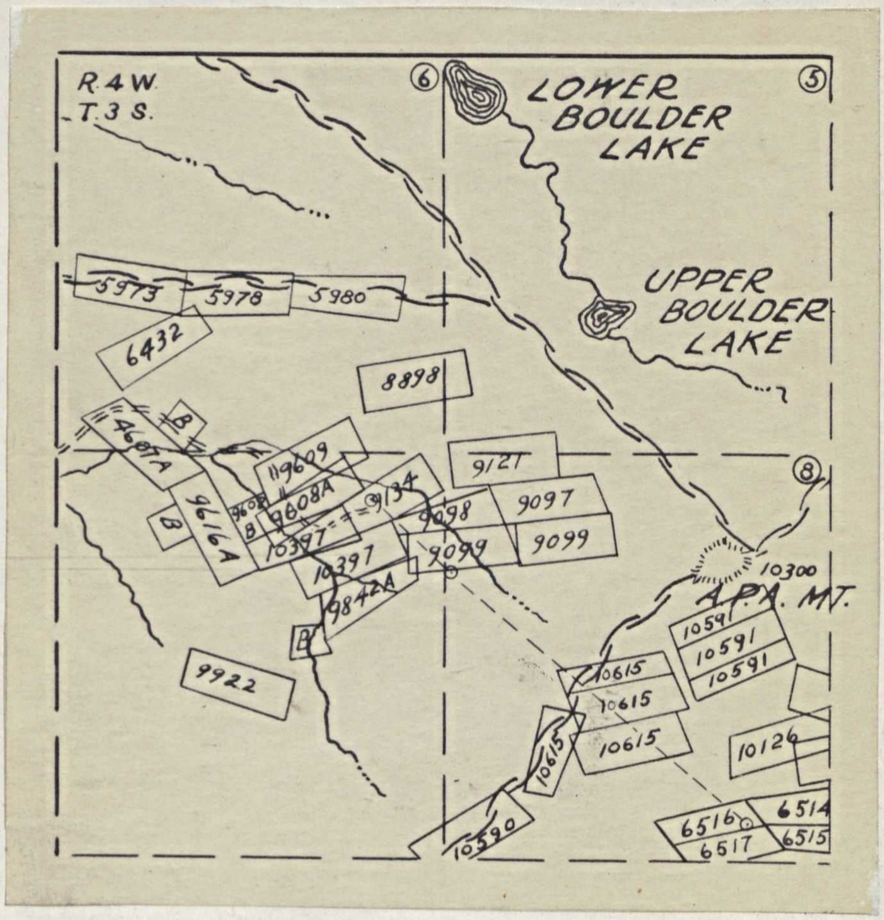


Figure 1--Patented claims in the Upper Bear Gulch and Dry Boulder Creek area.

The more important claims in the area are the Pritchett, Royal Bear, Aurora, Peter, Blue Jay, Jay Gould, Isabella, Lakeside, Josephine, Pete and Joe group, and Bielenberg and Higgins group. Patented claims are shown in Figure 1. The history of this district is a story of the romance of mining sprinkled with the remembrance of such men as Art Pollinger, John Holmes, Skinny Stencil, Bielenberg, Higgins, and Pritchett.

REGIONAL GEOLOGY

In general the Tobacco Root Mountains are a part of a large structural elongated dome with superimposed synclines and anticlines. Large bodies of igneous material intruding pre-Cambrian gneisses and Paleozoic sediments are exposed on ridges and in deeply eroded canyons, and it is likely that there is a genetic relationship between the batholithic magma and the structurally weak dome.(Reference No. 1, pp 20)

The gneisses and schists of the region are so complexly folded and faulted that their correct correlation is in doubt. It is generally accepted that they are part of the Pony series. However, Alexander N. Winchell (Ref. No. 2 pp 145) states that the presence of interbedded quartzites and limestones identifies them as Cherry Creek, and thus he assigns them to the Algonkian. Within the mapped area no limestones or quartzites were observed, and the writer prefers the name Pony series in describing these rocks.

Folded and faulted Paleozoic limestones, quartzites, and shales are exposed on the western flank of the dome two miles west of the mapped area, and they are intruded locally by igneous rocks. The present structure of the mountains and the Jefferson valley is believed to be related to a major normal fault paralleling the mountain front under alluvium. The valley may be largely a result of the down-dropped block.

Because of intense folding and faulting much of the early geologic history of the Tobacco Root Mountains is obscure. The Pony group, whether originally sedimentary or igneous rocks, was intensely metamorphosed in pre-Cambrian time and folded and intruded by igneous rocks of both acidic and basic composition. This was followed by depression beneath a sea, and the sedimentary detritus and limy muds of the Cherry Creek were laid down. Renewed uplift followed, and with it subsequent erosion. The land was again depressed to the westward, and Belt sediments were deposited. However, an eastern shore line to Belt deposition is believed to have been present between the area under discussion and Whitehall, because of the presence of a boulder Belt conglomerate near Whitehall and the absence of Belt strata between the gneisses and the Cambrian 10 miles south of Whitehall.

Paleozoic and Mexozoic rocks were laid down on a pre-Cambrian erosion surface in oscillating seas which produced local variations in thickness and lithology of strata.

During late Mesozoic time there was renewed orogenic activity and great thicknesses of lava flows, agglomerates, tuffs, andesites, and basalts were deposited conformly upon local Mesozoic sediments. Continued uplift, folding, and faulting elevated the region several thousand feet above sea level. The intrusion of numerous igneous bodies, including the Tobacco Root batholith and the Boulder batholith, occurred at the close of Cretaceous or in early Eocene time. Glaciation and rejuvenated streams have deposited large alluvial fans and glacial drift producing the present topography.

UPPER BEAR GULCH AND DRY BOULDER CREEK AREA

Rock Types

The most common and wide spread rocks in the area are complexly folded light-grey feldspar gneisses which grade into dark hornblend gneisses to the east. Numerous outcrops of acidic igneous rocks are exposed in Upper Bear Gulch with a few small outcrops of pegmatites in Dry Boulder Gulch. Quaternary allumium and glacial drift is restricted to the lower portions of the valley floors.

Metamorphic Rocks

Feldspar and Hornblend Gneisses

All gneisses in the area are believed to be of the Pony series, and they form the basal complex. Individual bands of gneiss differ greatly in thickness ranging from a fraction of an inch up to several feet. Strike of bands changes from N 30° E in Upper Bear Gulch to N 60° E in Dry Boulder Creek. The gneiss is hard and resistant to erosion, and cliffs several hundred to a thousand feet high form in areas adjoining glacial cirques. Mountain sides and the base of cliffs are covered with thick gneiss talus which obscures rock in place over extensive areas. (See Plate 1, C) Talus ranges in color from light grey to dark green.

The gneissic texture, observed in thin section, shows alignment of biotite plates and elongated feldspar crystals. A quantitative mineralogic determination on a sample of feldspar gneiss and a sample of hornblend gneiss is given in Table 1, and the type and compositional formula of the plagioclase is given in table 2. Several small crystals of microcline occur in both samples, and minor amounts of apatite are present in the feldspar gneiss.

A quantitative mineralogic determination of gneisses of this area is of no immediate value except that it may illistrate the differences in composition between the two extremes of varieties. Samples of any intermediate composition may be collected within a distance of perhaps a hundred yards. Photomicrographs of feldspar and hornblend gneisses are shown on Plate IV.

Garnet Gneiss

Passing through the ridge between the two glacial cirques, and lying immediately south of Lower Boulder Lake, is a large steeply dipping body of garnet-actinolite gneiss. The dip and strike of the gneissic banding is at variance with feldspar gneiss on either side. It is difficult to explain the presence of a large body fully 700 feet thick by calling it a pre-Cambrian dike which has been metamorphosed after intrusion. The writer prefers to believe that the block has been faulted into its present position, and because of the complex structure and presence of slide rock and talus, the fault is now obscure.

Bands in this garnet gneiss strike N 40° E and dip 58° northwest forming an angle of about 60° with the adjoining bands of feldspar and hornblend gneisses. Rock at the contact grades from a normal gneiss to one containing garnet crystals about one-fourth inch in diameter, and finally it grades to dense fine-grained garnet and actinolite gneiss having an average specific gravity of about 3.69. The ordinary feldspar gneiss has aspecific gravity of 2.67.

In order to determine the variety of garnet and to positively identify the actinolite, indicies of refraction of the minerals were determined. For the garnet grains n equals 1.780 and n is greater than 1.800. It was not possible to determine the upper limit since oils of greater index of refraction than 1,800 are not available. Nevertheless this serves to identify the garnet as alamandite, a member of the subgroup called pyralspite by Winchell. The actinolite was easily recognized by its prismatic cleavage and extinction angle of 11°. The indicies of refraction are 1.600 and 1.650 respectively, and cleavage fragments are pale green in color showing faint pleochroism.

Schists

The only schist found in the area was observed in an adit in upper Bear Gulch on the contact between a pegmatite dike and the gneiss countryrock. It is a band of biotite-chlorite schist about six inches thick which strikes N 48° E and dips 85° southeast. Because of the lack of fault guage, the writer believes the schist is a result of intense alt-

PLATE III

PHOTOGRAPHS OF GNEISSIC ROCKS

A. Glacial till composed almost entirely of gneiss. The large boulder in the background weighs many tons and is banded feldspar gneiss.

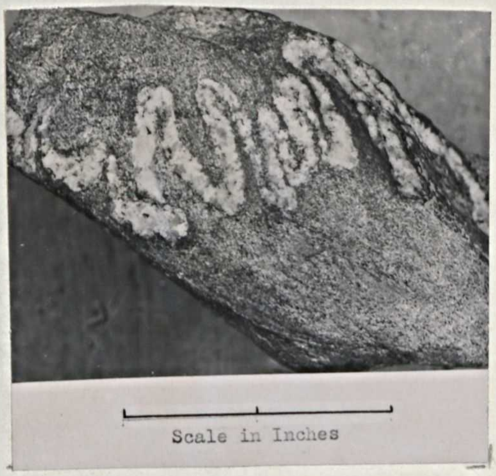
B. Ptygmatic folding in a hornblend gneiss which indicates folding while the rock was soft or in a semi-molten state.

C. Side view of gneiss in B.

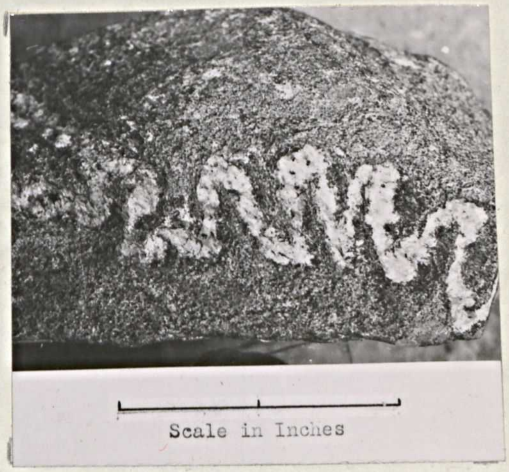
D. Feldspar-hornblend gneiss with bands probably deformed by a small drag fold.

E. Garnet-actinolite gneiss. Sample is dark red in color, dense, heavy, and fine grained.

A



B



C

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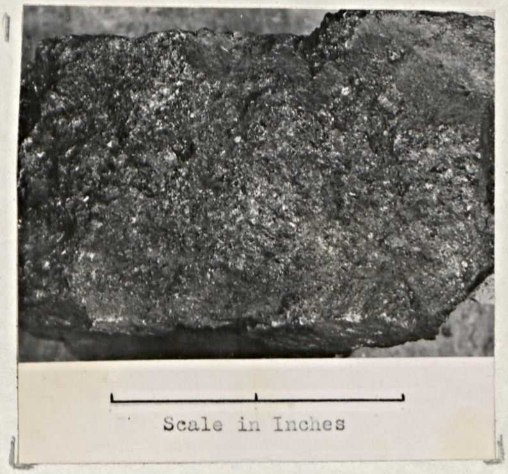


E

PHOTOGRAPHS OF GNEISSIC ROCKS

PLATE IV

PHOTOMICROGRAPHS OF GNEISSES

A. Orientation of biotite plates in a feldspar gneiss. (x 24) plane polarized light.

B. Orientation of feldspar crystals in feldspar gneiss. Dark patches are feldspar crystals in extinction. (x 24) Crossed-nicols.

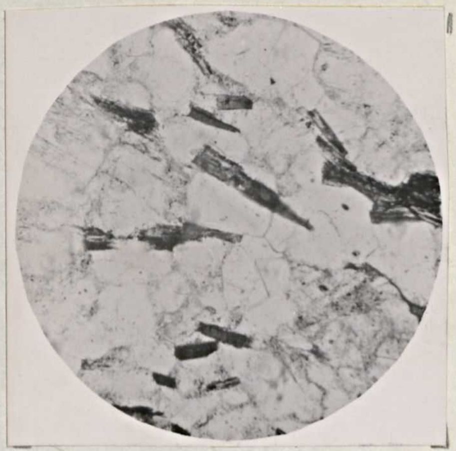
C. Microcline showing polysynthetic twinning among feldspar crystals in a feldspar gneiss. (x 24) Crossed-nicols.

D. A light-colored band in a hornblende gneiss. White patches are quartz and grey patches are feldspar crystals. (x 24) Crossed-nicols.

E. Hornblende gneiss with a grain of plagioclase showing albite twinning. (x 24) Crossed-nicols.

F. Quartz-feldspar band in a hornblende gneiss. (x 24) Plane polarized light.

PLATE IV



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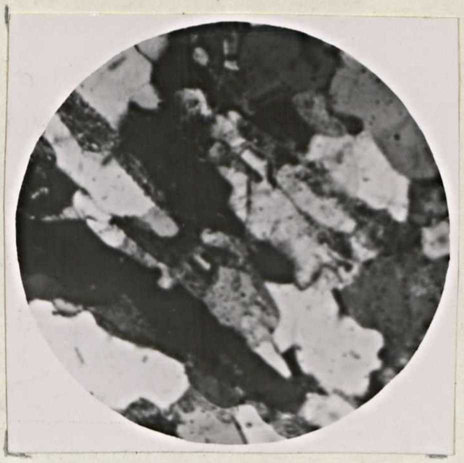


B

C

D

E

F

PHOTOMICROGRAPHS OF GNEISSES

Igneous Rocks

All igneous rocks in the area are of acidic composition ranging from granites to monzonites. Thin sections were made of the various types, and their quantitative mineralogic composition was determined with the aid of a micrometer stage. From this data and the texture, rocks were classified according to Johannsen. (Reference No. 3, pp 146-156)

It is reasonable to expect that all igneous rocks in the area are related to one magmatic reservoir. This is well substantiated by the similarity of minerals and mineral associations in the different outcrops. The composition of the plagioclase is remarkable uniform in the various rock types, ranging from sodic andesine with a composition $Ab_{69}Ab_{31}$ to calcic oligoclase with a composition $Ab_{73}An_{27}$. It is of interest to note that the range in composition of the plagioclase in the igneous rocks is identical to the range in the metamorphic rocks.

The biotite in both granite and monzonite is characterized by strong pleiochroism with an absorption formula X Y Z where X is light tan and Z is dark brown. Hornblend crystals in both rock types show good cleavage, and have an absorption scheme X Y Z where X is pale green and Z is dark green. Apatite occurs as minute six-sided prismatic crystals, and is closely associated with magnetite and biotite. Photomicrographs of thin sections of igneous rocks are shown on Plates V and VI.

Granite

A relatively large circular outcrop of granite about 800 feet across is exposed 300 feet northwest of the Bielenberg and Higgons mill. Because of its greater hardness and resistance to erosion, the contact between the granite and the gneiss countryrock is sharp, and the granite surface stands above the gneiss 20 to 40 feet. Near the contact dark-grey xenoliths may be found. According to Winchell (Ref. No 2, pp 150), "Both from their composition and mode of occurrence, it seems probable that these spots in the granite are not differentiation products, but represent the incompletely absorbed fragments of the country rock." The writer agrees with Winchell because of the occurrence of these spots only along the contact.

The granite is porphyritic with phenocrysts of pink orthoclase up to an inch in length set in a matrix of coarse quartz, feldspar, and biotite. In thin section the rock shows little to no alteration, and excellent feldspar twinning is present. The composition of the plagioclase was determined from albite twinning, and results were checked by using combined albite-carlsbad twins. The variety and compositional formula of the plagioclase is given in Table 2, and a quantitative mineralogic determination on the rock is given in Table 1.

Monzonite

A large monzonite cupola which may be an outlier of the

Tobacco Root Batholith is exposed in upper Bear Gulch. The irregular roof of the intrusive body is well shown in the extensive exposures which form a steep cliff at the head of the glacial cirque. Roof pendants of gneiss extend into the monzonite, andincompletely absorbed fragments may be found along the contact.

As seen in thin section, the monzonite is a medium grained rock with very little alteration, with no visable flow structure, and with numerous elongated prismatic crystals of hornblend haphazardly orientated. The mineralogic composition is given in Table 1, andthe variety and compositional formula of the plagioclase is given in Table 2.

Granodiorite

Several small bodies of granodiorite are exposed along the valley floor by glacial erosion. The largest outcrop underlies the B & H mill, and extends about 900 feet to the northeast. Like other igneous rocks in the area, contacts are sharp, and they dip steeply into surrounding gneiss talus. Adjoining the granodiorite to the northwest is the large granite outcrop previously discussed.

Three other outcrops of granodiorite lie near the head of the gulch, and differ from that at the B & H mill only in size. They are roughly circular in outline and range from 100 to 300 feet in diameter with an average relief of 10 to 15 feet. Megascopically the granodiorite is similar to the monzonite in texture, but it contains considerably less horn-

PLATE V

PHOTOMICROGRAPHS OF IGNEOUS ROCKS

A. Prismatic crystals of apatite associated with magnetite and biotite. (x 30) Crossed-nicols.

B. Micropegmatitic structure of quartz and orthoclase in a granodiorite. (x 24) Crossed-nicols.

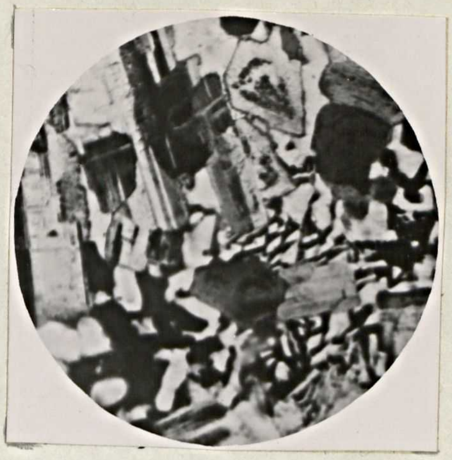
C. Association of biotite (B), hornblend (H), magnetite (M), and apatite (A). (x 24) Plane polarized light.

D. Same view as C under crossed-nicols.

E. Plagioclase and orthoclase altering to sericite and clay minerals. (x 24) Crossed-nicols.

F. Albite twinning in plagioclase. Plagioclase is calcic oligoclase with composition $Ab_{72}An_{28}$. (x 24) Crossed-nicols.

A



B

C

D

E

F

PHOTOMICROGRAPHS OF IGNEOUS ROCKS

PLATE VI

PHOTOMICROGRAPHS OF IGNEOUS ROCKS

A. Hornblende crystal in monzonite showing 56° and 124° cleavage. (x 24) plane polarized light.

B. Orthoclase crystal in granodiorite showing minute cracks formed by alteration. (x 24) Crossed-nicols.

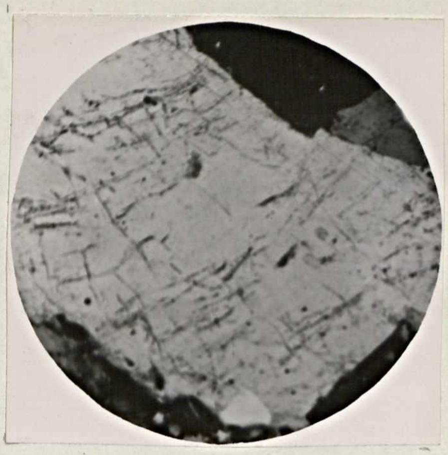
C. Hornblend carlsbad twin in granite associated with altered feldspar. (x 24) Plane polarized light.

D. Same view as C under crossed-nicols. (x 24)

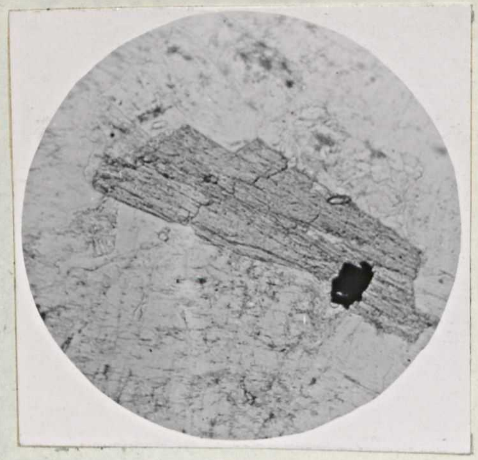
E. Hornglend crystals in granodiorite with inclusions of quartz and magnetite. (x 24) Plane polarized light.

F. Microcline in granodiorite showing polysynthetic twinning or "gridiron" structure. (x 24) Crossed-nicols.

A



B



C

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F

PHOTOMICROGRAPHS OF IGNEOUS ROCKS

blend. In this section the feldspars are partially altered to kaolinite, sericite, and other clay minerals. The quantitative mineralogic compositiion of the rock is given in Table 1, and the variety and compositional formula of the plagioclase is given in Table 2.

Pegmatites

Outcrops of pegmatites are not limited to any one area either horizontally or vertically, and they occur in the low-lying cirques as well as on the ridge between upper Bear Gulch and Dry Boulder Creek at elevations of 1,000 to 1,500 feet above the valley floor. They differ greatly in size and, shape but in general are less than 100 feet wide, and are roughly elliptical. To call these pegmatite outcrops, dikes, is a misnomer since the length is rarely more than two or three times the width. Unlike the other igneous, pegmatite outcrops have a low relief, and are dome shaped in profile. Probably a horizontal and vertical cross-section of such a body would be similar. They are composed of graphic intergrowths of feldspar and quartz with monor amounts of biotite. Muscovite is not uncommon, and plates an inch across were found.

Aplite

A small body of aplite crops out on the hillside about 2,200 feet northeast of the B & H mill. It is irregular in outline, and contacts are obscured by gneiss talus. The

Mineral	Granite	Monzonite	Granodiorite (1)	(2)	Feldspar Gneiss	Hornblend Gneiss
Quartz	10.2%	2.2%	13.0%	10.5%	19.8%	4.4%
Orthoclase	49.6	36.2	22.6	23.2	59.2	13.6
Plagioclase	25.5	32.6	48.4	45.3	13.6	3.5
Hornblende	---	24.0	6.8	12.2	4.3	78.5
Biotite	3.6	0.1	3.4	2.7	4.8	---
Magnetite	4.6	2.2	2.9	3.6	---	---
Apatite	2.1	2.4	2.9	2.5	---	---

Table 1. Results of quantitative mineral determinations of igneous and metamorphic rocks (in percent.)

	Granite	Monzonite	Granodiorite (1)	(2)	Feldspar Gneiss	Hornblend Gneiss
Type of Plagioclase	Oligoclase	Andesine	Oligoclase		Andesine	Oligoclase
Compositional Formula	$Ab_{73}An_{27}$	$Ab_{69}An_{31}$	Ab_{72} An_{28}	Ab_{70} An_{30}	$Ab_{68}An_{32}$	$Ab_{73}An_{27}$
Degree of Alteration	Fresh	Slight	Slight	Slight	Fresh	Fresh

Table 2. Variety, compositional formula, and degree of alteration of plagioclase in igneous and metamorphic rocks.

rock is very fine grained with black specks of biotite giving it a "salt and Pepper" appearance. Quartz and feldspar are in the ratio of about one to ten.

Glacial Drift and Alluvium

Alluvium in both upper Bear Gulch and dry Boulder Creek is restricted to a thin narrow venier along creeks on the valley floor, and is selfom over five feet thick. Cataracting streams on the floor of the cirques expose about 10 feet of glacial debris which consists of angular boulders very uniform in composition and free from sand. Because of the angularity of the material, it is likely that it is essentially slide rock carried on top of the glacier to the present location. The maximum extent of the valley glacier was about a mile above the mouth of Bear Gulch where over a hundred feet of angular terminal moraine was deposited. Recessional moraines that cover the valley floor between the cirque and the terminal moraine are also angular and well sorted. A marked contrast exists between the wide, U-shaped, glaciated upper parts of the valleys, and the narrow, V-shaped lower parts of the valleys.

Geologic Structure

It is believed that the Archean gneisses of the Tobacco Root Mountains have been subjected to at least two periods of folding previous to Laramide orogeny. The early orogeny developed a most intense deep-seated type of regional metamorphism which was practically completed in pre-Cambrian time. Complex structures formed by regional metamorphism and repeated folding and faulting have never been worked out in detail. It is reasonable to assume that structures present in Upper Bear Gulch and Dry Boulder Creek are local in nature, but directly related to the regional structure.

In general the area occupies the crest of a large gently plunging anticlinal fold whose axis strikes N 55° E. A large cliff to the west of Dry Boulder Creek exposes the gneisses and facilitates observation of excellent strikes and dips on individual bands. Bands range in strike from N 62° E in the northern portion of the area to N 30° E in the southern portion with dips changing from 29° north to 38° south. Locally the bands are extremely irregular, and can be followed only with great difficulty, and for short distances. Examples of minute folding or crumpling are shown in Plate III, B, C, and D.

Two systems of faults are present in the district. One system strikes about northeast almost parallel to the strike of the gneiss bands, and dips steeply to the northwest. Movements along these faults are obscure because of the complicated folding of the gneiss and also because of similarity of the gneissic bands, however, it appears to be less than 10 feet. At least four of these faults contain auroriferous pyrite and quartz.

The second system of faulting strikes almost due east and dips average about 80° to the south. Northeast faults are offset as much as 10 feet to the left by the east-west faults, indicating an earlier age relationship. Later mineralization of this east-west system has produced at least six fissure veins containing sulfide ores. Numerous small faults are visable about 1,000 feet west of Lower Boulder Lake, and seem to have no regular pattern. They probably represent late adjustments in stresses along shear planes roughly parallel to the banding. Several of the igneous outcrops show jointing, but since no definite structural pattern seems to exist, they are probably formed by weathering.

Ecenomic Considerations

Placer gold was discovered along stream beds in Dry Boulder Gulch and Bear Gulch as early as 1864. Claims soon covered all vein outcrops, and enriched surface zones were mined for their gold and silver content. Sulfide ores were not encountered until actual mining operations began. Although the district is well known for rich ore shoots or "pockets" of auroriferous pyrite and silver, no previous attempt has been made to correlate the veins into a definite system.

Vein System

Veins of the district were formed by mineralized solutions asscending through channelways resulting from the faulting described in Structural Geology. Therefore, the vein system of the area is similar to the fault system. Since northeast veins are offset to the left by east-west veins, it is obvious that either the northeast veins are earlier than the east-west veins, or the veins are of approximately the same age, but later strike faulting along the east-west veins has displaced the northeast veins. The writer believes that there has been two different periods of mineralization because of the difference in vein minerals. East-west veins contain sulfides of lead, zinc, and copper while northeast veins contain auroriferous pyrite and silver. Also, the presence of slickensides and fault gauge along the east-west veins indicate movement after mineralization.

Alteration of the country rock along the vein contacts is hardly noticeable in either system. A thin section made from monzonite taken about one foot from an east-west vein in the Bielenberg and Higgins mine shows only slight alteration of the feldspars. Contacts along veins in gneiss are also sharp with less than two inches gradational zone between ore and banded feldspar gneiss.

Mineralogy

Northeast veins contain thin stringers of massive pyrite in quartz gangue. Gold is associated with the pyrite and is not visable in hand specimens. A sample of ore gives a fractured appearance with pyrite filling small veinlets in bull quartz. With gold selling at $36.00 an ounce, rock of this type ranges in value from $20.00 per ton along the greater length of the veins to over $500.00 per ton in some small local ore shoots. (See Plate VIII, A)

East-west veins contain galena, sphalerite, chalcopyrite, and pyrite in quartz, calcite, and siderite gangue. Gold is associated with the sulfides and contains the major value of the ore. A polished surface of this ore shows small blebs of chalcopyrite in sphalerite indicating exsolution. Galena is easily identified color and relative hardness and by triangular pits. Photomicrographs of polished surfaces of the ore minerals are shown on Plate VIII, C, D, and E.

PLATE VIII

PHOTOGRAPHS OF SULFIDE ORES

A. Sample of auroriferous pyrite in "bull" quartz showing fractured appearance.

B. Radiating crystal of molybdenite lying in "bull" quartz. (x 4)

C. Polished surface of galena showing triangular pits. (x 30)

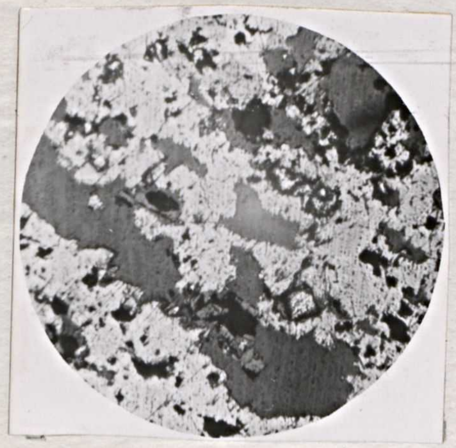
D. Sphalerite (S) in quartz (Q) as shown on a polished surface. Small grains of chalcopyrite occur in the sphalerite. (x 30)

E. Same view as D but enlarged to 45 diameters. Light spots of chalcopyrite are visable in the dark grey sphalerite. (x 45)

A

B

C



D

E

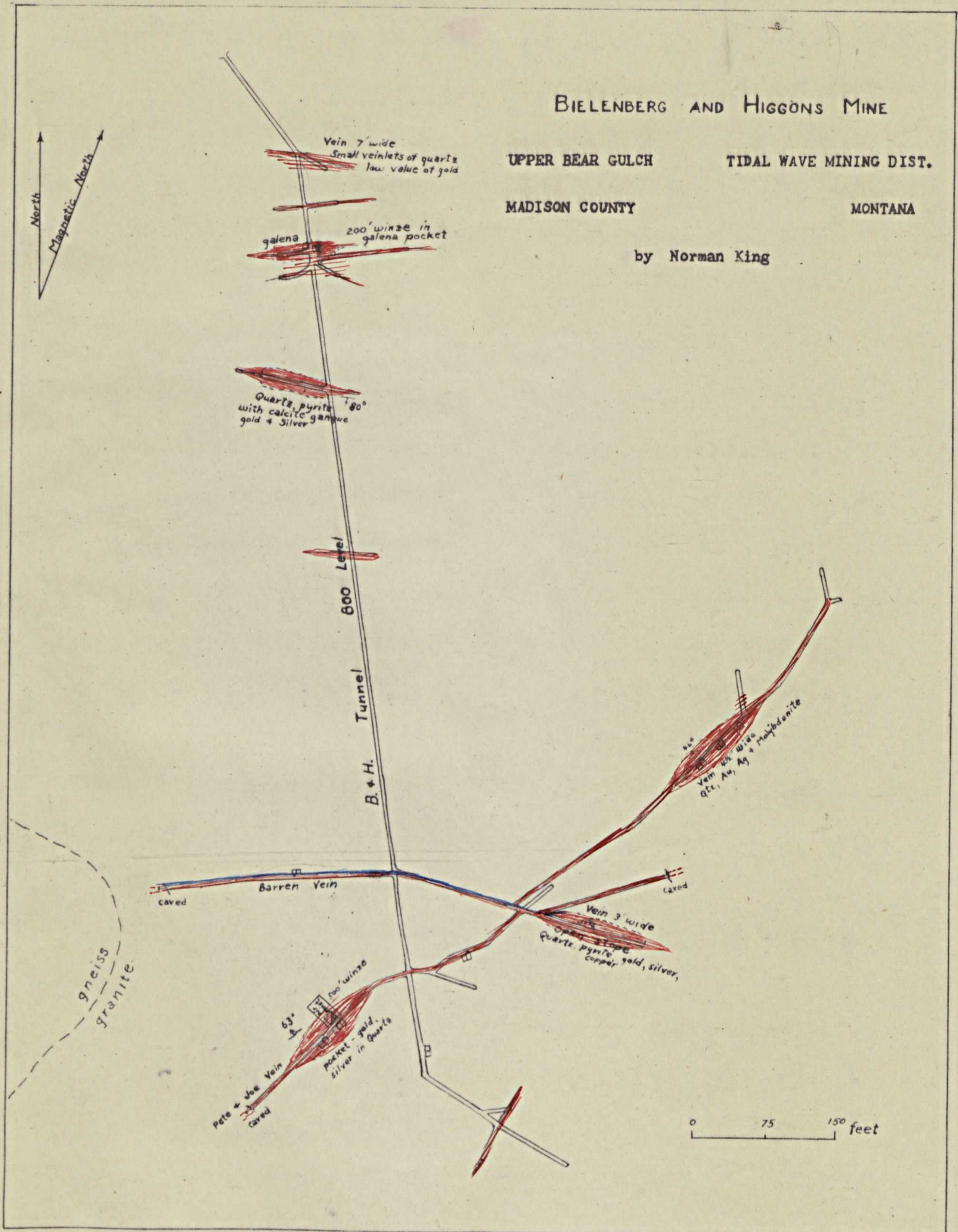
PHOTOGRAPHS OF SULFIDE ORES

Thin stringers of quartz, containing small clusters of molybdenite crystals, intersect both vein systems. These stringers indicate high temperature conditions, however, the molybdenite has no present economical importance. A broken crystal of molybdenite lying in "bull" quartz is shown in Plate VIII, B.

Bielenberg and Higgins Mine

The Bielenberg and Higgins mine (now operated by the Insperation Gold Mining Company) is in a small monzonite stock exposed at the head of upper Bear Gulch. Its 4,000 odd feet of workings expose five east-west veins and two northeast veins. A strong mineralized zone consisting of thin stringers of pyrite and quartz near the portal of the adit has yielded some ore, and holds potential promise with future development. The Pete and Joe vein which contains two ore shoots has been the large high-grade producer, and a 500 foot winze sunk on this vein about 75 feet west of the main adit in one of the ore shoots exposes strong ore to that depth. However, because of hoisting costs and large volumes of water, mining operations were suspended. In order to develope and mine this ore, an adit was started near the B & H mill at an elevation of approximately 500 feet below the mine level. By 1933 this "tunnel" was extended a total of 1,000 feet towards the downward projection of the winze, and about one thousand feet of advance remained. Little work has been completed in the adit since

PLATE IX


BIELENBERG AND HIGGONS MINE
UPPER BEAR GULCH
TIDAL WAVE MINING DIST.
MADISON COUNTY
MONTANA
by Norman King
North
Magnetic North
Vein 7' wide
Small veinlets of quartz
low value of gold
galena
200' winze in galena pocket
Quartz, pyrite 80°
with calcite gangue
gold + Silver
B. + H. Tunnel 800 Level
Barren Vein
caved
caved
Vein 3' wide
Open Stope
Quartz, pyrite, gold, silver, copper
Vein 4½' wide
Qtz, Au, Ag + Molybdenite
gneiss
granite
63°
200' winze
pocket - gold, silver in Quartz
Pete + Joe Vein
caved
0
75
150
feet

this time, but it is reported that the property will be reopened in the spring of 1948.

The monzonite country-rock is extremely hard and firm, and drift timber is not necessary. An occassional stull is used in the open stopes, and also manways, chutes, and the winze are timbered. The mine is in excellent condition and could be reopened with a minimum of labor and capitol.

Prospects

Many prospects dot the hillsides, but no other large mines exist in the area mapped. The most important of these prospects is the Art Pollinger group, now controlled by the Madison Mining Company. The vein on the property has never been followed because of fault complications and rugged topography; but results of field mapping, and similarity of mineralization, suggest that this vein may be a continuation of the Pete and Joe vein which is present on the Bielenberg and Higgins claims. Sorted ore shipped from this property yielded well over $100.00 a ton, but reserves are limited to small operations.

Other prospects are noted mostly for their strongly enriched surface zones. One shipment of 150 tons of ore from the surface of the Isabella claim in upper Bear Gulch yielded a little over $40,000.00. Ore below the enriched surface zones of prospects can be mentioned, but they are in general similar to those already discussed.

SUMMARY

Numerous outcrops of acidic igneous rocks occur among the pre-Cambrian gneisses of upper Bear Gulch and Dry Boulder Creek. Associated with and perhaps genetically related to these igneous bodies are numerous potential gold mines. Gold is found with pyrite and other base metal sulfides in narrow fissure veins which cut both igneous and metamorphic rocks. Locally, ore shoots have been formed which contain "bonanza ore".

Since veins have never been contoured, that is measured and surveyed in detail as to irregularities in trends and thicknesses, no probable pattern of ore shoots is known, and new ore bodies are found only by extensive development. The working out of some ore shoot pattern, assuming one does exist, would reward efforts with no small fortune. Since much of the area is open to discovery, opportunity awaits those who can solve the existing problems of geology.

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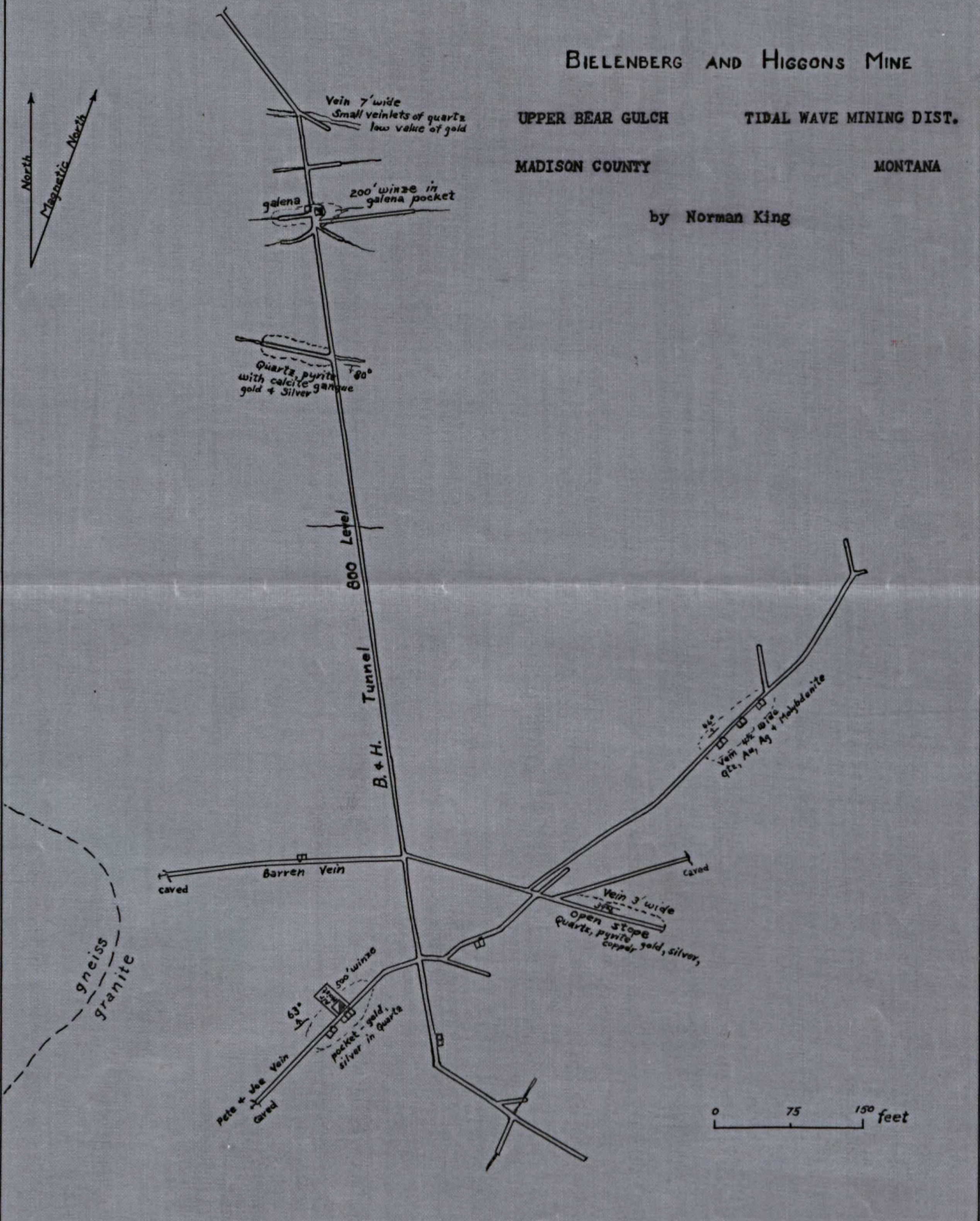
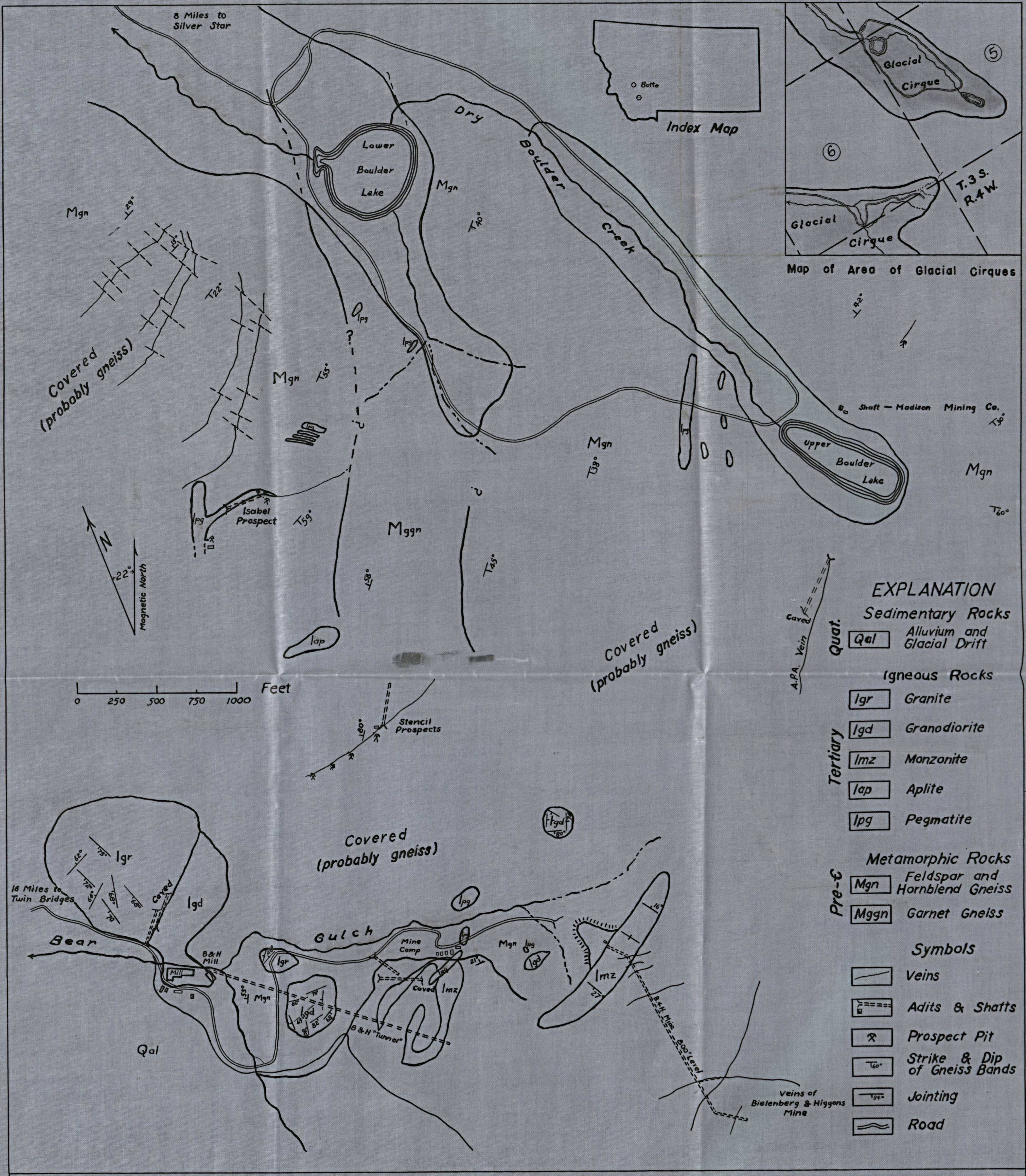
Bielenberg and Higgons Mine

UPPER BEAR GULCH — TIDAL WAVE MINING DIST.

MADISON COUNTY — MONTANA

by Norman King





GEOLOGIC MAP OF

UPPER BEAR GULCH AND DRY BOULDER CREEK AREA

MADISON COUNTY, MONTANA

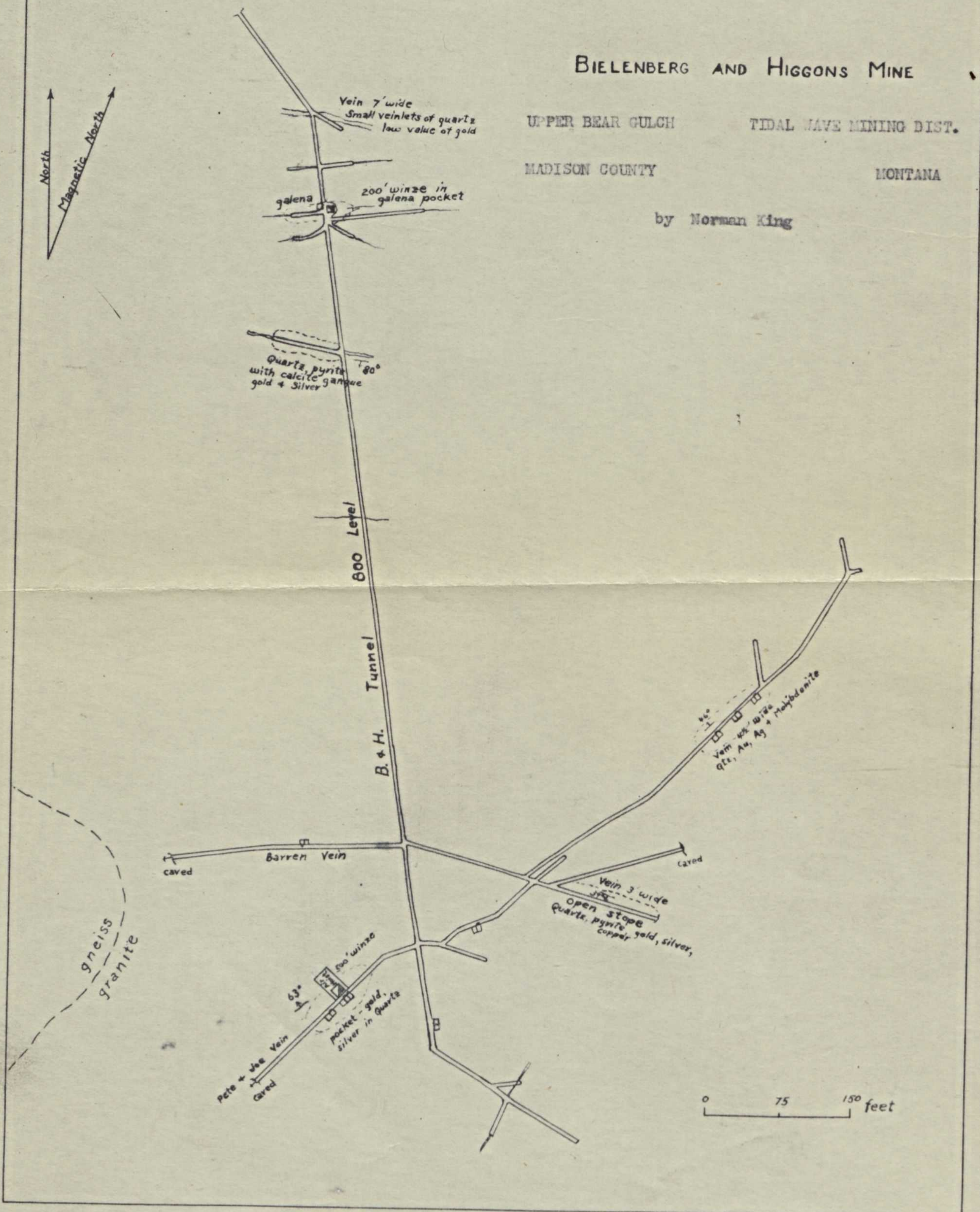
JULY 1947 NORMAN KING

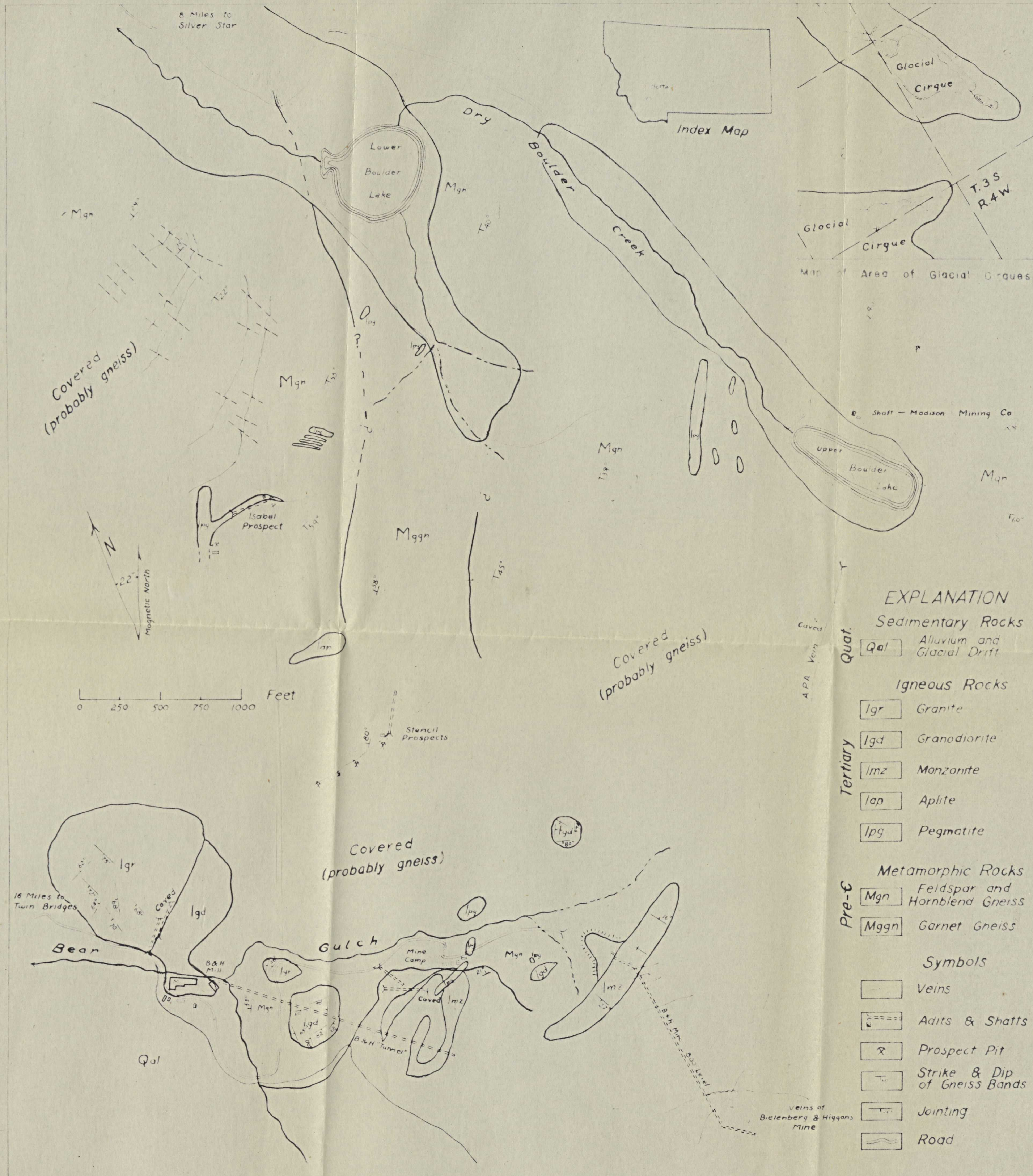
BIELENBERG AND HIGGONS MINE

UPPER BEAR GULCH TIDAL WAVE MINING DIST.

MADISON COUNTY MONTANA

by Norman King





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