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THE GEOLOGY AND ORE DEPOSITS OF UPPER MAYFLOWER GULCH
SUMMIT COUNTY, COLORADO

by

John Alexander Randall

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The geology and ore deposits of upper Mayflower Gulch
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Abstract

Upper Mayflower Gulch is on the highly glaciated western side of the Tenmile Range near Kokomo in central Colorado. Somewhat less than $500,000 in silver and gold has been produced from the area since the first mining in the 1880's.

In the mapped area high grade regional metamorphism has produced two varieties of gneiss and a granulite. Total thickness of the rocks is about 5,000 feet. Relict bedding is preserved in compositional banding which strikes north to N. 20° E. and dips 70° to 80° southeast. No significant folding was observed. Normal faulting has occurred since the Precambrian; two major sets of faults are recognizable: (1) a set striking N. 70° to 85° E. and dipping 75°-85° NW; and (2) a set striking N. 40°-50° W. and dipping 50°-60° SW. Tabular bodies of pegmatite and retrogressively metamorphosed schist along many faults indicate Precambrian movement.

The Mayflower fault, a 90 to 300 foot wide zone of silicification and shattered rock, strikes about N. 40° W. It extends the entire length of the gulch and appears to form the northern terminus for the northeast trending Mosquito Fault. The Mayflower fault shows repeated movement since the Precambrian, a total~~ling~~ about 3,000 feet of apparent dip slip and 640 feet of apparent strike slip.

Faulting during the Tertiary includes both additional movement along Precambrian faults and development of shears trending N. to N. 20° E. The shears served as channels for the intrusion of two varieties of quartz latite porphyry dikes.

Specular hematite and base-metal sulfide mineralization followed intrusion of the porphyry dikes; the minerals were deposited in open fault zones by high temperature solutions in a low pressure environment. The principal metallic minerals in order of deposition are: hematite, pyrite, chalcopyrite, sphalerite, galena, and rare argentite. The major mines are the Gold Crest, Payrock, Nova Scotia Boy, and Bird's Nest.

INTRODUCTION

Location and Geography

Near the headwaters of Mayflower Creek (Figures 1, 2, 3, 4) near Kokomo, Colorado, small veins have been mined intermittently for gold and silver since the 1880's (Henderson, 1926; pp. 235-236). Production has never been great although some of the veins have been very rich.

Mayflower Creek is a tributary to Tenmile Creek; the confluence is about a mile north of Kokomo, Summit County, Colorado. The mapped area lies in a cirque on the highly glaciated west side of the Tenmile Range, and is reached by turning off Colorado Highway 91 about one mile north of Kokomo and following an unimproved road.

The mapped area is included in U. S. Geological Survey Topographic Maps of the Leadville Quadrangle (1:125,000), Mount Lincoln Quadrangle (1:62,500), and the Tenmile Mining District (south half) (1:12,000) and covers all of Mayflower Gulch southeast of the Boston Mine to the crest of the Tenmile Range at Fletcher Mountain.

Purpose of Investigation

The purpose of this study was to examine an area of intensely faulted metamorphic rocks containing complex mineralization and accessible mine workings. Upper Mayflower Gulch was chosen because of its complex metamorphic and igneous geology and excellent exposures within an area of one square mile.

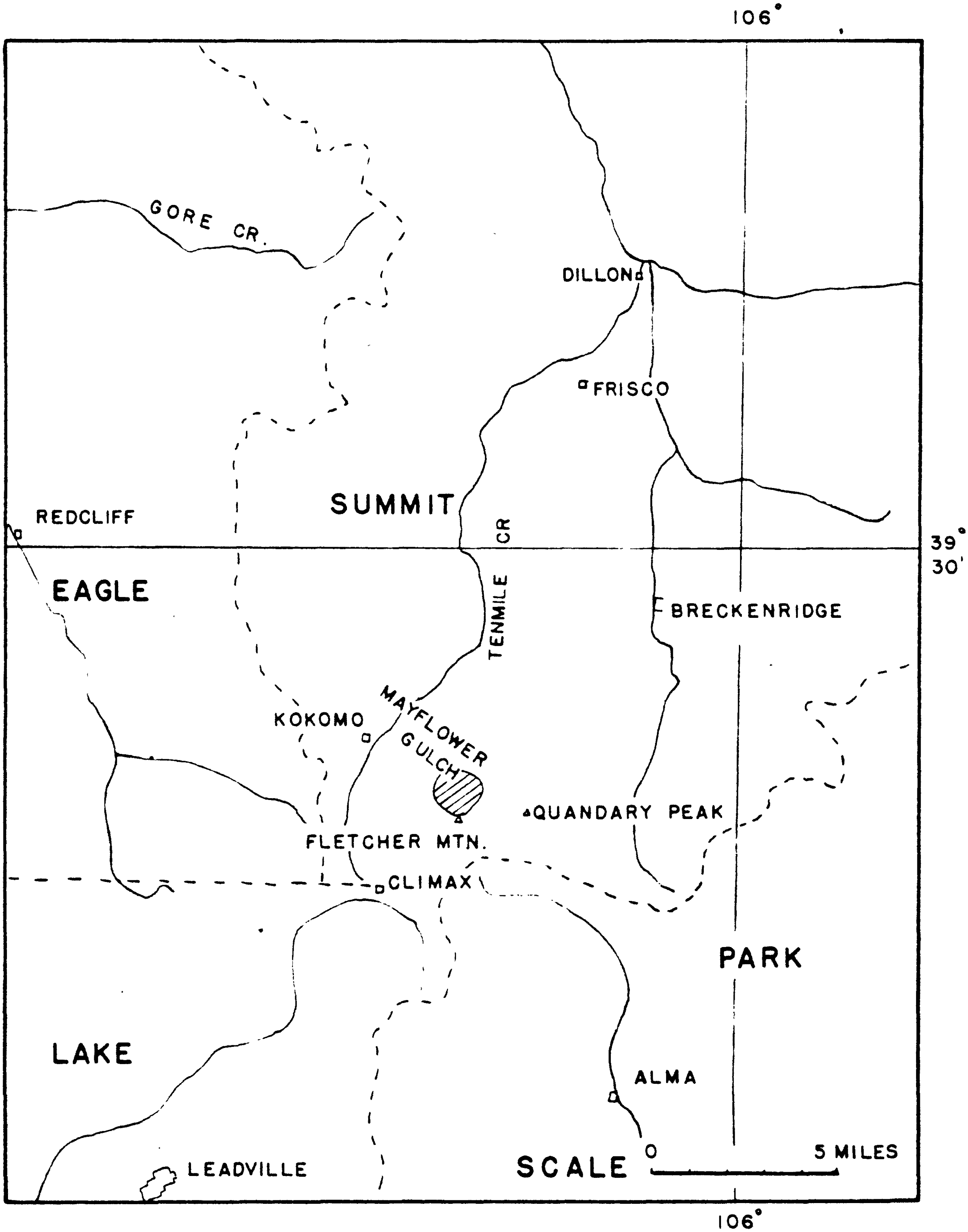

FIGURE I INDEX MAP SHOWING MAYFLOWER GULCH

MAPPED AREA IS SHADED

Figure 2. View looking east from Kokomo showing cirque in Mayflower Gulch. Fletcher Mountain is on right. Photograph by M. H. Bergendahl.

Figure 3. View looking southeast to Fletcher Mountain; the Gold Crest tramway tower is visible on the floor of the cirque.

Numbers refer to:
1. Nova Scotia Boy Mine
2. Bird's Nest(?) Mine

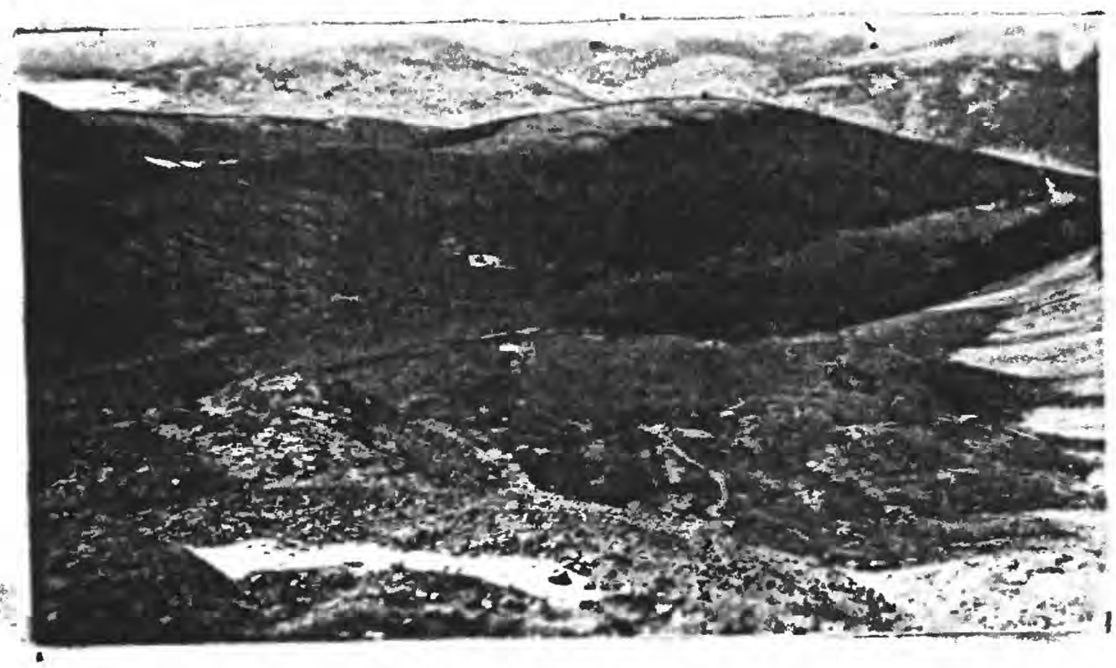

Figure 4. View looking west down Mayflower Gulch toward Kokomo. The Boston Mine is visible at timberline.

Methods of Investigation

Twenty-eight days were spent in the field in reconnaissance, plane-table and Brunton compass mapping of the surface, and underground mine workings from July through October 1957. Mapping was done at a scale of one inch equals 300 feet. U.S. Land Monument Gilpen, elevation 11,544 feet, at the Boston Mine was used as the reference point for the surveys.

Numerous discovery drifts (less than 50 feet in length), 60 feet of accessible drift in the Payrock Mine, and the lower drift of the Gold Crest were mapped and examined in detail. The upper drift of the Gold Crest, the Nova Scotia Boy, and most of the Payrock Mine were blocked by ice, two of the tunnels on the bottom of the Gulch were considered dangerous to enter, and the Boston Mine was outside the area of this report.

Laboratory investigations consisted of study of thin sections and polished sections during the winter of 1957-1958.

Previous Work

The Precambrian core of the Tenmile Range, although it is bordered by Kokomo, Breckenridge, and Climax Mining Districts, has not been mapped in detail. The first map that included Mayflower Gulch was made by Emmons in 1898 on a scale of 1:31,680; however, he did not show any of the structural features of the area. He mentions the presence of Tertiary dikes intruding the Precambrian rocks (1898, p. 1). Butler and Vanderwilt (1933, pp. 205-210, 217-219) described some of the Precambrian rocks and major structures south of Mayflower Gulch. Singewald (1951) mapped the upper part of Mayflower Gulch and located the Gold Crest vein and a few Tertiary dikes on a map with a scale of 1:48,000. He classified the Pre-cambrian rocks as belonging to the Idaho Springs formation and cited a similar classification after Lovering (1929, pp. 63-66).

Acknowledgments

Part of the field work for this report was done while the writer was working under Mr. A. H. Koschmann and Mr. M. H. Bergendahl on the Kokomo-Tenmile project.

Mr. Bergendahl gave many suggestions on mapping techniques. Mr. Koschmann introduced the writer to Mayflower Gulch and to the regional geology. Without his continuing help, the project could not have been undertaken. The writer is also deeply indebted to Dr. E. E. Wahlstrom of the University of Colorado for his advice and help in the laboratory and for reviewing the manuscript. Dr. L. A. Warner of the University of Colorado gave advice and reviewed the manuscript. Mr. A. R. Conroy of the University of Colorado assisted the writer in the mapping of the lower drift of the Gold Crest mine. Mr. Walter Byron of Kokomo gave information on the mines and history of the region as did other residents of Kokomo and Breckenridge, Colorado. Funds for the thin sections were provided by the Warren O. Thompson Fund of the University of Colorado.

GEOLOGY AND PETROLOGY

Precambrian Metamorphic Rocks

General statement. The metamorphic complex in the Tenmile Range has been described by Butler and Vanderwilt (1933, pp. 205-210) and by Singewald (1951, pp. 5-8). The metamorphic complex has been correlated by Lovering (~~1933~~ 1929, pp. 64-74) with the Idaho Springs formation. Inasmuch as there is no direct connection between the Tenmile Range complex and known Idaho Springs formation, there is some doubt in the correlation (Koschmann, personal communication, 1957).

Attempts have been made to map mineralogical units in the Tenmile Range (Singewald, 1951, p. 6, in discussing an M.S. thesis by R. E. Fellows, 1941, University of Rochester), but results have been poor. Previous work by Koschmann, not yet published, and additional mapping by Bergendahl and the writer in 1957 have has indicated that the units may be separated and mapped on the basis of textural variations. Four distinctive gneisses identified by Koschmann and Bergendahl have wide areal distribution and can be used to delineate structures. The units are: White Granulite, Banded Gneiss, Mixed Gneiss, and Foliated Gneiss.

White Granulite. The White Granulite appears in the field as a light colored gneiss with thin, discontinuous layers of biotite. The biotite layers emphasize a conspicuous foliation. This rock has the widest areal distribution of all the units in Mayflower Gulch and is especially well exposed near the Payrock Mine. Exposures of White Granulite near fault zones commonly contain considerable pegmatite in irregular lenses.

In thin section, the rock has an equigranular fabric with rare microcline or oligoclase porphyroblasts (Figure 8). Anhedral quartz is the most common mineral, and it forms grains with sutured boundaries. Feldspars are slightly less abundant than quartz; microcline is more abundant than oligoclase. Both minerals have subhedral crystal outlines and form grains up to five millimeters in length. Biotite forms thin, discontinuous bands between the grains of quartz and feldspar and in some specimens contains small allanite poikiloblasts surrounded by pleochroic halos. The accessory minerals are rounded zircons, magnetite altered to hematite and leucoxene and pyrrhotite(?). The feldspars are sericitized, and the biotite altered to chlorite and magnetite.

The White Granulite is more than a mile thick in Mayflower Gulch and dips under the Banded Gneiss to the southeast. The contact with the Banded Gneiss is generally sharp except near zones of pegmatite (Figure 5).

Banded Gneiss. The Banded Gneiss is a conspicuously laminated rock with alternating layers of light and dark minerals. The light colored layers are commonly thicker, but either may be from a fraction of an inch to a foot in thickness. The unit trends northeast and crosses Mayflower Gulch. The best exposures are near the upper tunnel of the Gold Crest Mine. The thickness across the layering decreases from southwest to northeast and is about 800 feet at the Nova Scotia Boy Mine and about 200 feet at the Gold Crest Mine. Individual layers are only slightly contorted and vary in continuity. At the Nova Scotia Boy Mine, six-inch bands extend about 20 feet along strike; however, at the Gold Crest Mine, six-inch bands have been traced 200 feet.

In thin section, the Banded Gneiss shows compositional foliation with dark layers of biotite and hornblende alternating with light colored layers of quartz and plagioclase. The fabric is mostly granoblastic with all grains less than one millimeter in length and most grains less than half a millimeter in length (Figure 7). Quartz is in anhedral grains showing strain fractures and is slightly more abundant than oligoclase. The oligoclase is in subhedral Carlsbad-albite twins associated with minor albite. Biotite is abundant in layers which also contain hornblende. Associated with these minerals are grains of sphene and magnetite. Fine needles of sillimanite and rounded zircons are present in the light colored layers.

The contact of the Banded Gneiss and the Mixed Gneiss is everywhere gradational. The transition zone is approximately ten to 100 feet wide.

<u>Mixed Gneiss</u>. The Mixed Gneiss is a highly contorted rock composed of felsic minerals with lenses or patches of biotite. In all exposures it contains masses of concordant and discordant pegmatite which appear to intrude the other constituents. This rock is present in the higher parts of the Gulch and is well exposed on the crest of the range.

Figure 5. Contact between White Granulite (left) and Banded Gneiss (right)- transitional over about 40 feet, with associated pegmatite.
Scale is shown by plane table board.

Figure 6. Frost-wedged blocks of mixed gneiss on the crest of the Tenmile Range in the northeast part of the map area.

Figure 7. Photomicrograph showing compositional layering in Banded Gneiss. (Plain Light). Sample from near Gold Crest Upper Drift.

X 30

Figure 8. Photomicrograph showing fabric of White Granulite; Quartz and Microcline are prominent, (Crossed Nicols). Sample from near Payrock Mine.

X 50

The rock contains numerous ptygmatic folds, and lenses of biotite may be one to five inches long (Figure 6). Near the extreme southeast part of the mapped area, the rock contains randomly oriented porphyroblasts of albite 20 to 30 millimeters in length that are not present elsewhere in the unit.

Thin sections show a contorted gneissic and, locally, an augen fabric, with a schistose fabric in biotite zones. Anhedral, sutured quartz is abundant and is present in about the same amounts as plagioclase. The most common plagioclase is calcic oligoclase in Carlsbad-albite and albite twins. Microcline is an uncommon constituent. Biotite in ragged or subhedral crystals has been altered to chlorite and magnetite. Minor amounts of muscovite and rounded zircons are present.

Foliated Gneiss. The Foliated Gneiss tends to be porphyroblastic and contains prominent dark minerals. It is locally a schist and occurs as concordant lenses in the White Granulite or as discordant tabular bodies in fault zones. It is well exposed in the Payrock vein. The unit is found in bodies from several inches to 40 feet in thickness. The texture is xenoblastic with all grains less than a half millimeter in length. Oligoclase and albite are more abundant than quartz but less abundant than biotite and hornblende; biotite alters to chlorite, hornblende alters to calcite and magnetite. Accessory rounded zircons and euhedral sphene grains are present.

<u>Silver Plume Granite</u>. Silver Plume Granite forms small elongate bodies throughout the mapped area, and a large mass forms the summit of Fletcher Mountain. The rock is quartz monzonite containing slightly more microcline than albite. The rock is well exposed near the Mosquito Fault, the only locality where it contains oriented microcline phenocrysts. The rock bodies are nearly everywhere discordant; some pegmatites are associated with the cross-cutting boundaries (Figure 9). No apophyses were observed.

The rock is porphyritic with tabular phenocrysts of microcline five to ten millimeters in length. The groundmass is xenomorphic granular and composed of zoned albite, orthoclase, quartz, and biotite. The accessory minerals are euhedral zircon, apatite, allanite(?), and magnetite. The igneous texture and discordant relations indicate at least partial fusion and mobilization of the rocks that formed the Silver Plume Granite. The Silver Plume Granite at Climax is described by Butler and Vanderwilt (1933, pp. 208-210).

<u>Biotite Tonalite</u>. A lens of mafic rock south of the Gold Crest Tramway Tower occurs in a small discordant body with the same trend as a nearby fault and is generally parallel to the Payrock-Gold Crest fault system. It is composed primarily of biotite, altered to chlorite, with varying amounts of zoned oligoclase-andesine, quartz, and hornblende. Accessory minerals are apatite, allanite, epidote, pyrite, and magnetite with secondary leucoxene. The plagioclase is sericitized.

The discordant field relations, zoned plagioclase, and mafic character of the rock indicate injection of a magma along a shear zone.

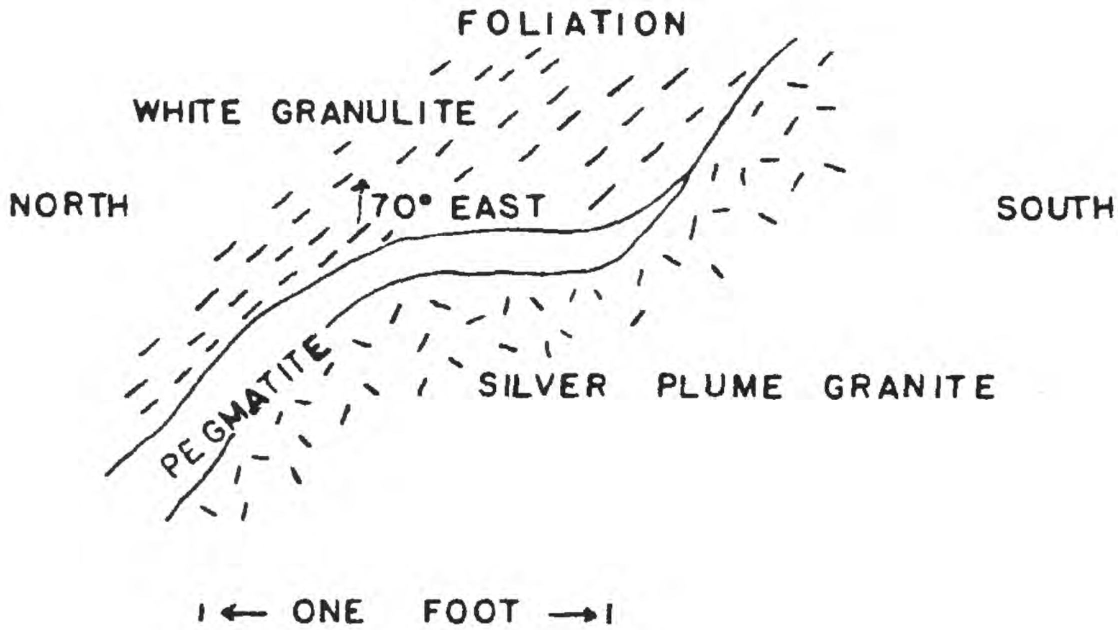

FIGURE 9 INTRUSIVE RELATIONS OF SILVER PLUME GRANITE

FIGURE 10 THE UPPER DRIFT OF THE GOLD CREST MINE SHOWING TABULAR PEGMATITES AT THE PORTAL. JACQUE PEAK IS IN LEFT BACKGROUND.

Pegmatite. The pegmatites of Mayflower Gulch are best exposed near the Gold Crest mine (Figure 10). They consist of grains of potash feldspar, quartz, and muscovite one to five centimeters in length. The pegmatites are both concordant and discordant, but the largest ones clearly cut across the wall rock. The large pegmatites are from one to 25 feet thick and have a similar composition throughout. Many of the pegmatites following Precambrian fault trends have nearly constant thickness and were probably emplaced through structural control. Their concentration in the vicinity of the Gold Crest Mine is noteworthy.

Tertiary Intrusive Rocks

Discussion. In Mayflower Gulch, there are two varieties of porphyry in dikes: Elk Mountain porphyry and Lincoln porphyry. Of the two varieties, Elk Mountain porphyry is the more common both in this area and in the Kokomo-Tenmile district (Koschmann and Wells, 1946, p. 77). In composition, the dikes are quartz-latites; Lincoln porphyry may be somewhat more mafic. Tweto (1951, p. 509) considers the intrusions as Tertiary in age.

The dikes range in thickness from ten to 100 feet, but most of them are 30 to 40 feet thick. They strike north 10°-50° east and dip 65° to 80° northwest. The footwalls of some of the dikes show slight faulting and weak pyrite mineralization. Borders of the dikes commonly show six inch to one foot chilled zones. Because many of the dikes show faults on the footwall and follow a major fracture pattern, it is probable that the dikes were intruded along faults.

<u>Elk Mountain Porphyry</u>. The Elk Mountain Porphyry contains prominent phenocrysts of quartz, orthoclase, and zoned albite-oligoclase. Plagioclase is slightly more abundant than orthoclase; both feldspars are highly sericitized. Clinopyroxene, probably augite, and minor biotite are present in varying amounts and are altered to chlorite, epidote, and magnetite-hematite. Magnetite also occurs in separate grains altered to leucoxene. Other accessory minerals are zircon and apatite. The highly altered condition of the rock and deeply embayed quartz phenocrysts indicate the presence of abundant late magmatic or hydrothermal solutions.

<u>Lincoln Porphyry</u>. The Lincoln Porphyry is characterized by its large, euhedral, Carlsbad-twinned orthoclase phenocrysts approximately one to four centimeters in length. The phenocrysts are highly sericitized, especially on the borders and have poikilitic inclusions of plagioclase and quartz. The orthoclase is about equal in abundance to zoned, calcic oligoclase. Biotite, clinopyroxene, and rare muscovite occur as microphenocrysts or in the groundmass. The accessory minerals are sphene, zircon, apatite, epidote, magnetite, and leucoxene. The rock is not so altered as the Elk Mountain Porphyry but contains many embayed quartz phenocrysts.

STRUCTURE

General Statement

Upper Mayflower Gulch lies within the Precambrian core of the Tenmile Range, near its southern end. The Tenmile Range has the same general trend as the Gore Range to the north and continues into the Mosquito Range to the south. Emmons (1898, p. 1) considers that the Mosquito-Tenmile Range is a "recent" uplift formed by lateral compression on the edge of the older Sawatch Range. The effect of compression is considered by him to have been expressed by about 5000 feet of movement along the Mosquito Fault.

The Mosquito Fault lies on the extreme southwest boundary of the map area and was not studied in detail. However, a large fault striking northwest appears to cut the Mosquito Fault in Mayflower Gulch. There are a great many other faults, representing many periods of deformation in the map area. Many of these faults are mineralized and constitute the major ore control. Some of these shears are related to the intrusion of the Tertiary porphyry dikes.

During the extensive metamorphism of the Precambrian rocks, there was complex folding. In the present study, the major folds could not be identified. No significant smaller folds are exposed in the mapped area. Structures observed consist of foliation and lineation, where present. Lineations in the Mixed Gneiss observed in the northern part of the Tenmile Range by Bergendahl and the author are randomly oriented. None of the rocks in Mayflower Gulch show any megascopic mineral lineation.

Foliation

Foliation was mapped in all of the Precambrian rocks except the small biotite tonalite body. The three major Precambrian units (White Granulite, Banded Gneiss, and Mixed Gneiss) generally are conspicuously foliated. Parallelism of foliation and bedding is especially notable in the compositional layering of the Banded Gneiss. Where the White Granulite is intruded by irregular pegmatites, its foliation tends to be indistinct or absent. In certain areas, the Mixed Gneiss is so contorted that no local trend of foliation could be established.

Foliation from the White Granulite, Banded Gneiss, and Mixed Gneiss was plotted on a Wulff Net (Figure 11). The only major concentration of poles indicates a strike of north to north 20° east and a southeast dip of 70° to 80°. Erratic foliations are concentrated in the White Granulite on the northeast ridge bounding the cirque, near pods of Silver Plume Granite and Tertiary porphyry dikes, and near the Mesquite Fault.

Foliated Gneiss occurs in shear zones where it is more schistose than foliated and in small generally conformable pods in the White Granulite. Silver Plume Granite shows foliation (lineation ?) of the tabular feldspar phenocrysts in only one exposure.

Faulting

__Precambrian trends__. All of the major faults in the mapped area indicate several periods of movement over a long period of time.

probably extending back to the Precambrian. Evidences of repeated movement are: (1) Most of the veins show several periods of mineral filling and brecciation. (2) The Gold Crest and Payrock veins, the Mayflower Fault, and several barren faults contain a two to six foot band or bands of Foliated Gneiss within the sheared zone. (3) Especially along the Gold Crest vein, there are discordant pegmatites parallel to the sheared zone.

Although several periods of brecciation in the veins may have occurred in a relatively short period of time, the presence of pegmatite and Foliated Gneiss are strong evidence for a Precambrian origin to the faults. Precambrian trends follow two major directions which distinguish them from later fault zones: (1) N 70°-85° E--principally the Gold Crest-Payrock system, and (2) N 40°-50°W--principally the Mayflower Fault. Certain elongate bodies of Silver Plume Granite and pegmatite and porphyry dikes follow one or both of these trends. The elongate body of biotite tonalite has a trend very close to N 70° E.

Although many of the faults are Precambrian, there is considerable brecciation of ore-bearing quartz that indicates additional faulting in the Tertiary. The amount of movement along the faults during the Precambrian could not be determined.

Tertiary trends. Tertiary faulting in Mayflower Gulch consisted of renewed movement along old zones of weakness and the development of new faults. Faults developed in the Tertiary are mostly minor fractures, although some of them controlled the intrusion of porphyry dikes.

The Mosquito Fault was probably active before the Tertiary (Butler and Vanderwilt, 1933, p. 219). In Mayflower Gulch, the fault brings white granulite into contact with Leadville limestone of Mississippian age. Both rocks are highly fractured and silicified near the contact, and the silver-lead ore body of the Boston Mine is close to the fault in the Leadville limestone. Although Emmons (1898, p. 1) mentioned 5000 feet of displacement along the Mosquito Fault in the Mosquito Range, Koschmann (Personal communication, 1958) suggests that the fault has considerably less displacement in Mayflower Gulch. He doubts that the Mosquito fault extends to the north beyond the Gulch. Although it was not possible to determine the displacement along the Mosquito Fault in Mayflower Gulch, a zone of silicification along it is much narrower than the altered zone along the Mayflower Fault. Butler and Vanderwilt (1933, p. 218) note that: "In the Phillipson tunnel, at Climax, the rocks on both sides of the fault are much broken for a distance of 100 feet. . . ." Climax is about three miles southwest of Mayflower Gulch. The dip of the Mosquito Fault in Mayflower Gulch is unknown.

The Mayflower fault is the strongest fault in Mayflower Gulch. A 90 foot wide silicified zone along the fault forms a knoll on the ridge just north of Fletcher Mountain. The fault was traced for a distance of a mile in the gulch and undoubtedly extends for the entire length of the gulch. Sediments displaced by the fault are northwest of the mapped area, but Figure 12 based on mapping by the writer and discussion with Koschmann in 1957-1958 shows the areal relations.

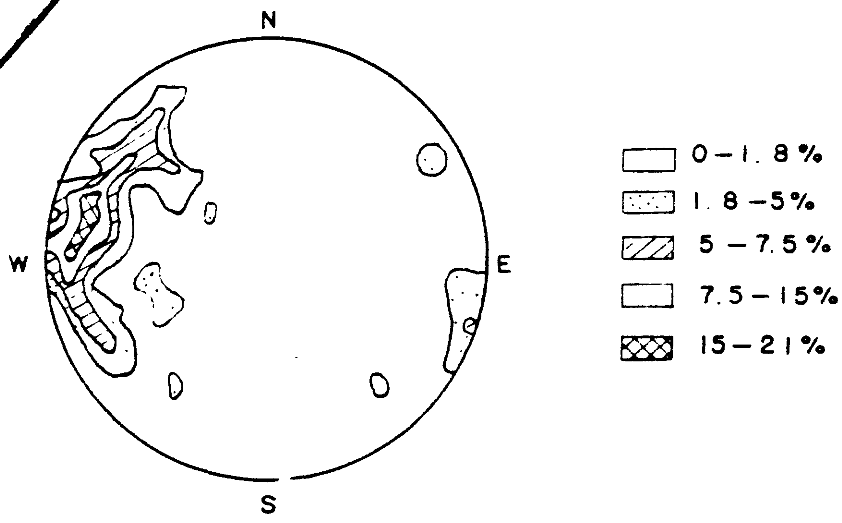

FIGURE 11 CONTOUR DIAGRAM OF 66 POLES OF FOLIATION FROM WHITE GRANULITE, BANDED GNEISS, AND MIXED GNEISS: PLOTTED ON LOWER HEMISPHERE

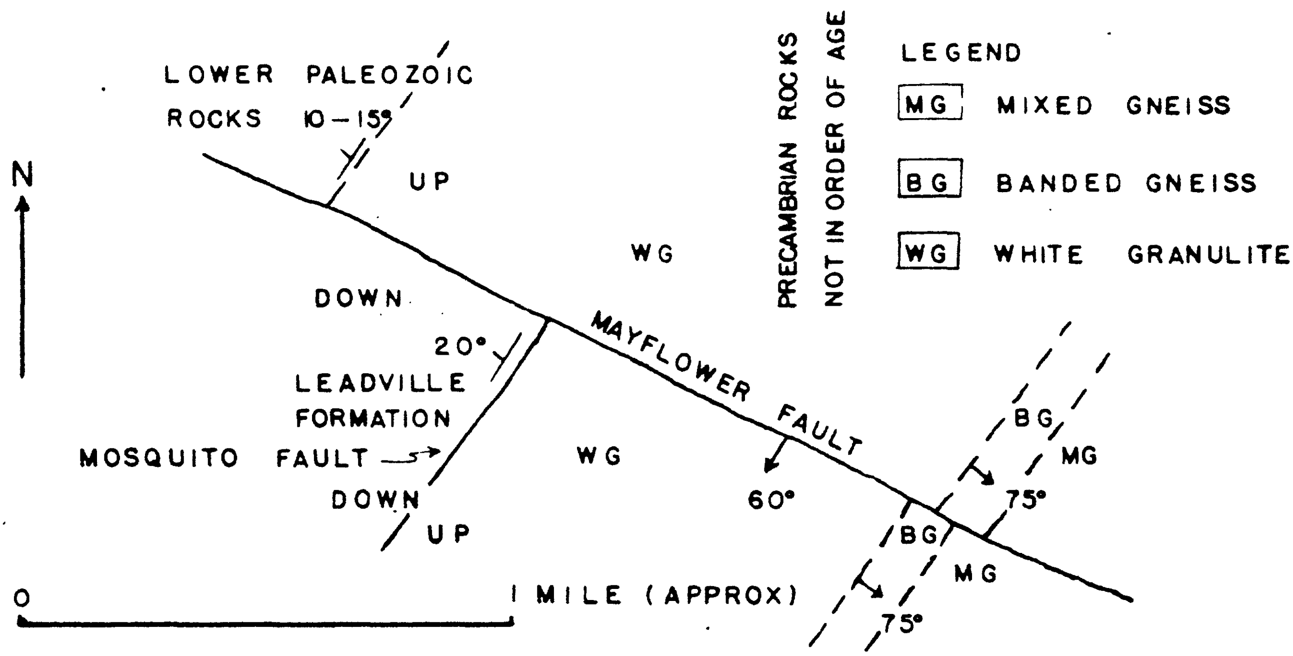

FIGURE 12 STRUCTURAL RELATIONS IN MAYFLOWER GULCH

The apparent difference is displacement of Precambrian rocks compared to Paleozoic rocks along the Mayflower fault is readily explained by the flatter dip of the sediments. Because there were many periods of movement of the Mayflower fault, no attempt was made to calculate net slip. The apparent dip slip is about 3000 feet and the apparent strike slip about 680 feet as calculated from displaced Precambrian units.

The Mayflower fault dips 50°-60° southwest, and the northeast side is up-thrown. The zone of fractured rock along the fault increases from 90 feet near Fletcher Mountain to over 300 feet near the Boston Mine. The Mosquito fault cannot be traced northward beyond Mayflower Gulch (Koschmann, personal communication, 1958), and the Mayflower Fault may be assumed to be its termination. Therefore, it is probable that the last movement on the Mayflower fault post-dates that of the Mosquito fault, although the Mayflower fault has been a zone of weakness since Precambrian time.

The faulting along the Gold Crest and Payrock veins will be discussed together because both faults are similar in attitude and effect on the wall rock. Both strike N 70°-85° E and dip 75°-80° northeast. On Gold Crest vein the footwall is thrown relatively upward and to the east, with approximately 160 feet of apparent strike slip and 50 feet of apparent dip slip. The nature of the displacement along the Payrock vein is unknown but probably similar to that of the Gold Crest vein. Slickensides on the fault of the Payrock drift plunge S 75° W at 64°. If the relative movement were the same as along the Gold Crest vein and the slickensides are significant, the net slip for each of the faults would be 150 to 180 feet. Brecciated vein minerals indicate several periods of movement during the Tertiary.

The small faults which were probably formed during the Tertiary have many different trends. Several trend N 30° to 40° E; one of the faults displaces a Tertiary dike, so that the footwall has moved relatively up and to the northeast. The apparent strike slip is approximately 50 feet and apparent dip slip 75 feet. Most of the Tertiary faults are probably of this magnitude, although the older faults show much more Tertiary movement.

Geologic History

Mayflower Gulch has undergone extensive deformation since the Precambrian; major effects of deformation have been metamorphism, faulting, intrusion, and hydrothermal mineralization.

During the Precambrian, more than 5000 feet of sediments were laid down in the mapped area. High grade regional metamorphism produced gneisses and a granulite, and some of the rocks, Silver Plume Granite and biotite tonalite, appear to have been mobilized. Some felsic constituents were mobilized, especially along faults, to produce pegmatites. Extensive faulting with attendant retrogressive metamorphism produced dark schists along the fault planes.

Structures in the sedimentary rocks at Kokomo indicate continued deformation during the Paleozoic (Koschmann and Wells, 1946, pp. 86-89).

In the Tertiary, during the Laramide Revolution, intrusion of felsic porphyry dikes occurred. In addition, there was faulting along both Precambrian trends and Tertiary trends. The dikes were intruded along Tertiary faults. Ore minerals were deposited in open spaces along faults of various ages.

Throughout the Tertiary, the Tenmile Range was slowly elevated to its present height of nearly three miles above sea level. Alpine glaciation during the Pleistocene was the final event in the geologic history of Mayflower Gulch.

MINERAL DEPOSITS

Fracture Systems

The ore minerals in Upper Mayflower Gulch are deposited in open fault zones. Open-space filling is indicated by vugs and crustified deposition, and the fractures show brecciation of both ore and gangue minerals. Certain veins, notably the Mayflower Fault, contain breccia fragments and horses of wall rock cemented by quartz.

It is shown of Plate 1 that the major trend of ore-bearing zones, including the Payrock-Gold Crest system, is north 70°-85° east. The Mayflower fault and parallel veins form another ore-bearing trend. In contrast to these two fracture systems with a Precambrian origin, eight or nine veins of probably Tertiary age are neither extensive nor have economic significance.

Hematite Veins

Crystalline, platy hematite is abundant in many veins and in certain veins is the major metallic mineral. The largest vein of hematite occurs about 600 yards northeast of the Boston mine. In a small exposure of white granulite projecting through the talus, a 40 foot drift has been driven on a five foot series of veins, extending nearly 200 feet. The largest vein is a foot thick. The ore minerals are hematite and minor pyrite in a quartz gangue. Hematite is contemporaneous with or later than the quartz; pyrite occurs as scattered cubes which cut across blades of hematite. Crystalline hematite alters to a massive, powdery form. Microscopic vugs indicate open-space filling. No brecciation was observed, nor were there pegmatites or Foliated Gneiss bands associated with the vein. The fracture is probably Tertiary.

On the Mayflower Fault, about 650 yards southeast of the Boston Mine, there are several prospect pits on two hematite veins parallel to the Payrock-Gold Crest system. The veins are in the zone of shattered rock along the Mayflower Fault and may be in horses rotated by that fault. Considerable pyrite is present; this probably was the cause for gold prospecting. The wall rock is White Granulite.

Abundant platy hematite is shown in a small vein about 200 yards west of the Gold Crest Tramway Tower. The vein, striking N 50° E with a vertical dip, has been explored by a 15 to 20 foot shaft and two trenches, and is four to five feet thick. Vein material is highly brecciated; one to five inch fragments of silicified White Granulite are common. Following massive quartz deposition, cubes of pyrite were formed. Hematite partially replaces pyrite along grain boundaries (Figure 15). Hematite and a later generation of quartz were deposited in vugs. The White Granulite wall rock is highly silicified and partially chloritized and epidotized.

The veins in which platy hematite is the principal metallic mineral are of simple mineralogy (Figure 13). Limited workings of these veins indicate low, if any, gold-silver values. The presence of crystalline hematite in vugs indicates high temperature and low pressure deposition.

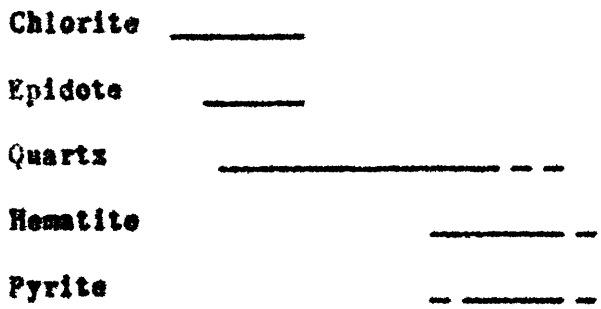

Figure 13. General Paragenetic Diagram of Hematite Veins

Sulfide Veins

The sulfide veins include all the veins ~~of the veins~~ from which any production is recorded. The most common type contain quartz and pyrite, but many of the larger veins also contain chalcopyrite, sphalerite, galena, and argentite.

Typical of the pyrite-bearing veins is one located about 550 yards east of the Gold Crest Tramway Tower on the headwall of the cirque. It is ~~four~~ 4 to ~~six~~ 6 feet thick and extends at least 400 feet. An ~~eight~~ 8- foot discovery drift has been driven on one edge of the vein. The mineralogy consists of pyrite, altered to limonite, and rare sphalerite in a quartz gangue. A four foot channel sample, taken by the author, assayes 0.19 ounce gold and 0.16 ounce silver to the ton. Slickensides on the fault plunge S 7° W at 75°, but the relative movement is not known. The wall rock is Banded gneiss.

Numerous small veins exploited by discovery drifts and shafts near the Mesquito fault are characterized by pyrite in veinlets or scattered cubes in a quartz gangue. A small amount of galena was found on the dump of a 15 to 20 foot shaft about 600 yards south of the Boston Mine. The ore here is characterized by vuggy and crustified quartz with scattered cubes of pyrite and minor galena. It is typical of the small quartz-pyrite veins that are scattered throughout the area. The veins probably carried some gold. The veins probably were formed during the Tertiary as they parallel the porphyry dikes and have no associated pegmatites.

DESCRIPTION OF MINES

Gold Crest mine

The Gold Crest Mine consists of two drifts on a prominent shear zone. The shear strikes N 80°-85° E and dips 85° NW and is exposed on the surface for nearly 1100 feet. The vein occupies a fault containing pegmatite and a ~~four~~ 4- to ~~five~~ 5- foot thick body of Foliated Gneiss; ore-bearing quartz and chloritic material was never observed to exceed two feet in thickness. Ore was transported from both adits by aerial tramways. Reference to the Minerals Yearbook, 1935-1940, indicates production of ore from 1934 to 1939. The Gold Crest Mine was the last serious attempt at mining in the gulch.

The upper drift, elevation 13,118 feet, was the more productive according to Koschmann and Byron (personal communication, 1958). The first mention of production was in 1934 when ". . . 25 tons of hand picked ore containing 36.53 ounces of gold and 84 ounces of silver. . ." were shipped (Minerals Yearbook, 1935, p. 231). The adit is in a tabular pegmatite (Figure 10) but is blocked by ice. Samples collected at the portal are highly pyritic in a quartz, chlorite, and calcite gangue. Chalcopyrite, sphalerite, galena, rare argentite, and a *few* tiny grains of gold(?) are visible under the microscope (Figure 14). According to Koschmann and Byron (personal communication, 1958) free gold occurs in the ore.

The Lower Drift, elevation 12,409 feet (Plate 3) was studied in detail by the author and Conroy. It is over 1100 feet in length but contains ore only in small shoots. The ore has been exploited by a raise and four stopes. Much of the drifting probably was done in 1939. "The Gold Crest Mining Co. drove 600 feet of tunnel at the Gold Crest Group and shipped 177 tons of gold-silver ore to the Leadville Smelter." (Minerals Yearbook, 1940, p. 308.) Samples collected from the largest stope on a one foot vein show abundant chalcopyrite and sphalerite. Minor amounts of platy hematite are present (Figure 16).

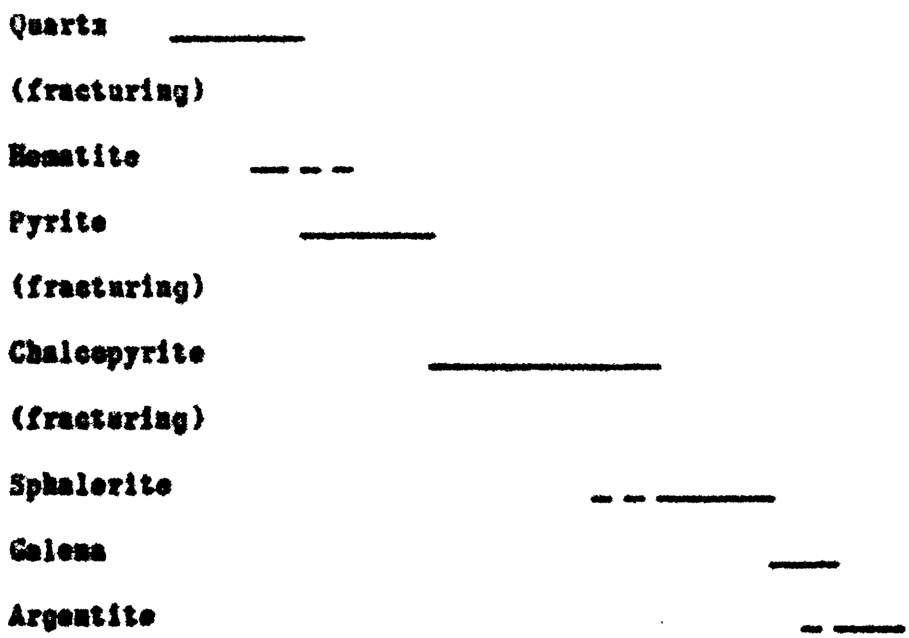

Figure 14. Paragenetic Sequence of Minerals in the Lower Drift of the Gold Crest Mine

Figure 15. Photomicrograph of platy hematite replacing a cube of pyrite. Sample from shaft on small vein near Gold Crest Tramway Tower.

X 110

Figure 16. Photomicrograph of platy hematite and chalcopyrite from stope of Gold Crest Mine. (On Lower Drift).

X 110

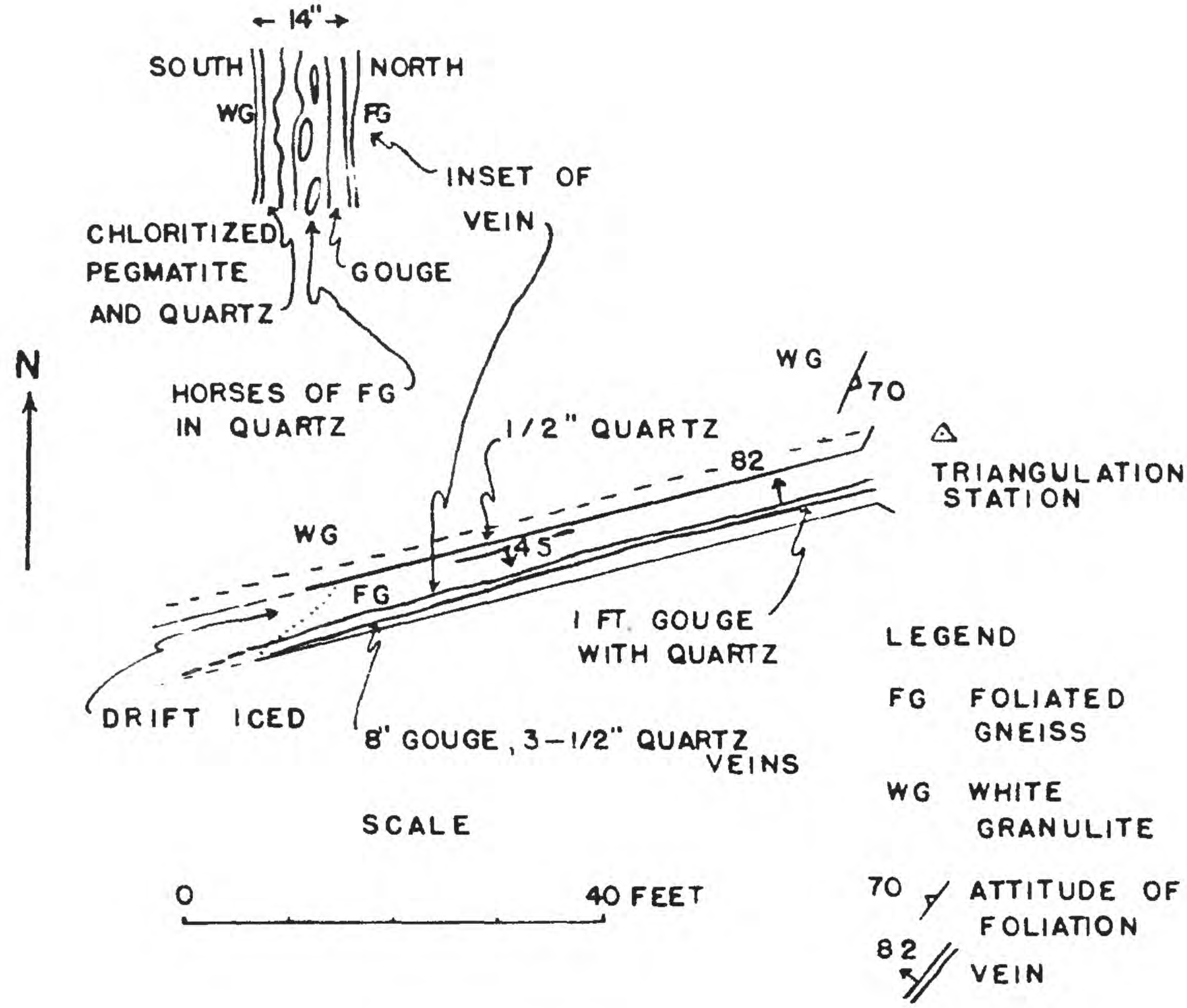

FIGURE 17 PLAN OF ACCESSIBLE PART OF THE PAYROCK MINE

BRUNTON – PACE TRAVERSE, J. A. RANDALL

It is evident from Figure 14 that movement along the fault occurred during ore deposition. Post-ore faults on the vein are common and pose a problem in genesis as they trend parallel to the Mayflower Fault system of probable Precambrian age.

Payrock

The Payrock Mine is a drift on a five to ~~six~~ 6- foot shear zone with an included body of Foliated Gneiss. At the adit, elevation 11,960 feet, the vein strikes N 74° E and dips 84° NW. The dark band of sheared rocks forms a prominent trench which extends about 600 feet.

Production was recorded only in 1936 when ore was shipped to the Bryant Custom Mill near Leadville (Minerals Yearbook, 1936, pp. 334-335). Indications of ore are weak; the vein never exceeds a foot in thickness and shows only scattered pyrite. According to Byron (personal communication, 1958), the mine never appeared to have been successful.

The drift was mapped in detail for 60 feet until it was blocked by ice (Figure 17), but the size of the dump indicates about 400 feet of drift. Blocks of Foliated Gneiss in the drift are sheared and locally show slickensides; otherwise, the Payrock and Gold Crest veins are similar.

Nova Scotia Boy

The Nova Scotia Boy Mine, elevation 12,388 feet, is an attempted cross-cut to the Mayflower Fault. According to Byron (personal communication, 1958), the fault was never reached. The adit is blocked by ice, but the size of the dump indicates about 200 to 250 feet of tunnel. The cross-cut probably represents the Nova Scotia Boy No. 2 which was started by the Croesus Mining Co. in 1883 (Henderson, 1926, pp. 238-239, quotations from Burchard, 1885, pp. 236, 237, 238, 240, 426-433).

Mineralization had been found when the operation ceased, as the following minerals are visible under the microscope: abundant pyrite, and minor sphalerite, galena, argentite, and gold(?). The ore is brecciated and in a quartz and gneiss gangue. The adit is in Banded Gneiss. Deposition of sphalerite in fractured pyrite crystals indicates movement on the Mayflower Fault during ore deposition.

<u>Bird's Nest(?) Group</u>

A series of prospect tunnels high on the west side of Fletcher Mountain and one drift, now caved, on the crest of the range, elevation 13,660 feet, probably represent the Bird's Nest Group (Henderson, 1926, p. 243, quotations from Roberts, 1903, pp. 118-120, 132). This source mentions that, in 1902, "The Bird's Nest Group shipped about 200 tons of ore averaging as high as 2½ ounces in gold and 20 ounces in silver to the ton." The work was done on the Mayflower Fault and on smaller veins parallel to it. None of the workings appears to exceed 50-100 feet in length.

Ore from the Mayflower Fault is highly brecciated and consists of pyrite, galena, and argentite in a calcite, quartz, and silicified gneiss gangue. Hematite is present in traces. Much of the vein shows crustification with at least three generations of quartz, separated by periods of fracturing.

A ten foot discovery drift in Silver Plume granite is on a one foot thick vein of crustified quartz with pyrite veinlets. The vein strikes N 30° W and has a vertical dip.

"Valley" Mines

There are two adits and a shaft on the floor of the cirque about which little information could be obtained. The largest is a drift on a five foot thick zone of pegmatite and gouge with quartz fragments. No metallic minerals were observed on the vein which strikes N 65° W and dips 83° SW. Above the adit is a shaft, now caved, on a one foot thick vein of crustified quartz with minor pyrite. The vein trends N 43° W and is not a continuation of the vein in the drift. Apparently, none of the workings were very productive, although the dump on the major adit indicates at least 200-250 feet of drift. The wall rock is white granulite.

SUMMARY AND CONCLUSIONS

The upper part of Mayflower Gulch is in the Precambrian metamorphic complex of the Tenmile Range. Metamorphic rocks are exposed in three major units totaling more than a mile in thickness. High grade regional metamorphism has recrystallized the rocks which now consist mainly of a granulite and two varieties of gneiss. Relict bedding is recognizable and is preserved in compositional layering.

In the thesis area there are two sets of faults on which the footwall moved relatively upward: (1) striking N 70°-85° E and dipping 75°-85° NW; (2) striking N 40°-50° W and dipping 50°-60° SW. The Mayflower Fault belongs to the latter set and includes a 90 to 300 foot zone of shattered and silicified rock, extending the entire length of the gulch. The fault displaces Paleozoic as well as Precambrian rocks and appears to form a terminous for the northeast-trending Mesquite Fault.

The major fracture systems contain tabular bodies of foliated gneiss and pegmatite which indicate Precambrian movement. They have also been active in the Tertiary. Faults with only Tertiary movement are less well defined; they strike north to N 40° E and form zones of weakness along which Tertiary porphyry dikes were intruded.

Widespread pyrite, base-metal sulfide, and hematite mineralization in open spaces followed intrusion of the porphyrites. The presence of platy hematite with crustified quartz indicates high temperature but low pressure deposition. The strongest mineralization is in faults with Precambrian as well as Tertiary movement.

Mining has continued intermittently from the 1880's to the present. The largest mine, the Gold Crest, operated only during the 1930's. None of the observed records note the removal of more than 200 tons of concentrate in any one year. Total value of ore shipped from the gulch was probably somewhat less than $500,000.00.

Large scale production from the district is unlikely. The veins are generally narrow, and the ore is discontinuous although locally of high grade. Some ore remains in the lower drift of the Gold Crest Mine.

Future development should include driving the Nova Scotia Boy cross-cut to the Mayflower fault. The Mayflower fault is the largest structure in the gulch and has produced quantities of high grade ore in the past.

BIBLIOGRAPHY

Butler, B. S. and J. W. Vanderwilt. (1933) "The Climax Molybdenum Deposit, Colorado" U.S.G.S. Bull. 846-C.

Emmons, S. F. (1898) "Tenmile District Special Folio" U.S.G.S. Folio 48.

Henderson, C. W. (1926) "Mining in Colorado" U.S.G.S. Professional Paper 138, pp. 235-236, 237, 238-239, 243.

Koschmann, A. H. and F. G. Wells. (1946) "Preliminary Report on the Kokomo Mining District, Colorado" Colorado Scientific Soc. Proc., Vol. 15, No. 2.

Lovering, T. S. (1929) "Geologic History of the Front Range, Colorado" Colorado Scientific Soc. Proc., Vol. 12, pp. 59-111.

Minerals Yearbook 1935-1940, U. S. Dept. of the Interior, Bureau of Mines. 1935, p. 231; 1936, p. 270; 1937, pp. 334-335; 1938, p. 278; 1939, p. 305; 1940, p. 308.

Singewald, Q. D. (1951) "Geology and Ore Deposits of the Upper Blue River Area, Summit County, Colorado" U.S.G.S. Bull. 970.

Tweto, O. L. (1951) "Form and Structure of Sills Near Pando, Colorado" Geological Society of America Bull. 62, pp. 507-532.