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RECONNAISSANCE OF IRON FORMATION IN THE COPPER MOUNTAIN AREA, FREMONT COUNTY, WYOMING.

by

M.L. Millgate and J.P. Gliozzi

April, 1966

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INTRODUCTION

The area (Fig. 1) is located in northwestern Wyoming and occupies parts of Township 39 North, Ranges 92 and 93 West; Township 40 North, Ranges 92, 93, and 94 West; and Township 41 North, Range 93 West, Sixth Principal Meridian. Topographic coverage is provided by U. S. Geological Survey Birdseye Pass and Guffy Peak ($7\frac{1}{2}$') quadrangles. Parts of this area are not mapped.

Access to the area is provided by the Birdseye Pass road (Fig. 1) and unimproved roads leading to the south edge of the Bridger Range along Tough Creek, Hoodoo Creek, West Fork Dry Creek, and Dry Creek. Numerous unimproved roads extend further into the Copper Mountain area, mostly from the north and west, but most are suitable for travel only by four-wheel drive vehicles.

The area is of economic interest because of the occurrence of copper, tungsten, and gold in association with quartz veins; and copper, beryl, lepidolite, and columbite-tantalite in associaton with pegmatite. The occurrence of iron formation in the Copper Mountain area has been known for some time, but the distribution and lithology are poorly known in this geologically unmapped area. In addition to these occurrences in rocks of Precambrian age, secondary uranium deposits have been mined south of Copper Mountain in rocks of Tertiary age.

The first regional geologic mapping of the area was done by Darton (1906). More recent work, primarily on sedimentary rocks south and west of Copper

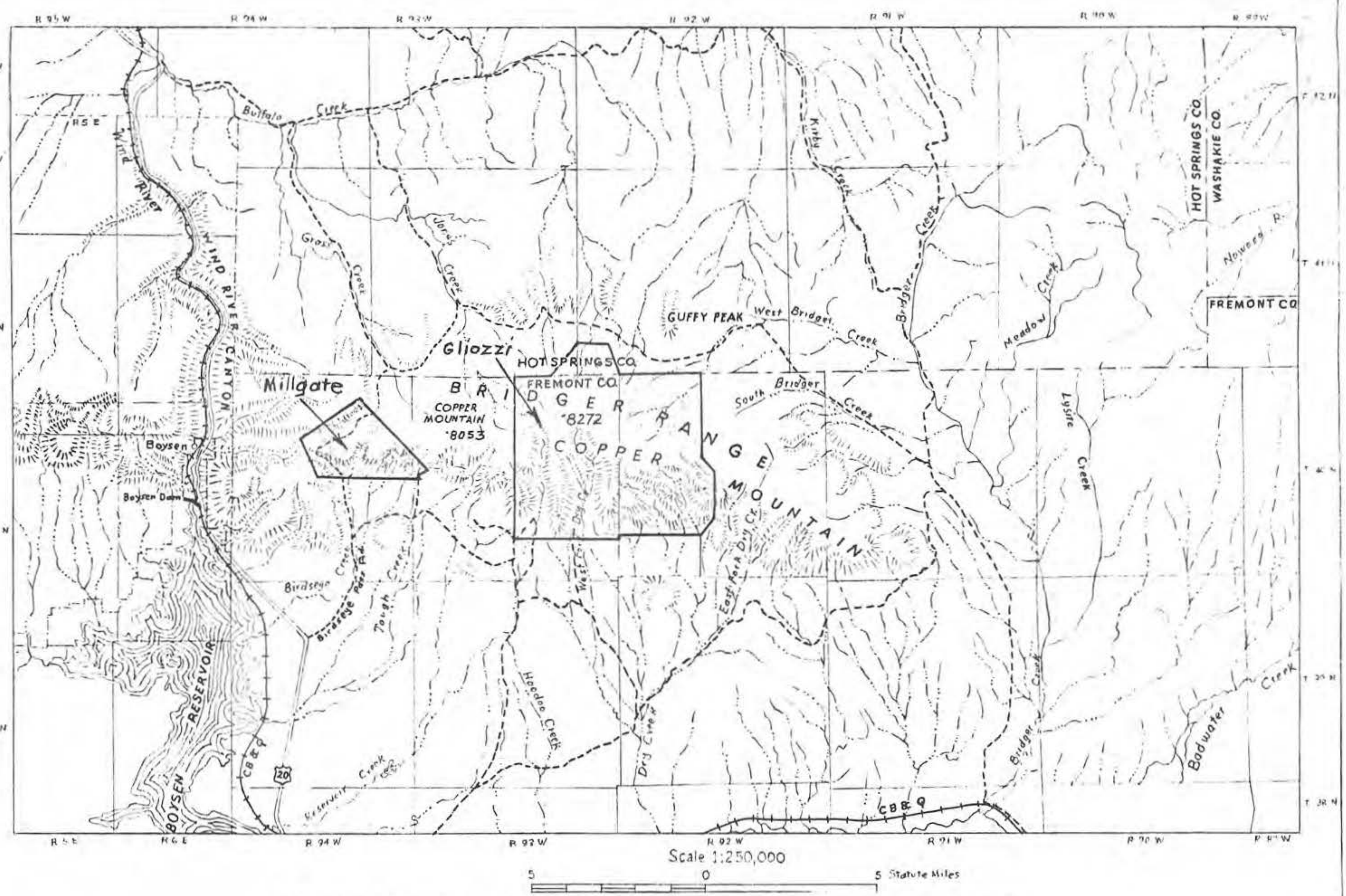

Fig 1- Index map of the Copper Mountain vicinity showing salient topographic features and principle routes of access; mapped areas shown in pink.

Mountain has been done by Tourtelot and Thompson (1948) and Tourtelot and Christman (1953). Lyon (1956) mapped the northeast flank of the Bridger Range with emphasis upon the sedimentary rocks. The uranium deposits of the area have been included in investigations under the auspices of the U. S. Atomic Energy Commission; Loomis and Mark (1957), Loomis (1956), and Love (1954). Pegmatites have been examined by McLaughlin (1940) and by Hanley and others (1950). Tungsten properties have been examined by the U. S. Bureau of Mines; Gunnell (1943) and Frey and Wilson (1950).

This report briefly summarizes the work of J. P. Gliozzi during the summer of 1960 and spring of 1961, W. H. Wilson in the summer of 1960, and M. L. Millgate during the summer of 1965. J. P. Gliozzi mapped much of the Guffy Peak quadrangle as part of a doctoral dissertation (in preparation), but the text was not available at time this report was prepared. Mr. Gliozzi's map was reduced, generalized, and is included in this report (Pl. 1, in pocket ~~at rear~~). Available text material is appended at the rear of this report. Descriptions of rock units can be found in the notes of W. H. Wilson (Appendix I ~~II~~), but most descriptions are of rocks at the west end of Copper Mountain and thus may not be wholly applicable to rocks in the central and east parts of the area. This report emphasizes the distribution of rocks of Precambrian age; detailed information concerning rocks of other ages must be gained from other sources (see References Cited).

TOPOGRAPHY AND CLIMATE

Copper Mountain is essentially the east-west trending highlands of the Bridger Range. Other uplands exist north of Copper Mountain, and in places are higher, but the summit and higher peaks of the Bridger Range are located on Copper Mountain. Elevations range from about 6,000 feet along the south edge of the area to 8,272 feet at the highest point. The area is precipitous, gradients of 1,000 feet per mile are common. For mapping purposes the area is best traversed on foot.

Vegetation consists of native shrubs and grasses, juniper and pine at higher elevations; and cottonwood, aspen, willow, elder, and ash along drainageways. On some slopes dense stands of juniper interfere with mapping, but the chief obstacle to the mapping of bedrock units is talus and slopewash derived from rocks upslope.

The climate is characterized by short, cool summers and harsh winters. In most years field work may be conducted from April to mid-October without serious inconvenience caused by weather. However, in some years field work can be done year-round in the lowlands south of Copper Mountain.

GENERAL GEOLOGY

Copper Mountain includes most of the outcrops of rocks of Precambrian age in the Bridger Mountains. There are some outcrops south of the mountain front in the lowlands, but these outcrops are of small extent. Rocks of Precambrian age consist of amphibolite, quartzite, greenschist, muscovite schist, biotite schist, diabase, granite, pegmatite, and quartz veins. For mapping purposes, the metamorphic rocks are divided into three units, marker units or marker zones are provided by well-foliated metamorphic rocks and can be traced for about three miles at the west end of Copper Mountain.

Amphibolite of varying texture and mineralogic composition occurs abundantly in the metamorphic sequence. For mapping purposes, amphibolite is included in the unit in which it occurs, although Gliozzi (pl. 1) mapped some of the larger amphibolite outcrops separately. The amphibolite is discussed separately.

The terms upper, lower, above, below, underlying, and overlying bear no age conotation when used with respect to rocks of Precambrian age. These terms refer to the present attitude of the rocks which, in general, strike easterly and dip southerly.

UNIT 1

Unit 1, the lowermost of the metamorphic complex, is found at the west end of Copper Mountain and can be traced about three miles eastward. Throughout most of this distance the unit is poorly exposed, being much covered by soil and detritus. The unit is cut by granite and pegmatite, and for this reason the lower layers are not known owing to their removal as a result of intrusion. Unit 1 lies below the iron formation and the top of the unit is arbitrarily defined at the top of a very distinctive tan to green, fine- to medium-grained, fuchsitic quartzite as much as 20 feet thick. Thus, the unit includes those metamorphic rocks below the top of this distinctive quartzite and between this quartzite and the granite outcrops to the north. Gliozzi (explanation, field map) mapped a "migmatite" unit below the iron formation consisting of "megoscopically veined hornblende schists with intercalated quartzites and quartz-mica schists". Gliozzi's map shows a layer of quartz-mica schist overlying this "migmatite" and in about the same stratigraphic position as the fuchsitic quartzite at the west end of Copper Mountain. Further, the first few layers of rocks overlying unit 1 are similar in both places. On the basis of gross similarity of rock units, unit 1 is correlated with Gliozzi's "migmatite" (Pl. 1).

Outcrops of unit 1 consist chiefly of amphibolite, micaceous quartzite and quartzite. Some thin layers of coarse-grained muscovite schist can be found in place and commonly expressed in float, but contacts are rarely seen. Gneissic amphibolite and amphibolite are abundant in the unit and in places make up most outcrops. Metasedimentary rocks seem to be mostly micaceous quartzites.

The thickness of the unit is variable because numerous amphibolites and lack of persistent marker beds have thus far prevented measurement between points of definite stratigraphic position. Gliozzi's map shows a maximum of about 2,200 feet of metamorphic rocks measured from the top of the quartz-mica schist to the granite outcrops to the north.

UNIT 2

Unit 2 is the best defined unit of metamorphic rocks in the area because of the included iron-bearing, magnetic quartzites and greenschists. Basal layers are not everywhere the same owing to abundant amphibolite. At the extreme west end of Copper Mountain the basal layer, overlying the fuchsitic quartzite of unit 1, is a coarse-grained muscovite schist of variable thickness; immediately below iron formation. In Gliozzi's area a coarse-grained muscovite-andalusite (?) schist overlies the quartz-mica schist in places, again immediately below iron-formation. However, in many places the basal layer is amphibolite or the basal layers are covered and their nature is not known. The top of the unit is more easily traced because it is arbitrarily placed at the top of the highest magnetic layer occurring in the area. This layer can be traced from the Birdseye Pass Road westward about three miles and is a very fine-grained, color banded, magnetic quartzite. Similar iron-bearing quartzites are shown on Gliozzi's map.

Individual layers of metasedimentary rock show good continuity along strike wherever they crop out. This characteristic is especially true of erosion-resistant quartzites. Many layers of the unit exhibit similar lithology. Thus only the distinctive layers, such as the erosion-resistant, magnetic quartzites, can be definitely followed from place to place.

Unit 2 is composed of amphibolite, magnetic quartzite, quartzite, magnetic greenschist, greenschist, muscovite schist bearing garnet, andalusite (?), or magnetite in places and a few thin layers of biotite schist.

Muscovite schist layers up to 50 feet thick underlie iron formation but in most places are not well exposed. Thin layers of biotite schist were measured in the course of measuring some of the magnetic layers, but unless biotite schist is intercalated with erosion-resistant quartzite or amphibolite it is generally not exposed.

Unit 2, again, is of variable thickness because of included amphibolite. At the west end of Copper Mountain the unit is about 1,750 feet thick, and Gliozzi's area iron-bearing layers are distributed through a stratigraphic interval of about 2,000 feet.

There are two iron-bearing, magnetic rock series; a lower magnetic series occurring near the base of the unit and an upper magnetic series at the top. Rocks occurring between the two series are composed chiefly of barren non-magnetic quartzite, amphibolite, and some muscovite schist.

Lower magnetic series. The lower series is about 150 to 200 feet thick and composed mostly of black to grey, poorly banded, platy, very fine-grained, magnetic quartzite interlayered with much, dark grey to black, fine-grained amphibolite. Hematite and goethite are present on weathered surfaces, but oxidation is not pronouced. Magnetite is the main iron oxide. Most iron-bearing quartzites are less than 30 feet thick.

The lower series is poorly exposed in many places. At the west end of Copper Mountain the best exposures are found in the E$\frac{1}{2}$ sec. 14, T. 40 N., R. 94 W., where the exposures are comparatively free of talus and slopewash. Here, there is less amphibolite than in most localities to the east or west. By visual estimate of incomplete exposures, at least 50% of the thickness of the lower magnetic series is composed of essentially barren amphibolite. In places, most of the series is composed of amphibolite. For example, in the NW$\frac{1}{4}$ sec. 14, there are thin, magnetic quartzites at about the top and bottom of the series, but the central portion consists entirely of amphibolite.

In section 13, T. 40 N., R. 94 W., and north of the point where Tough Creek debouches from the mountain front; the metamorphic rocks are fragmented by numerous pegmatite bodies. Pegmatite makes up hill tops and ridges and outcrops of metamorphic rocks are thus largely restricted to the sidehills where they are extremely difficult to trace because they are partially concealed by talus and slopewash. The pegmatite bodies are sills in part and represent a considerable addition of tough, barren material to the iron-bearing rocks.

Upper magnetic series. The upper magnetic series (App. III) consists of about 125 feet of magnetite-bearing quartzite and greenschist distributed through a stratigraphic interval about 375 feet thick. The series is composed of amphibolite, greenschist, quartzite, and some thin layers of muscovite schist and biotite schist. Four distinct magnetic units can be found in most places. In some places the top two magnetic units are separated by not more than 20 feet of amphibolite and greenschist. The thickest magnetic unit (App. III) thus far definitely known is the basal unit of the upper magnetic series consisting of magnetic layers aggregating at least 68 feet thick which are distributed through an interval about 91 feet thick; the barren layers being chiefly amphibolite and greenschist.

The magnetic portions of the upper magnetic series are composed of greenschist, some layers of which contain subhedral magnetite crystals over 1/4 inch long; and dark, poorly color banded, very fine-grained quartzite in much of which the contained magnetite can be identified in the field only by the magnetic properties of the rock. Oxidation due to weathering is not pronounced. In most places rocks showing hematite and goethite still retain their magnetic properties. Weathering is most pronounced in those areas where the erosion surface at the base of the Flathead formation of Cambrian age, formed on rocks of Precambrian age, has not been removed. Such areas occur in SE$\frac{1}{4}$NW$\frac{1}{4}$ and NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 15, T. 40 N., R. 94 W.

The upper magnetic series is essentially continuous from the Birdseye Pass Road eastward to the SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 13, T. 40 N., R. 94 W. where the series becomes largely concealed by detritus. Beyond section 13, the series is apparently missing for some distance because it is transected by the Boysen fault. The continuation is presumably subsurface south of the Boysen fault. Continuity of the series further eastward has not been established.

UNIT 3

Unit 3 includes the rocks above the iron formation. At the west end of Copper Mountain very little of the unit is exposed because outcrops are situated close to the south front of the Bridger Range and thus transected by the Boysen fault. To the east a greater thickness is exposed and on the southeast is in contact with a granite pluton. In general, the upper layers are poorly known at this time and a recognizable top is not established.

At the west end of Copper Mountain the unit consists chiefly of greenschist, gneissic amphibolite and amphibolite. Some non-definitive, poorly exposed quartzite and muscovite schist layers overlie iron formation and comprise the base in places. Gliozzi also shows some quartzite and muscovite schist lying immediately above iron formation from place to place, but most outcrops are composed of "hornblende-quartz-plagioclase gneiss" and "migmatite". The relationship, if any, between this migmatite and that included in unit 1 is not known at this time.

Other Exposures of Iron Formation.

Significant outcrops of iron formation occur in the east wall of the Wind River Canyon along U.S. Highway 20. These outcrops occur about $3\frac{1}{2}$ miles west of westernmost exposures at Copper Mountain. These magnetic layers are probably an extension of the iron formation at Copper Mountain because they are of similar lithology. If these layers are the equivalent of iron formation to the east, the extension should be revealed by magnetometer traverses across the intervening area which is largely covered by sedimentary rocks of Cambrian and later ages. Possible extensions of iron formation west and beyond Wind River Canyon are not known at this time. Similarly, extensions of iron formation to the northeast of Copper Mountain beyond section 7, T. 40 N., R. 92 W, are not known.

In the outcrops of rock of Precambrian age found in the lowlands south of Copper Mountain, iron formation is known to exist in the SW$\frac{1}{4}$ sec. 24 and NE$\frac{1}{4}$ sec. 25, T. 40 N., R. 94 W. The outcrops in sec. 24 are poorly exposed in places, but have not been mapped or closely examined. Outcrops in section 25 are of thin, poorly color banded, very fine-grained magnetic quartzites which are continuous for at least 1/2 mile. The thickness and possible relation to outcrops in section 24 are not known. The rocks strike easterly and dip at a high angle to the south. Although the lithology of the outcrops of iron formation in section 25 is similar to quartzites occurring at Copper Mountain a relationship between the two is not established.

The outcrops of rocks of Precambrian age south of Copper Mountain make up low hills which trend south into the Wind River Basin. Intervening valleys, between these hills, contain rocks of Tertiary and Quaternary age which conceal the older rocks. The rocks of Tertiary age consist of an andesitic tuff sequence (Tourtelot and Christman, 1953) which forms a veneer, probably on rocks of Precambrian age. Thus, these broad valleys near the mountain front may provide excellent areas for prospecting iron formation by geophysical methods and geophysical anomalies are probably sufficiently close to the surface to be explored by drilling.

Amphibolite

Amphibolite of varying texture and composition is abundant in the metamorphic complex. Near the tungsten prospects, amphibolite is apparently cross cutting with respect to the metasedimentary rocks (Gunnell, 1943, p. 4; Frey and

and Wilson, 1950, p. 4) and thus represents mafic igneous intrusives emplaced prior to metamorphism.

At the west end of Copper Mountain, no clear cross-cutting relationships were observed, although in places amphibolite seems to occur where one would normally expect to find a layer of quartzite or greenschist. The iron-bearing layers of the upper series contain amphibolite from place to place, but are not appreciably distorted and in no place can be clearly demonstrated to be missing. In the lower magnetic series, some iron-bearing layers seem to be missing - but this occurs in areas of poor outcrop and the absent layers may eventually be found. The amphibolite occurs as sills greatly persistant along strike, and probably distending the metasedimentary rocks which they intrude. The sills range from one foot to several hundred feet in thickness and in most places are closely spaced. Amphibolite is more resistant to erosion than much of the metasedimentary rock and makes up most outcrops in areas where soil and detritus are abundant. ~~common.~~

Amphibolite ranges in character from nearly monomineralic, black, fine-grained, well foliated hornblende schists through equigranular, medium- to coarse-grained hornblende-plagioclase hornfels to very fine- to medium-grained, poorly foliated, gneissic amphibolite in which thin ($\lt 1$ cm.) feldspathic veins give the rock its gneissic appearance. Some quartz occurs in most amphibolite, both in veins and as discreet grains.

Some of the light colored amphibolite (App. III) which occurs chiefly in quartzose metasedimentary rock may ultimately be shown to contain considerable amounts of ziosite or clinozoisite, because these minerals have been found near the tungsten prospects to the east.

Granite

Gliozzi mapped two extensive exposures of "two feldspar, homogeneous granite". These exposures are apparently a granite pluton or plutons.

At the west end of Copper Mountain in the vicinity of the headwaters of Birdeye Creek large granite masses, cross cutting the metamorphic rocks in part and much intruded by pegmatite, make up the higher ridges. To date the granite is inadequately mapped, but is mostly a coarse grained, pink, microcline (?) granite. The chief dark mineral in the granite is biotite.

Granite Pegmatite

Pegmatite dikes and sills, some of large size, intrude granite and metamorphic rocks. Most pegmatites are of simple mineralogy with quartz and potash feldspar the main constituents. There are some pegmatites which con~~t~~din appreciable plagioclase feldspar and have complex mineral assemblages including beryl, columbite-tantalite, and lepidolite (Hanley and others, 1950, p. 109-112).

At the west end of Copper Mountain the pegmatites occur as dikes which strike about north-south and dip to the west from 50 to 90 degrees. These dikes are mostly quartz-potash feldspar rich varieties.

In the vicinity of Tough Creek the pegmatites are complex sills and associated dikes, again mostly composed of quartz and potash feldspar. Sills may be as much as 50 feet thick, and where closely spaced, sills may aggregate well over 100 feet in total thickness. These numerous pegmatite dikes and sills are deleterious with respect to iron formation and greatly complicate evaluation of the iron resources.

Quartz Veins

Abundant quartz veins transect all rocks. Most veins are composed of coarsly crystalline, milky, anhedral quartz aggregates commonly stained by thin coatings of hematite and limonite. Weak copper and gold mineralization is associated with some of these veins. In two pegmatite dikes there occurs cross-cutting, coarsly crystalline, subhedral to euhedral, quartz masses. Associated with these masses are minor amounts of copper-iron sulfides and their weathering products.

In addition to the veins there occurs fairly large areas of silicification due to quartz emplacement. These areas appear to be made up of innumerable, small, coalescing and branching quartz veins and veinlets in a matrix of metamorphic rocks and pegmatite. Much of the matrix appears silicified. No mineralization directly associated with silicified zones was noted - however the areas were not examined for the occurrence of scheelite nor tested for gold.

Rocks of Cambrian and later Ages

Sedimentary rocks of Cambrian, Ordovician, Mississippian, and Pennsylvanian age occur on the flanks of Copper Mountain. In the lowlands south of Copper Mountain rocks of Paleozoic age are exposed in fault blocks which make up the higher hills.

Rocks of Tertiary age are found in the lowlands and are chiefly the andesite tuff sequence of Tourtelot and Thompson (1948). On ridges next to the mountain front and in some valleys the tuff sequence contains bentonitic clays. Where observed, these bentonitic clays support very little vegetation and when dry exhibit ~~the friable,~~ a friable and a desiccated structure typical of bentonite beds of Cretaceous age found elsewhere in Wyoming. In most places these clays are carpeted with coarse sand and gravel derived from the gravels of Quaternary age which overlie the tuff sequence. The bentonitic clays have not been closely examined so the thickness, persistence, and physical character of theclays are not known. However, outcrops of bentonitic clay are quite extensive and the clay should be evaluated because it may prove to be a usable commodity. Specifically, outcrops of bentonitic clay occur on ridges in the SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 14 and E$\frac{1}{2}$E$\frac{1}{2}$ sec. 24, and in a broad valley located in SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 24 and NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 25, all in T. 40 N., R. 94 W.

Structure

Considered in a regional sense, the structure of rocks of Precambrian age is fairly simple, but in detail is extremely complex. For example, the attitudes of the metamorphic rocks in the Bridger Range define a homocline, but the configuration of granite and pegmatite bodies and the structural significance of many amphibolite layers is difficult to decipher. The metamorphic rocks are fairly continuous and other than a steep southerly dip do not seem to be greatly deformed. The occurrence of iron formation in the lowland, and considerably removed from similar rock at Copper Mountain is suggestive of faulting and/or folding of the metamorphic rocks, but the nature of such deformation is at this time speculative. In view of the assumption that most amphibolite is probably intrusive into a now metasedimentary and metavolcanic sequence and the fact that the pegmatites are most likely intrusive, the metasediments are not greatly displaced. Numerous zones and layers are continuous along strike for several miles. These statements may not be entirely true of Gliozzi's area because of the occurrence of large outcrops of granitic rocks and because Gliozzi mapped a fault zone in metamorphic rocks for a considerable distance. However, Gliozzi was able to trace some essentially continuous rock layers for distances of about 4 miles.

Several small faults striking about N 60° E and having a near vertical dip occur cross cutting iron formation in section 15, T. 40 N., R. 94 W. These faults consist of breccia zones 2 to 15 feet wide and some layers of iron formation show horizontal displacements of not over 10 feet.

Attitudes of rocks of Cambrian through Pennsylvanian age define a large east-west trending, asymetric anticline. The steep limb is the south limb, and the oldest rocks exposed in the ~~core of the~~ anticline are the rocks of Precambrian age of the Bridger Range. The Boysen fault transects the north ~~south~~ limb of this anticline and near the Birdseye Pass Road the Amsden formation of Pennsylvanian age is placed against rock of Precambrian age to the north. Thus, the throw of the fault in this area is well over 1000 feet. The dip of the Boysen fault is not known, but judging from fault trace, the dip is probably high angle to the south. Thus, the Boysen fault is a normal fault here as it is elsewhere (Fanshawe, 1939). The fault can be traced from the western edge of the area to where Tough Creek emerges from the mountains and here, the fault apparently extends up Tough Creek and cannot be traced in rocks of Precambrian age. The Boysen fault is probably later than the andesitic tuff sequence of Tertiary age, because none of tuff sequence was observed north of the fault. However, no effort was made to find broken rocks of Tertiary age along the fault.

The Boysen fault has economic significance with respect to the iron formation because it transects layers of the upper magnetic series in the vicinity of Tough Creek and may transect iron formation in places in subsurface between Copper Mountain and the Wind River Canyon.

The outcrops of iron formation in sec. 25, T. 40 N., R. 94 W. are bounded on the south by a high angle fault (Tourtelot and Thompson, 1948) along which the Gros Ventre and Gallatin formations of Cambrian age are placed against rocks of Precambrian age. This fault is apparently earlier than rocks of Tertiary age. The fault in section 25, and the fault zone extending to the east, mark about the southern limit of the area in which iron formation found in the lowlands may be reasonably expected to occur near land surface.

ECONOMIC CONSIDERATIONS

Iron Formation

Present information indicates that the iron formation in the Copper Mountain area is not anywhere sufficiently rich in iron to constitute direct shipping iron ore. The iron in the rock occurs mostly as magnetite which can be concentrated and used as a source of iron. The value of the iron formation depends upon its ammenability to mining and concentration.

J. P. Gliozzi, by X-ray fluorescence methods, assayed samples of iron formation for total iron content. Fe_2O_3 - SiO_2 mixtures were used as standards and SiO_2 as a dilutent for iron rich samples (App. ~~III~~ II). Gliozzi analyzed eight samples of iron formation (Table 1) which range from about 20.1 to 30.4 percent iron and average 24.8 percent iron. No information is presently available to indicate the thickness of iron formation represented by Gliozzi's samples and in this report are considered to be grab samples.

Table 1 - Location and grade of samples of iron formation determined by X-ray fluorescence methods.

Sample No.	Location in T. 40 N., R. 93 W. (approximate)	Total Fe * %
IF-100-32	1250 ft. W., E. line; 1790 ft. S., N. line; sec. 12	28.17
IF-100-33	1250 ft. W., E. line; 1790 ft. S., N. line; sec. 12	25.86
IF-100-34	1250 ft. W., E. line; 1790 ft. S., N. line; sec. 12	30.40
IF-100-51	440 ft. E., W. line; 2360 ft. N., S. line; sec. 13	20.06
IF-100-7	1170 ft. E., W. line; 1620 ft. S., N. line; sec. 13	22.09
IF-100-8	1070 ft. E., W. line; 1520 ft. S., N. line; sec. 13	24.94
IF-100-13	810 ft. E., W. line; 260 ft. S., N. line; sec. 23	25.23
	Average (7 samples)	25.2
IF-100-52	Location not known	21.62
	Average (8 samples)	24.8

* Analyst, J.P. Gliozzi

W. H. Wilson (App. ~~II~~ I) found that a composite of grab samples from the area near Hoodoo Creek assayed 31.1% iron

Samples and assays were obtained for a section (App. III) of the upper magnetic series in sec. 15, T. 40 N., R. 94 W., (Pl. 1). The samples are mostly chip samples taken at the surface across exposed intervals. Some are grab samples. Samples taken from the uppermost magnetic unit (CM-16-11-11 and CM-17-11-11) were combined for assay because they are essentially grab samples even though available outcrops were chipped. The results of assay of samples CM-14-11-11 and CM-15-11-11 were combined for presentation in the table because there is no great difference in the character of rock samples.

For iron determination, the pulverized sample was leached in 1:1 boiling HCl designed to take the iron oxides into solution and, as nearly as possible, to leave quartz and iron-bearing silicates in the residue. Assay results are intended to represent iron oxide content of the rock and give some indication of the magnetite which might be available for concentration by magnetic methods. For this reason the iron content is finally expressed as equivalent magnetite. Some of the iron oxides are hematite and goethite not readily separable by magnetic means, but most of the iron oxide is magnetite.

The grade of the samples was assumed to represent the grade of the magnetic layers (Table 2). The magnetic units include layers of essentially barren rock and have less iron content (Table 3.) These included barren layers probably would not be avoided during any mining operation and would constitute a dilutent of the iron formation. The nature of the barren layers included in magnetic units as well as those between magnetic units can be found in Appendix III.

Table 2 - Samples and Assays * of the Upper Magnetic Series, Unit 2.

1. Sample No.	2. Magnetic unit in series	3. Sample thickness (ft.)	4. Thickness of magnetic layers (ft.)	5. Fe oxide (%)	6. 3 x 5	7. 4 x 5
CM-16 & 17-11-11	4	4.2	22.2	15.6	65.5	346.1
CM-14 & 15-11-11	3	13.6	13.6	10.1	137.2	137.2
CM-12-11-11	3	4.9	8.5	6.6	32.3	56.1
CM-11-11-11	2	2.9	4.6	9.8	28.4	45.1
CM-10-11-11	2	5.6	7.8	9.8	54.8	76.5
CM-9-11-11	1	11.7	11.7	8.1	94.8	94.8
CM-8-11-11	1	4.4	4.4	10.6	46.6	46.6
CM-7-11-11	1	8.1	8.1	12.0	97.3	97.3
CM-6-11-11	1	13.0	13.0	6.9	89.8	89.8
CM-5-11-11	1	10.5	10.5	19.1	200.5	200.5
CM-4-11-11	1	1.1	1.1	7.8	8.6	8.6
CM-3-11-11	1	4.4	4.4	10.9	48.0	48.0
CM-2-11-11	1	5.2	5.2	16.3	84.8	84.8
CM-1-11-11	1	9.2	9.2	19.1	175.8	175.8
	SUM.	98.8	124.3	162.7	1164.4	1507.2

Average grade of the sampled thickness 11.8% Fe (16.3% Fe_3O_4 equiv.)

Average grade of magnetic layers, assuming sample grade is representative of the layers, 12.2% Fe (16.7% Fe_3O_4 equiv.)

Average grade of magnetic units within series - not including thick, intervening barren layers (App. III).
9.5% Fe (13.1% Fe_3O_4 equiv.)

* Samples assayed by Natural Resources Research Institute, University of Wyoming, Laramie, Wyoming.
Analysts, B. Davis and R. Wise.

Table 3 - Percent Iron and Percent Equivalent Magnetite for Magnetic Units of the Upper Magnetic Series, Unit 2.

1. Magnetic unit in series	2. Total sample thickness (ft.)	3. Total thickness of magnetic layers (ft.)	4. Total thickness of unit (ft.)	5. Summation 3 x 5 Table 2	6. Summation 4 x 5 Table 2	7. 5/2 Average grade of samples %	8. 6/3 Average grade of magnetic layers %	9. 6/4 Average Fe content as oxide %	10. 9 X (1.38) ~~6/4 (1.38)~~ Average equivalent magnetite %
4	4.2	22.2	24.0	65.5	346.1	15.6	15.6	14.4	19.9
3	18.5	22.1	27.8	169.5	193.3	9.2	8.8	7.0	9.6
2	8.5	12.4	15.7	83.2	121.6	9.8	9.8	7.7	10.7
1	67.6	67.6*	91.2	846.2	846.2	12.5	12.5	9.3	12.8
SUM.	98.8	124.3	158.7	1164.4	1507.2				

* A 14 foot thick zone, magnetic in part, was poorly exposed and not sampled. This zone is considered as being without value.

iron

The iron content (as oxides) of the magnetic layers range from 6.6 to 19.1 percent and average 12.2 percent. The magnetic units contain 7.0 to 14.4 percent iron and average 9.5 percent. Equivalent magnetite content of the magnetic units ranges from 9.6 to 19.9 percent and averages 13.1 percent.

The assay data indicate that iron formation in the central and eastern parts of the Copper Mountain area may have higher iron content than the upper magnetic series at the west end.

The magnetic units composed mostly of magnetic greenschist do not contain as much iron as the quartzites. For example, the two middle magnetic units (Table 3) contain less than eight percent iron whereas the other two units contain more. This difference is also generally true of individual magnetic layers. Most magnetic quartzites contain considerably more iron than magnetic schists.

Two samples of magnetic quartzite were assayed for titanium and phosphorous (App. III). Titanium content ranges from 0.3 to 0.4 percent and phosphorous content is about 0.1 percent. It is not known to what extent titanium and phosphorous will follow the concentrate during magnetic separation.

Available information indicates that the magnetite in iron formation is liberated only by fine grinding. Wilson (App. I, p. 3) found that iron formation from Hoodoo Creek yielded 99 percent concentrate when ground to between 40 and 100 mesh and that about half the magnetite was not liberated. The writer passed essentially minus-100 mesh material through a magnetic separator and recovered about 93 percent of the material in the magnetic fraction. Much of the material was of fine size and did not flow regularly, so part of the 93 percent concentrate represents entrapment of barren material. Assays conducted on samples ground to minus-100 mesh yielded erratic results. Because of erratic assays the initially pulverized samples were ground about 18 hours in laboratory, ceramic ball mills. This final grinding yielded material about 99 percent minus-200 mesh, which was assayed for iron.

The enormous tonnages of iron-rich rock necessary to a mining operation where bulk concentration is required, are not readily available at land surface in the places examined. Dips range from about 45 degrees to over 70 degrees and known magnetic units are on the order of 100 feet thick. Thus, much stripping would be required to gain access to appreciable quantities of iron formation. At the west end of Copper Mountain there is considerable barren rock interlayered with iron formation. Most likely some provision must be made to eliminate much of this barren rock from the final concentration process to prevent grinding of excessive quantities of worthless material.

Copper

Small occurrences of copper-bearing minerals are found widely distributed in the area, mostly in prospect pits and cuts and in the dumps of adits and shafts. Copper mineralization is associated with some of the numerous quartz veins and possibly with pegmatite dikes and sills. Most of the occurrences are inadequately prospected and little can be said of their economic potential. Exposures of mineralization in place are poor and little information can be gained concerning the structure of the deposit. Prospects in which copper mineralization was noted are indicated on the map (Pl. 1). At the west end of Copper Mountain none of the prospects have yielded copper ore.

In most places the chief copper-bearing mineral is malachite occurring as fracture and surface coatings, along the contacts of quartz veins with country rock, and sparsely disseminated in the country rock, chiefly the micaceous quartzites. Iron-copper sulfides occur in some prospects in the SW$\frac{1}{4}$ sec. 13, T. 40 N., R. 94 W. Those prospects in SE$\frac{1}{4}$ sec. 13 show sparse malachite in places.

In the SW$\frac{1}{4}$ sec. 13 sulfides occur in association with quartz in pegmatite in two places and in association with quartz veins in metamorphic rock in the bottom of a ravine on about the center line of sec. 13 (Pl. 1). The quartz veins in the pegmatites are probably cross cutting and in places enlarge to form irregularly shaped, poorly crustiform and comb structured masses bearing some chalcopyrite, bornite, covellite (?), malachite, hematite and goethite. Mineralization seems mostly restricted to the periphyry of the masses because most interiors are composed of white, clean, quartz crystals. In the bottom of the ravine 2 quartz veins, mostly cutting amphibolite are mineralized. Mineralization on weathered surfaces is malachite coatings. In 2 prospect pits a quartz vein striking about N 54° W, parallel to the metamorphic rocks but dipping more steeply to the south, is mineralized. The vein is three inches to one foot thick, vuggy and contains sparse chalcopyrite, bornite, pyrite, covellite (?), malachite, hematite and goethite. A few small patches of manganese oxides are found on some surfaces.

Gold

Gold Nugget Mine. According to local residents this mine was worked for gold in the ~~early~~ 1930's, but at this time nothing further is known of the mining history.

Mine workings consist of two adits, now caved at the portal, and some prospect pits located in NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 14; and one adit, caved at the portal, some prospect pits, and a small open pit in SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 11; all in T. 40 N., R. 94 W. Most of these workings are shown on the Birdseye Pass (7$\frac{1}{2}$') topographic quadrangle. The adit in sec. 11 may still be accessible through two ventilation shafts, but the shafts are badly caved and entry was not attempted.

Remnants of the mining camp, including a mill house which is standing, are located in NW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 14, along an east fork of Birdseye Creek.

Judging from material still in the bins of the mill house and from dump material of the adits, most production of rock came from the adit in sec. 11 and was trammed or chuted via a trestle to a loading point about half way between the adit and the mill.

The rock presumably milled consisted of medium to coarsly crystalline, hematite and limonite stained quartz won from quartz dikes and sills in the metamorphic complex. A few, small patches of malachite and a fleck of grey sulfide, possibly galena, were observed on the adit dump. Elsewhere, no mineralization was found.

The adit in sec. 11 bears about N. 64° E. at the portal, transverse to the metamorphic rocks which strike about N. 86° W. and dip 61 degrees southwest. At the surface, the quartz sills and dikes, mostly sills, are 1/2 to 2 feet thick and bear sparse potassium feldspar and muscovite. Thus these sills and dikes may be more closely related to pegmatites than to the later stage of quartz veins. The country rock is chiefly hornblende amphibolite, biotitic in part, and micaceous quartzite.

CONCLUSIONS

Iron formation occurs extensively in rocks of Precambrian age in the Copper Mountain area. Outcrops are in places concealed by rocks of later age, displaced along the Boysen fault, and not completely mapped or sampled. Thus, the potential of the iron formation as a source of magnetite concentrate is subject to change with the accumulation of additional geological information as well as with improving technology and fluctuating economic conditions.

Outcrops of iron formation can be traced discontinuously for about 11 miles from the east wall of Wind River Canyon eastward into sec. 7, T. 40 N., R. 92 W. Other outcrops of unknown extent occur in the lowlands immediately south of Copper Mountain. The extent of iron formation in subsurface is not known but can probably be determined in many places by use of magnetometers.

At the west end of Copper Mountain, individual magnetite-bearing layers of greenschist and quartzite are 5 to 30 feet thick, and where intervening barren layers are thin these layers comprise essentially magnetic units ranging from 15 to over 90 feet thick. The units may be separated by barren schists and quartzites up to 150 feet thick. The magnetite-bearing rocks occur in two magnetic series occupying stratigraphic intervals which range from 150 to about 375 feet in thickness. Thicknesses of iron formation are not well known elsewhere in the Copper Mountain area, although Wilson (App. I, p. 1) found thicknesses of iron-bearing rock up to about 75 feet thick.

Available assay data show the iron content of the rock ranges from 6.6 to 31.1 percent. In some assays for total iron, all iron does not occur as magnetite and cannot be readily separated by magnetic methods. The outcrops of iron formation occurring in the central and western parts of the Copper Mountain area may be richer in iron than those found at the west end of the area. In general, magnetite is the only mineral of importance with respect to iron and occurs most abundantly in the magnetite-bearing quartzites. The magnetic schists contain less iron and therefore less magnetite. Magnetite occurs chiefly in very small particles, because magnetic separation of magnetite was not achieved when samples were ground to essentially minus-100 mesh particle size.

Amphibolite, pegmatite, and quartz veins occur within and cross cutting iron formation. These rocks do not contain appreciable quantities of magnetite and thus are essentially barren rock which may imperil the success of mining and milling procedures. For example, iron formation in the vicinity of Tough Creek may never be exploited, solely because of the occurrence of thick, closely spaced pegmatite sills which are interlayered with the metamorphic rocks. In addition to barren rocks, tonnages of iron formation available at land surface are limited because of steep dips.

Iron formation in subsurface can be prospected by geophysical methods and in some places is near land surface. The area between the west end of Copper Mountain and the Wind River Canyon, the broad valleys covered by rocks of Tertiary age south of Copper Mountain, and the area near the East Fork Bridger Creek all are favorable for prospecting by geophysical means. Areas in which iron formation might be thickened by faulting or folding are not known at this time, but may ultimately be found either in subsurface by geophysical means or at the surface in extensions of known outcrops.

Other commodities of interest occurring at the west end of Copper Mountain include copper, gold, and bentonitic clay. Copper and gold mineralization occurs in association with quartz veins, but these commodities are mostly within the prospect stage of development. Bentonitic clays, possibly of economic significance, occur south of Copper Mountain in an andesitic tuff sequence of Tertiary age but little is known of their extent or physical properties.

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NOTES ON IRON OCCURRENCES ON COPPER MOUNTAIN, FREMONT COUNTY

Introduction

Two distinct types of iron deposits occur in ~~Copper Mountain. They are~~ the Precambrian rocks of Copper Mountain. The first, and of possible economic significance, is a taconite-type of deposit that crops out on the Hoodoo Creek drainage and is also reported to crop out on the Dry Creek drainage to the east (J. Gliozzi, oral communication). These deposits are currently being studied by Gliozzi as part of his doctoral dissertation at the University of Wyoming.

The second type of occurrence, ~~is~~ crops out as local concentrations of specular hematite in granite. These are of mineralogical interest ~~only~~, but ~~since they~~ have no economic significance because of their small size.

Location: SE¼ sec. 15, NE¼ sec. 22, NW¼ sec. 13, T. 40 N., R. 93 W.
Elevation: 7,000 to 7,300 feet.
Date Examined: May 28, 1960.

Field Occurrence

Rocks cropping out in the Hoodoo Creek area consist of an unknown thickness of metasediments crosscut by pegmatite dikes and lenses. In the area of iron mineralization, these beds strike N. 50° - 65° E. and dip about 50° south-southwest. Approximately 125 feet of iron-stained quartzite, magnetite schist, amphybolite and/or hornblende schist, and banded taconite are partially exposed here. Approximately 75 feet of this sequence is believed to be iron-bearing. Although the quartzite appears to rest on top of the iron-bearing sequence, it is possible that the units are overturned. No evidence was observed, however, which would substantiate or reject this possibility.

Similar beds, having approximately the same strike, are also known to occur on West Fork of Dry Creek (NW$\frac{1}{4}$ sec. 13). If iron mineralization is continuously present between the two exposures, then the deposit is at least one and one-half miles long.

About one-half mile further up Hoodoo Creek (NE$\frac{1}{4}$ sec. 15) is another sequence of similar rocks containing magnetite schists and taconites. Although these were not examined by the writer, Gliozzi (oral communication) reports that the total thickness is in the order of 1,800 feet. It is not known at this time how much of this sequence is mineralized.

Lithology

At least two lithologic types of iron-bearing units are present. The exposed upper ~~[illegible]~~ (not necessarily stratigraphic) cartographic unit is a massive layered taconite which is composed of bands of dark gray magnetite and quartz varying from ~~one~~ 1 to ~~six~~ 6 mm in thickness. Intercalated within the above are orange-gray laminations $\frac{1}{2}$ - 3 mm thick which are composed mainly of magnetite and other unidentified silicates and thin red laminations of hematite and quartz up to 1 mm in thickness. Minor crenulations and folds of shallow amplitude occur in this unit.

The lower exposed cartographic unit is a finely banded magnetite schist. It is composed of alternating laminations of dark gray magnetite up to $2\frac{1}{2}$ mm thick separated by grayish-orange laminations of quartz and other silicates up to 1 mm thick. Individual units as described above probably vary from 10 to 15 feet thick, however, some are not entirely exposed and may be thicker.

Grab samples from the above beds were collected and composited. The composite sample was ground to between 40 and 100 mesh. This was run through a magnetic separator, but was unsuccessful, since about 99 percent of the faction was magnetic. Microscopical exmaination indicated that the grinding was not fine enough, since, about 50 percent of the magnetite was not liberated from the matrix. The sample was then assayed by the Natural Resources Research Institute (at the University of Wyoming) who reported that it contained 31.1 percent iron.

Location: NW$\frac{1}{4}$ sec. 32, T. 40 N., R. 92 W.
Elevation: 5,900 feet.
Date Examined: December 12, 1960.

Field Occurrence

Specular hematite, disseminated in Precambrian granite, occurs in at least three separate outcrops. Two of these crop out on small ~~hills~~ knolls of the low hills in the NW$\frac{1}{2}$ NW$\frac{1}{4}$ sec. 32. The third, which is exposed in a shallow, partially caved, shaft is located about 600 feet south of the north quarter corner of section 32. All three of the deposits are located just west of the contact of the Upper Eocene Tepee Trail formation with the Precambrian rocks. Just east of these iron occurrences, in NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 32, is a small sub-surface uranium deposit that has been blocked out by the Utah Construction and Mining Corp. No data is currently available on this deposit; however, it is known to occur in the Tepee Trail formation.

The easterly occurrence of the two hematite prospects (in NW$\frac{1}{2}$ NW$\frac{1}{4}$ sec. 32) is a lens- or vein-like body that is approximately 90 feet long, 20 feet wide, and is exposed to a depth of about 15 feet. The body strikes about N.75°E. and dips 78° northwest. The westerly body, which occurs approximately on the projection of the above strike, is more pod-shape in outline. It is about 40 feet in diameter and exposed to a depth of about 20 feet. Actually this body grades from unmineralized pink granite to a more progressively increasing concentration of specular hematite towards the center.

The third occurrence of hematite is exposed in a 10-foot deep, partially caved shaft which was sunk a seven-foot wide zone of hematite-impregnated altered granite. This zone appears to dip about 52° to the south. Within this zone is a vein-like structure that is composed almost entirely of specular hematite that varies in width from 23 inches at the bottom of the shaft to 5 inches at the top. This structure strikes about N. 80° W. with a vertical dip. The length of the zone is unknown, since, it is not exposed along the strike beyond the shaft.

Lithology

The host rock is a pink coarse-grained granite composed of quartz, orthoclase feldspar, and a varying percentage of specular hematite. This grades locally into a medium-grained granitic rock in which the percentage of hematite increases markedly to more than 50 percent. The specular hematite occurs as irregular veinlets and clots between the interfaces of individual feldspar and/or quartz veins. In places, it partially penetrates fracture and cleavage surfaces in such grains.

Locally, the percentage of hematite increases to the point where it makes up at least 90 percent of the rock. These irregular masses occur grading into a light gray medium-grained granite that appears to contain less quartz than the pinker variety. At the shaft, the light gray granite is crosscut by a random network of irregular quartz veins, lenses, and pods up to several inches wide. In this case, the granite appears to have been fractured and mildy brecciated by the invasion of these quartz veins, since individual granitic fragments are surrounded by a thin veneer of specular hematite. Specular also occurs lining or coating on the interface between granite and quartz.

Signed.

/s/ W. H. Wilson

A preliminary investigation of the rocks of the Copper Mountain district, Fremont County, Wyoming, by means of x-ray fluorescence.

by

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- -

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April 1, 1961

INTRODUCTION

This paper represents a limited x-ray study of the amphibolites and iron formations of the Copper Mountain district, Fremont County, Wyoming. The investigation involves a two-fold analysis: 1) a study of the trace element content of the representative rock units, and 2) a study of the iron content of the iron formations of the area.

The first area of investigation was undertaken in hopes of discovering some critical constituent of the amphibolites which might aid in subdiving the seemingly homogeneous lithology which appears to vary only in texture. It was also the writer's hope that the character of the trace element content might indicate a possible origin for these rocks as suggested in much of the current literature on amphibolite paragenesis.

The second area of study stemmed from an earlier project in which a rapid method for determining the iron content of various mixtures of minerals by x-ray fluorescences was attempted. This method was then applied to the iron formations in order to asses rapidly their economic potential.

PROCEDURE

General Statement

This research project was performed with the aid of a General Electric XRD-5 x-ray unit equipped with a tungsten tube. This unit was operated at 50 K.V.P. and 50 M.A. power with a range of 5,000 C.P.S. and a time constant of 1 second for all phases of the study.

Trace Element Study

Representative samples of the amphibolites of the Copper Mountain district were prepared for the x-ray fluorescent study by grinding the samples in a Fisher Mortar Grinder until they were reduced to a fine powder which could readily be packed in the x-ray sample holder. The samples were then subjected to tungsten radiation through a 2θ angle ranging from 5 to 130 degrees at which time a continuous chart record was made. The chart record was then read for its trace element content.

Iron Content Determination

A rapid method of determining the iron content of mineral mixtures was attempted by mixing known quantities of Fe_2O_3 and SiO_2. The intensity of the $K\beta$ peak of iron was determined and a graph was prepared from this information.

The iron ores of the Copper Mountain district were diluted with SiO_2 to prevent saturation of the counter and then irradiated for the $K\beta$ intensity. The intensity was then checked against the determined graph for the iron content of the mixture of iron ore and silica. This apparent concentration was then used to calculate the actual concentration of the ore according to the calculations:

1) $\frac{\text{weight of iron ore}}{\text{weight of iron ore} + \text{silica}}$ equals percent ore in diluted sample ;

2) $\frac{\text{percent iron(determined from intensity \& graph)}}{\text{percent ore}}$ times $\frac{X}{100}$

where X equals the actual percent concentration of iron.

Mixtures of iron ore and silica were used so that the x-ray unit could be operated at full power and not have the K_β peak intensity greater than the recording capacity of the apparatus. Also, the prepared graph is good only for mixtures of below 18 percent iron concentration. It was found that mixtures of higher concentration were almost impossible to mix properly, and the dashed line just beyond 14 percent concentration on the graph represents the area in which normal mixing procedures fail.

RESULTS

Trace Element Study

The chart record for both amphibolite and iron formation samples indicated that these rocks contain cobalt, manganese, strontium, and nickel in minor quantities. The results of this part of the study are summarized in Table I (page 4).

Cobalt, if present, is in extremely small quantities and limited to the amphibolite rocks. Its presence in most of the amphibolite samples, however, is questionable since the peaks for this element are barely greater than the intensity of the background count.

The greatest quantity of manganese is found in the amphibolite samples. Some iron formation samples also indicate the presence of manganese, but the intensity of these peaks is consistantly lower than those of the amphibolites.

Table I. Trace element distribution in the rocks of the Copper Mountain district, Fremont County, Wyoming

Sample Number	Co	Mn	Sr	Ni
Am 100-28	?	x	x	?
If 100-33	-	-	-	-
If 100-7	-	-	-	-
If 100-34	-	-	-	-
Am 100-11	?	x	x	x
If 100-8	-	-	-	-
If 100-32	-	x	-	-
If 100-13	-	*	-	-
If 100-52	-	x	-	-
If 100-51	-	x	-	-
Am 100-50	?	*	-	-
Am 100-17	?	*	x	-
Am 100-30	?	x	*	-
Am 100-61	?	x	x	-
Am 100-12	?	x	*	-
Am 100-43	?	x	x	-
Am 100-27	?	x	x	x
Am 100-14	?	x	x	?
Am 100-18	?	x	x	-

Explanation

Am - Amphibolite rock samples.
If - Iron formation rock samples.
x - Good peak, element definitely present.
* - Peak distinguishable, minor amount present.
? - Peak questionable above background, minor trace if present.
\- - Element definitely not present.

The element strontium is limited in its occurrence to some of the amphibolite rocks. Here it is probably present in limited substitution for calcium of the plagioclase feldspars. Though not present in all the amphibolite samples, no significance could be inferred from its distribution.

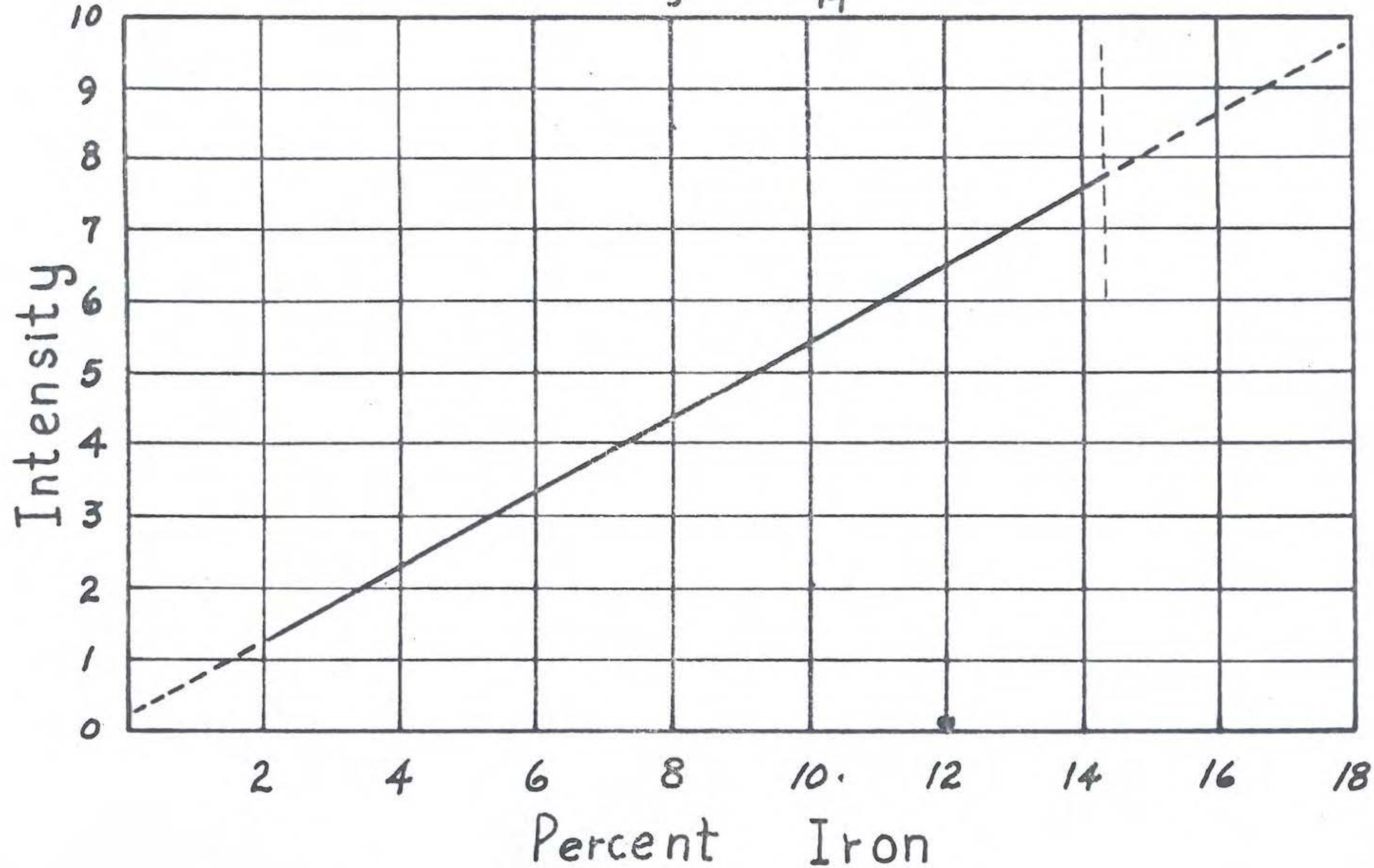
Nickel was detected in only a few of the amphibolite samples. It is interesting to note, however, that only amphibolite bodies which the writer interpreted in the field as of possible igneous origin contain nickel. The sampling is much too limited at this time to make any conclusions.

In general, no pattern as to the distribution of trace elements is discernable by the writer for further subdiving the amphibolite rocks. Likewise, no conclusions as to paragenesis can be attempted at this time.

Iron Concentration Study

It was found that simple mixtures of iron minerals and silica could easily be evaluated for their iron content. These mixtures with simple matrices give a uniform, low background count which makes the interpretation of the iron K_β peaks quite accurate. The results of the information obtained from the prepared mixtures of Fe_2O_3 and SiO_2 are represented on Graph I (page 6).

Slope Representing Function of Concentration and Intensity for K_{β_1} of Iron



The results of the quantitative study of the iron content of the amphibolites and iron formations are summarized on Table II (page 8). It can be seen that the iron formations contain a generous amount of iron and may eventually be of economic value. The amphibolites contain the normal range of iron concentration values which would be expected of rocks of their composition.

CONCLUSIONS

Trace Element Stddy

The present study is far too limited to make any final conclusions regarding the trace element distribution and its significance. No discernable relationship can be seen by the writer, except that nickel may be characteristic of amphibolite bodies which have apparent igneous features in the field.

Iron Content Study

X-ray fluorescence appears to offer a rapid and accurate method for ascertaining the iron content of a given unknown sample. The method is limited only in the investigator's ability to mix properly the unknown sample with a diluent and for the unknown sample to have a simple matrix which gives a relatively low background count.

Table II. Iron content of the rocks of the Copper Mountain district, Fremont County, Wyoming

Sample Number	Weight Percent Iron
Am 100-28	9.4
If 100-33	25.86
If 100-7	22.09
If 100-34	30.40
Am 100-11	8.4
If 100-8	24.94
If 100-32	28.17
If 100-13	25.23
If 100-52	21.62
If 100-51	20.06
Am 100-50	11.6
Am 100-17	10.6
Am 100-30	6.6
Am 100-61	8.2
Am 100-12	13.0
Am 100-43	8.1
Am 100-27	7.7
Am 100-14	7.4
Am 100-18	7.9

Average iron concentration value for amphibolites-8.99

Average iron concentration value for iron formations-24.80

Sample locations from J. Gliozzi's map

Sample No.	Location
IF 100-7	1170' E., W. Line; 1620' S., N. Line; sec. 13, T. 40N., R. 93 W.
IF 100-8	1070' E., W. Line; 1520' S., N. Line; sec. 13, T. 40N., R. 93 W.
IF 100-13	810' E., W. Line; 260' S., N. Line; sec. 23, T. 40N., R. 93W.
IF 100-32	1250' W., E. Line; 1790' S., N. Line; sec. 12, T. 40N., R. 93W.
IF 100-33	"
IF 100-34	"
IF 100-51	440' E., W. Line; 2360' N., S. Line; sec. 13, T. 40 N., R. 93 W
IF 100-52	(?)
AM 100-11	890' E., W. Line; 2150' S., N. Line; sec. 24, T. 40 N., R. 93 W.
AM 100-12	1410' E., W. Line; 1000' S., N. Line; sec. 24, T. 40 N., R. 93 W.
AM 100-14	960' E., W. Line; 210' S., N. Line; sec. 23, T. 40N., R. 93 W.
AM 100-17	1490' E., W. Line; 180' S., N. Line; sec. 23, T. 40 N., R. 93 W.
AM 100-18	1860' W., E. Line; 570' N., S. Line sec. ~~1220' S., N. Line; sec.~~ 12, T. 40 N., R. 93 W.
AM 100-27	170' W., E. Line; 1500' S., N. Line; Sec. 23, T. 40 N., R. 93 W.
AM 100-28	190' E., W. Line; 1580' S., N. Line; Sec. 24, T. 40 N., R. 93 W.
AM 100-30	280' E., W. Line; 178' N., S. Line; sec. 26, T. 40 N., R. 93W.
AM 100-43	650' E., W. Line; 2370' N., S. Line; Sec. 24, T. 40 N., R. 93 W.
AM 100-50	440' E., W. Line; 2360' N., S. Line; Sec. 13, T. 40 N., R. 93 W ~~2220' E., W. Line; 1060' N., S. Line; sec.~~ (?)
AM 100-61	2220' E., W. Line; 1060' N., S. Line; sec. 14, T. 40 N., R. 93 W

Can not locate sample IF-100-52 on Gliozzi's map. Sample AM-100-50 may be improperly located. (JD)

APPENDIX III
(see summary and assays at end of appendix [illegible])

Section of iron bearing rocks of Precambrian age.
Located in SE$\frac{1}{4}$, NE$\frac{1}{4}$, sec. 15, T. 40 N., R. 94 W.,
6th P.M., Fremont County, Wyoming.
Chained over hill 6581, Refer U.S.G.S. Birdseye
Pass Topographic Quadrangle ($7\frac{1}{2}$'), Wyoming.

Cumulative (ft.) Thickness

Thickness = 1.3 ft. (1.3)

Light greenish-grey, weathering dark grey to black, fine-grained, hornblende amphibolite. Unit is probably concordant with underlying quartzite. Underlying quartzite is light green to dark grey, weathering light brown to pinkish-brown, very fine-grained, thin bedded (2 mm. laminae), platy, banded in places. Quartzite is poorly exposed and most likely underlain by mica schist.

Thickness = 14.8 ft. (16.1)

Grey to redish-grey (hematitic), weathering light brown, tan, and pinkish brown with a hematite stain, very fine-grained, thin bedded quartzite. Interlayered are some layers of light to dark grey, fissile, very fine-grained quartz-muscovite schist. Unit is poorly exposed along tape; the description was taken about 20 feet west of the tape. Hematite content is not sufficient to warrant sampling. Tape ends at the bottom of an amphibolite, thus the overlying covered unit is amphibolite in part.

Thickness = 21.8 feet (37.9)

Interval covered

Thickness = 11.3 feet (49.2)

Greenish-grey (dark green to white grain-size mottled), weathering dk grey to black (blk and white grain-size mottled), fine- to medium-grained, poorly foliated hornblende amphibolite.

Thickness = 6.0 feet (55.2)

Light greenish grey, weathering dark greenish grey, very/fine-grained, fissile, quartz-muscovite schist.

Thickness = 4.7 feet (59.9)

Dark grey (mottled), weathering dark grey to black (mottled), medium-grained hornblende amphibolite.

Thickness = 11.0 feet (70.9)

Light grey to greenish-grey, weathering light greenish-grey to tan with manganese oxides stain, very fine-grained, finely banded, quartzite. Bands are slightly etched by weathering and weathered foliate planes are greenish-tan and micaceous in places. Tan and pale yellow to white, needlelike amphibole crystals up to 5 cm long are common on some foliate planes and occur in layers ½ to 6 inches thick.

Thickness = 2.7 feet (73.6)

Dark greenish-grey, weathering black, very fine-grained, fairly well foliated, hornblende amphibolite. Needlelike hornblende crystals up to 1 mm long on some surfaces not foliation surfaces.

Thickness - 2.7 feet (76.3)

Very light tan, weathering light brown, fine-grained, well foliated, amphibole schist. Unit appears fibrous and composed chiefly of needle-like, light tan to white amphibole crystals up to 3 mm long. The matrix looks like granular quartz.

Thickness = 2.9 feet (79.2)

Light tan to light grey, weathering brown, fine- to coarse-grained but mostly medium-grained, muscovite-amphibole-quartz schist. The amphibole is light colored. The unit is poorly exposed.

Thickness = 2.4 feet (81.6)

Dark grey to greenish-grey, weathering black and brown, fine-grained, amphibolite. Thin, non-persistent, dark hornblende layers are interlayered with lighter (color) amphibolite.

Thickness = 7.4 feet (89.0)

Interval covered, probably a soft schist.

Thickness = 1.6 feet (90.6)

Light grey, weathering dark brown to dark grey, fine- to medium-grained, hard, poorly banded, amphibolitic quartzite. Characterized by sparse, discontinuous, light grey to light pink quartzose bands.

Thickness = 3.5 feet (94.1)

Very light grey to white, weathering light silvery-grey, medium- to coarse-grained, soft, muscovite schist. The unit is poorly exposed.

Thickness = 17.2 feet (111.3)

Light grey, weathering light greenish-grey to tan to light pink commonly with limonite streaks along foliation, very fine-grained, hard, thick bedded, delicately banded quartzite. Banding (color) is slightly etched by weathering. Some layers less than 1 foot thick are thin bedded and platy over short lateral intervals.

Thickness = 35.9 feet (147.2)

Covered, approximately 35 feet to W, along strike are some poorly exposed hornblende amphibolites.

Thickness = 18.5 feet (165.7)

Covered, outcrops 10 feet to west and 35 feet to east, along strike, indicate mostly fine-grained hornblende amphibolite.

Thickness = 5.8 feet (171.5)

Grey, weathering dark grey to black, medium-grained, hornblende amphibolite. Unit is fractured and commonly exhibits grain size mottling in greys and black.

Thickness = 10.7 feet (182.2)

Covered.

Thickness = 0.4 feet (182.6)

Light grey, weathering silver-grey, very fine-grained, hematite stained, knotted, muscovite-quartz schist. Unit is poorly exposed, but made more resistant to erosion by interlayers (up to $\frac{1}{2}$ inch thick) of coarsly-crystalline quartz.

Thickness = 15.7 feet (198.3)

Covered, an incipient 1 foot thick amphibolite is exposed 20 feet east of tape 8.4 feet from top of interval.

Thickness = 21.3 feet (219.6)

Light grey, weathering silver-grey, very fine- to fine-grained, soft, knotted, fissile, muscovite-quartz schist. Muscovit is greatly predominant. Sparse limonite and hematite stain occurs along folia and in knots. This unit is the persistent muscovite schist below the iron-bearing units.

Thickness = 5.1 feet (224.7)

Light grey, weathering mostly dark grey, fine-grained, muscovite-quartz schist. This unit is more resistant to erosion and contains less muscovite than the underlying unit. Sparse hematite and limonite stain on weathered surfaces.

Thickness = 9.9 feet (234.6)

Grey with some tan, weathering grey, tan, and light brown, thin bedded (0.3 feet maximum), quartzite. Quartzite is much interlayered with thin muscovite and quartz-muscovite schists and contains sparse coarsly-crystalline quartz layering parallel to folia. Unit commonly weathers in plates with abundant muscovite on foliate surfaces but with quartzite, muscovite poor, interior.

Thickness = 9.2 feet (243.8)

First magnetic layer! Dark grey to greenish-black, weathering pink to brown to dark red, through black, very fine- to fine-grained, hard, very poorly color banded quartzite. Bottom 2 feet is weakly magnetic to no detectable magnetism. Weakly to moderately magnetic elsewhere except for 1.0 ft. muscovite-biotite-quartz schist in center of interval. Bottom mostly very fine-grained; some medium-grained quartzite occurs at top of unit. In lower part are thin ($<\frac{1}{4}$ inch) concordant (to fol.) layers of felted hornblende crystals. At top is a 0.5 foot brown, coarsly crystalline, magnetic micaceous layer.

C
Sample No. ÇM-1-11-11 (chip)

Sample extends over entire interval.

Thickness = 2.1 feet (245.9)

Dark grey (grain size mottled), weathering black, medium-grained feldspathic, hornblende amphibolite. Coarsly crystalline quartz layers 5 - 10 mm thick are common.

Thickness = 2.7 feet (248.6)

Light to dark grey, weathering dark grey to black, fine- to very fine-grained, quartz-biotite-muscovite schist. Sparsely quartz knotted (up to 4 inches in diameter) and layered, quartz associated with potassium feldspar, (pink).

Thickness = 14.0 feet (262.6)

Mostly covered, magnetic in part, not sampled because of poor exposures. Apparently thin, interlayered, mica schists and quartzites.

At 1.9 feet (base), 0.1 feet soft, nonresistant, grey, medium grained, thin layered, biotite-muscovite-quartz schist; at 3.3 feet, 0.15 feet, grey, very fine-grained, quartzite with muscovite layers at the top; at 6.5 feet, 1.3 feet, grey, weathering dark grey to brown, very fine-grained, fissile, muscovite schist interlayered with thin (0.1 ft.) dark grey to black, very fine-grained, magnetic quartzite. In the upper part muscovite schist in knotted with probably hematite after magnetite, now limonitic and non-magnetic. At 10.0 feet, 0.2 feet, grey, weathering brown, quartzite; at 10.9 feet, 0.4 feet grey, fine-grained, micaceous quartzite; at 11.9 feet, 0.4 feet grey, weathering grey and brown, fine-grained, hard quartzite.

Thickness = 5.2 feet (267.8)

Light grey to black to brown, weathering darker with heavy hematite and limonite coatings, very fine grained (spare fine grains), poorly banded quartzite. Color bands 1 mm to 2.5 cm thick are ill-defined. Moderately magnetic band 0.4 feet thick at 2.6 feet, lower part very weakly magnetic, upper part weakly magnetic, did not obtain lower limit of magnetic bands - which is presumably in the upper part of the underlying unit.

Sample No. CM-2-11-11 (chip)

Entire interval sampled.

Thickness = 2.8 feet (270.6)

Light brown to yellow with grey layers, weathering tan to dark brown, fibrous, amphibolite. Amphibole fans of needlelike crystals up to 7 mm long. Some thin, grey, very fine-grained, quartzite layers with intergrown amphibole needles.

Thickness = 4.4 feet (275.0)

Dark grey, weathering dark redish-grey to black with pitted surface, very fine-grained, muscovitic, moderately color banded quartzite. This unit is thin layered in places, limonitic at the top; pits up to 1 cm long by 3 mm thick are elongate parallel to layering and after magnetite. The unit is weakly to moderately magnetic.

Sample No. CM-3-11-11 (chip)

Entire interval sampled. Magnetite crystals up to 3 mm long occur on some foliate planes.

Thickness = 1.1 feet (276.1)

Greenish-grey, weathèring redish-black to black, very fine-grained, fibrous appearing, amphibole schist; non- to weakly magnetic. Needlelike amphibole crystals up to 1 mm; looks hornblendic (black) in places.

Sample No. GM-4-11-11 (chip)

Entire interval sampled.

Thickness = 0.7 feet (276.8)

Grey, weathering redish-grey, very fine-grained, sparsely micaceous, non-magnetic, quartzite.

Thickness = 10.5 feet (287.3)

Grey, weathering redish-grey, greyish-green to black with hematite and limonite stain, mostly very fine-grained, thin layered, amphibolitic quartzite. Tan to green needlelike amphibole crystals up to 2 mm long in many layers; weakly to moderately magnetic in most places; some non-magnetic layers; some thin mica- (mostly muscovite) garnet schist; surface pits up to 2 mm probably after magnetite; ill defined redish-grey, grey, and dark grey color bands.

Sample No. CM-5-11-11 (chip)

Entire interval sampled.

Thickness = 13.0 feet (300.3)

Dark grey, weathering dark grey to black and red with hematite coatings, very fine-grained, thin layered, platy, tough quartzite. Very poorly color banded on fresh exposure, weathers with crude black, red, and yellow (limonite) $\frac{1}{4}$ - 1 inch thick color bands. Magnetite crystals up to 3 mm are common on foliate surfaces. Subhedral garnet crystals up to 4 mm are common in bottom 2.4 feet where there are also 4 - 6 thin muscovite-biotite-garnet-quartz schist layers. Thin partings of biotite schist are common throughout the interval, upper 2 feet of the unit is very micaceous - both muscovite and biotite.

Sample No. CM-6-11-11 (chip)

Thickness = 8.1 feet (308.4)

Dark grey to greenish-grey, weathering mostly grey with some drab red, black, and yellowish- to greenish grey; very fine- to medium- mostly very fine-grained; quartzite (?). The unit is tough, thin layered, micaceous in many layers, amphibolitic in some layers; poorly color banded in discontinuous bands of drab grey, green, and brown.

Sample No. CM-7-11-11 (chip)

The lower part of the unit is very hard and tough; the sample is probably biased to the upper half of the unit.

Entire interval sampled.

Thickness = 1.3 feet (309.7)

Interval covered, probably soft schist, may be iron-bearing.

Thickness=4.4 feet (314.1)

Greyish-green to light green, to yellowish-green, weathering buff to green with hematite and limonite coatings; mostly very fine-grained, medium grained in some layers (may be recrystallization), well layered, fissile, amphibolitic quartz (?) schist. Sparsely muscovitic in some layers; sheared; abundant magnetite crystals elongate and flattened parallel to foliate planes, up to 10 mm x 5 mm viewed down dip and 1 cm x 1 cm on foliate planes. Magnetite weathers with heavy limonite and sparse hematite coating and yields pitted surface where weathered out. Large magnetite crystals most abundant in upper part. Moderately to strongly magnetic in most places.

Sample No. CM-8-11-11 (chip)

Entire interval sampled.

Thickness = 11.7 feet (325.8)

Grey to dark grey to greenish-grey, weathering greenish-grey to black with limonite and hematite stained and pitted surfaces, very fine-grained quartzite (?) - thin layered. Unit weathers in 2 inch thick plates in upper part; schistose along plate partings, weather 1 foot thick blocks in lower part. Magnetite crystals are abundant. Strongly to moderately magnetic throughout

Sample No. CM-9-11-11 (chip)

Entire interval sampled

Thickness = 3.3 feet (329.1)

Black, weathering black to very dark brown, fine-grained, hard, dense, hornblende amphibolite.

Thickness - 3.4 feet (332.5)

Bottom 0.9 feet covered; light grey, weathering light brown and streaked, fine- to very fine-grained, well foliated, quartzite. Weathered surface shows discontinuous laminae (streaks) of brown and black, some light grey colors. 0.7 feet of silvery, weathering-silver grey to silver-brown, coursly crystalline, soft, muscovite schist at 1.9 feet above base.

Thickness - 22.6 feet (355.1)

Dark grey to dark greenish-grey, weathering mostly black with some dark brown and limonite stain, fine- to medium grained, grain size mottled, hard, dense, hornblende amphibolite. The unit is well foliated, forming 1 - 8 inch thick slabs.

Thickness - 3.9 feet (359.0)

Dark grey to light tan, weathering brown with limonite stain, medium grained, quartz veined (parallel to folia), tough, amphibolite. Veins composed mostly of fine-grained quartz crystals, some medium-grained. Rock of light tan to light grey, needlelike, up to 4 mm x 5 mm, amphibole crystals in fans in what may be a quartz matrix of very fine grain - secondary quartz confuses. Presents fibrous appearance on most surfaces.

Thickness - 17.3 feet (376.3)

About 50% of interval is well exposed consisting of grey to dark grey and greenish-grey, weathering mostly dark grey to black and brown with sparse limonite stain, fine-grained, well foliated, streaked, hornblende amphibolite. Much of outcrop exhibits black and grey grain size mottling. Black portions commonly reflect with greenish sheen in direct sunlight.

Thickness = 7.8 feet (384.1)

Interval covered at the tape, description and sample taken 25 ft. west of the tape along strike. Light greenish-grey to dark grey, weathering greyish green and light red with hematite and limonite stain, very fine-grained, thin layered, fissile in part, fairly hard, muscovitic quartzite (?) - schist like! Unit exhibits poorly developed, drab green and red color bands on weathered surfaces. Unit is moderately magnetic and quartz veined.

Sample No. CM-10-11-11 (chip)

Recovered 5.6 feet of interval in partially concealed rock. Top 1/3 of interval is poorly represented.

Thickness = ~~2~~5.3 feet (386.4)

Greenish-grey, weathering black and grey (grain size black and grey mottling); mostly medium-grained, fine-grained along southern border; hornblende amphibolite. Some quartz veining parallel to foli ation.

Thickness = ~~5~~4.6 feet (392.0)

Light grey to dark grey, weathering moderately color banded black, red, and brown in persistent bands up to 1 cm thick, very fine-grained quartzite. Thin muscovite laminae interlayered parallel to foliation (banding). Strongly magnetic except in poorly exposed upper part. Uppermost 1 ft. is light grey to greenish grey, weathering green to buff, non-magnetic, thin layered, micaceous, fissile, amphibolitic schist.

Sample No. CM-11-11-11 (chip)

Recovered 2.9 feet of sample, lower 1.2 feet well represented, upper 1 foot not included in sample - thus sample is biased to more-resistent quartzites in the lower part. A weakly to moderately magnetic, poorly exposed, schistose unit above the lower 1.2 feet is poorly represented.

Thickness = 1.3 feet (393.3)

Grey, weathering fibrous brown with tan to brown amphibole crystals, medium-grained, amphibolite. Non-persistent lineation on foliate surfaces.

Thickness = 2.8 feet (396.1)

Covered, probably soft amphibolite.

Thickness = 1.6 feet (397.7)

Light grey to tan, weathering light grey to greenish-grey and brown, fine-grained, amphibolite. Unit is hornblendic (black) in some layers.

Thickness = 8.6 feet (406.3)

Interval largely covered, sparse outcrops indicate brown and black weathering amphibolite, much of the float is hornblendic. A medium-grained, black to brown, quartz layered, amphibolite is exposed at top of interval.

Thickness = 8.5 feet (414.8)

Interval covered at the tape, spare adjacent outcrops indicate amphibolite, with brown variety predominant.

Thickness = 0.9 feet (415.7)

Light grey, weathering grey to brown, very fine-grained, hard, dense, pegmatitic layered quartzite. Bottom about at beginning of interval, top not exposed.

Thickness = 7.8 feet (423.5)

Interval covered, may be metasedimentary rock.

Thickness = 0.7 feet (424.2)

Dark grey, weathering dark brown, very fine-grained, hornblendic quartzite.

Thickness = 3.6 feet (427.8)

Light grey, weathering brownish grey, fine- to medium-grained, gneissic, amphibolitic quartzite with green amphibole crystals. Commonly mottled dark grey and white, green and white.

Thickness = 21.9 feet (449.7)

Mostly covered, light grey to dark grey, weathering grey and brown with dark green and black 3 cm thick layers, medium- to fine-grained, quartzose, well-foliated, hard, dense, gneissic amphibolite.

Thickness = 6.9 feet (456.6)

Light greenish-grey, weathering greenish-grey, medium grained, greyish-green and light grey grain size mottled, hornblende amphibolite.

Thickness = 6.1 feet (462.7)

Light grey to light greenish-grey, weathering greenish-grey, brown, and tan, very fine-grained, quartzose and micaceous, amphibolitic metasediment. Amphibole layers (some to 6 inches thick) (Some hornblendic). Some of the fissile, micaceous layers weather dark green, much like the underlying magnetic beds.

Thickness = 1.8 feet (464.5)

Greenish-grey, weathering green, brown, and black, variable grain size - 5 mm in most places, amphibolite with many coarsly crystalline pegmatitic (quartz with some pink feldspar) veinlets parallel to foliation.

Thickness = 7.0 feet (471.5)

Covered, probably grey and brown amphibolites.

Thickness = 5.2 feet (476.7)

Greenish-grey and dark grey, weathering greyish-green, brown, and black, fine- to medium-grained, well foliated, gneissic, hornblende amphibolite.

Thickness = 24.6 feet (501.3)

Mostly covered, probably gneissic amphibolite.

Thickness = 14.7 feet (516.0)

Loser 9.5 feet covered, but well exposed east of tape. Dark grey to greenish-grey, weathering dark greyish-green to black and dark brown, fine= to medium=grained, pegmatitic veined, gneissic, hornblende amphibolite.

Thickness = 18.1 (534.1)

Light grey, weathering silver-grey, most very fine- to fine-grained with some medium grains along foliate planes, commonly knotted, much warped, andalusite (?) muscovite schist. Al_2SiO_5 knots up to 1 x $\frac{1}{2}$ inch.

Thickness = 10.3 feet (544.4)

Mostly covered; small, sparse outcrops east of tape indicate soft greenschist and non-resistant quartzite.

Thickness = 4.9 feet (549.3)

Greenish-grey, weathering black and greenish-black with black and grey grain size mottling, medium-grained, hornblende amphibolite.

Thickness = 8.5 feet (557.8)

Light green, weathering dark green, green, and brown with hematite and limonite stain, very fine-grained and less, soft, thin layered, tending to fissile, greenschist; weakly to moderately magnetic throughout.

Sample No. CM-12-11-11 (chip)

Recovered 0.3 feet sample from 2.2 - 2.5 feet above the unit base, recovered top 4.6 feet of unit. Sample thickness = 4.9 feet, rest of interval covered.

Thickness = 5.7 feet (563.5)

Light greenish-grey, weathering greenish-yellow some green and sparse limonite and hematite stain; very fine-grained and less, fissile, soft schist. Only 1.4 ft. exposed about 4 feet east of tape. Resembles mashed or iron poor equivalent of underlying unit. Non-magnetic at outcrop.

Sample No. CM-13-11-11 (grab)

Grabbed sample about 4 feet east of tape at outcrop.

Thickness = 13.6 feet (577.1)

Light grey and greenish-grey, weathering green, brown, and dark grey at the bottom and mostly dark grey to black at the top, very fine-grained, fairly soft, compact, thin-bedded in part, tough schist. Unit is strongly magnetic, hematite after magnetite spotted along folia, tends to fissility on weathered points.

Sample No. CM-14-11-11 (chip)

Bottom 6.1 feet of unit.

Sample No. CM-15-11-11 (chip)

Top 7.5 feet of unit.

Thickness = 8.1 feet. (585.2)

Well covered, may be iron-bearing schist.

Thickness = 1.4 feet (586.6)

Greenish grey, weathering dark grey to black with black and grey grain size mottling, medium-grained, hard, dense, hornblende amphibolite.

Thickness = 2.5 feet (589.1)

Grey, weathering dark greenish-grey to black with hematite stain, very fine-grained, thin layered, tending to fissility, quartzite. Strongly magnetic. Magnetite as imperfect crystals 1 x 5 mm on foliate surfaces.

Sample No. CM-16-11-11 (chip)

Recovered only lower 1.5 feet.

Thickness = 1.8 feet (590.9)

Dark greenish-grey, weathering black to greenish-black, fine-grained, hard, dense, well foliated, homogeneous, hornblende amphibolite. Weathers in plates.

Thickness = 19.7 feet (610.6)

Mostly covered, all outcrops are dark grey to black, weathering brown, red, green, black, and grey with heavy hematite and limonite coating, well color banded, platy, brittle, hard, very strongly magnetic quartzite.

Sample No. CM-17-11-11 (grab)

Grabbed off the few outcrops available. Recovered 2.7 feet of the interval.

Thickness = 0.8 feet and beyond (611.4)

Black, medium-grained, hornblende amphibolite.

SUMMARY

A total of 611.4 feet of metamorphic rocks were measured. Iron-bearing rocks are restricted to the top 376 feet of this section and occur in 4 mappable units, the top two of which occur very close together at the point of section measurement and may be considered as one iron-bearing zone. Three categories of rock are considered as follows: (1) iron-bearing and containing sufficient magnetite to be easily identified with a hand magnet; and are well exposed, (2) possible iron-bearing or iron-bearing in thin, widely separated layers; but not readily determinate because of poor exposure, (3) barren metamorphic rocks, including probably barren rocks because of poor exposure.

The lowermost iron-bearing zone contains 67.6 feet of magnetic rock, 15.3 feet of possible and partially magnetic rock, and 8.3 feet of barren rock.

This zone is overlain by 50.5 feet of barren material.

The middle zone contains 13.4 feet of magnetic rock and 2.3 feet of barren rock.

Summary of Iron Assay Results of the
Upper series measured in $SE\frac{1}{4}$, $NE\frac{1}{4}$, sec. 15, T. 40 N., R. 94 W., Refer U.S.G.S. Birdseye Pass Topographic Quad. ($7\frac{1}{2}$'), Hill 6581

	Cumulative Thickness (ft.)	Interval (ft.)	Sample Type (feet represented)	Assay* % Fe % Ti % P	Description
17	376.0	19.7 (Top)	Grab 2.7		Mostly covered; color banded, platy, strongly magnetic quartzite.
	356.3	1.8		18.6	Greenish-grey, hornblende amphibolite.
16	354.5	2.5	Grab 1.5		Thin layered, strongly magnetic quartzite; ~~visible~~ large magnetite crystals.
	352.0	9.5			Mostly covered, dark greenish-grey hornblende amphibolite at top. Barren zone

Cumulative Thickness (ft.)	Interval (ft.)	Sample Type (feet represented)	Assay* % Fe % Ti % P	Description
342.5	13.6	Chip 13.6	15.1 0.30 ** [illegible]	Grey and green, tough, strongly magnetic greenschist and quartzite.
328.9	5.7	Grab	5.6	Fissile, soft, non-magnetic greenschist with some hematite.
323.2	8.5	Chip 4.9	6.6	Soft, magnetic greenschist.
314.7	157.3			Barren zone; mostly dark amphibolite and some green-schist, quartzite, and thin muscovite-andalusite-(?) schist.
157.4	4.6	Chip 2.9	9.8	Color banded, micaceous, strongly magnetic quartzite.
152.8	3.3			Quartz veined, hornblende amphibolite.
149.5	7.8	Chip 5.6	9.5	Poorly color banded, magnetic schist and magnetic, micaceous quartzite.
141.7	50.5			Barren zone; mostly dark amphibolite, some quartzite and muscovite schist.
91.2	11.7	Chip 11.7	8.1	Dark magnetic schist and quartzite; ~~visible~~ magnetite crystals.
79.5	4.4	Chip 4.4	10.6	Amphibolitic, magnetic greenschist; large magnetite crystals.
75.1	1.3			Covered.
73.8	8.1	Chip 8.1	13.0	Amphibolitic, micaceous, magnetic schist and quartzite.
65.7	13.0	Chip 13.0	6.9 0.40 0.10	Poorly color banded, platy, magnetic quartzite; large magnetite crystals.
52.7	10.5	Chip 10.5	19.1	Poorly color banded, magnetic quartzite and some schist; molds after magnetite.
42.2	0.7			Non-magnetic, micaceous quartzite.
41.5	1.1	Chip 1.1	7.8	Magnetic, amphibole schist.

Magnetite Unit 3

Magnetite Unit 2

Magnetite Unit 1

** [illegible]

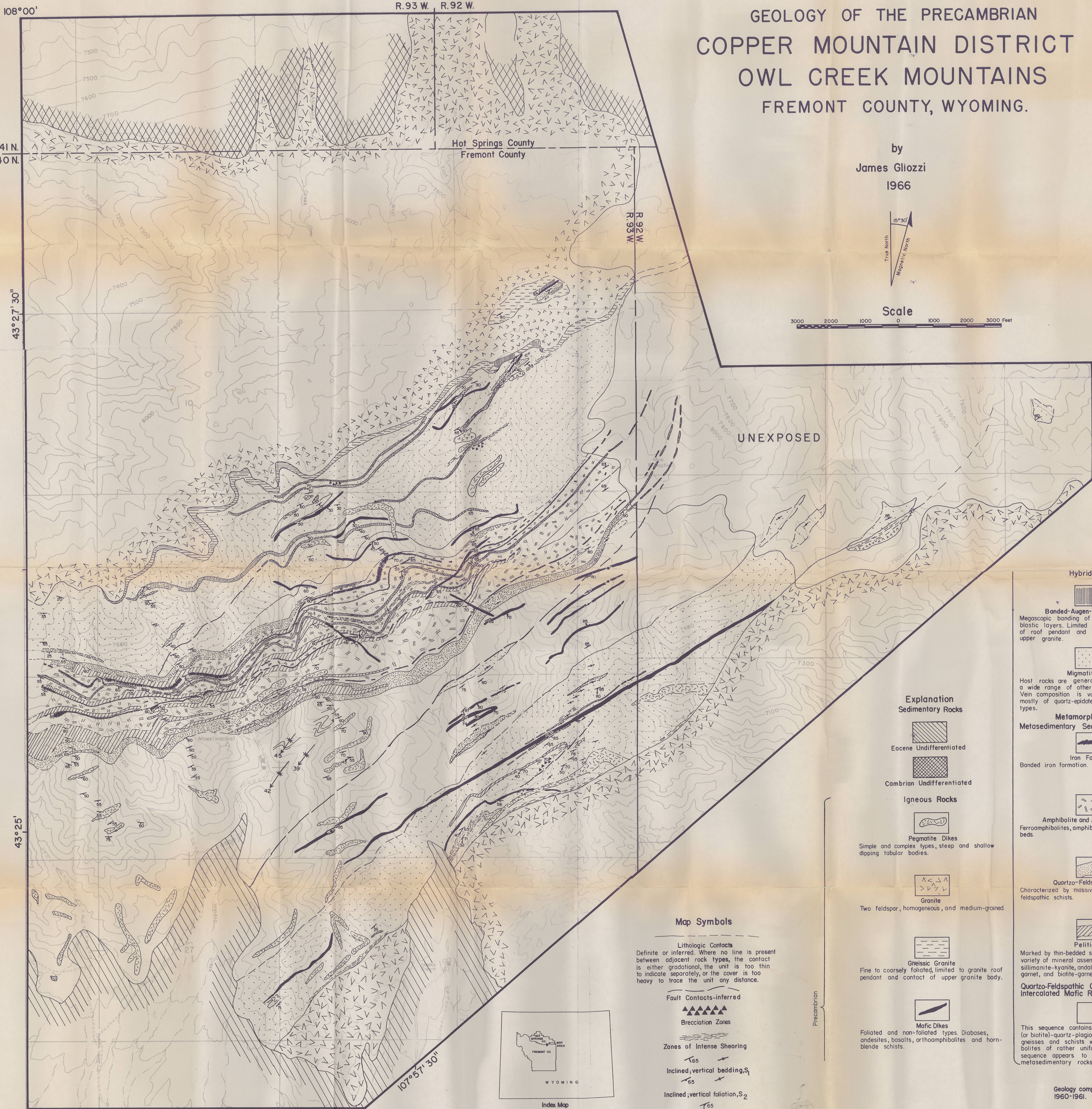
	Cumulative Thickness (ft.)	Interval (ft.)	Sample Type (feet represented)	Assay* % Fe % Ti % P	Description
3	40.4	4.4	Chip 4.4	16.[illegible]	Color banded, muscovitic, magnetic quartzite, molds after magnetite.
	36.0	2.8			Dark amphibolite.
2	33.2	5.2	Chip 5.2	16.3	Poorly color banded, magnetic quartzite.
	28.0	14.0			Mostly concealed, magnetic quartzite in part.
	14.0	4.8			Dark amphibolite.
1	9.2	9.2	Chip 9.2	19.1	Amphibolitic, micaceous, magnetic quartzite.

Magnetite Unit 1

* Analyst, B. Davis, NRRI

GEOLOGY OF THE PRECAMBRIAN
COPPER MOUNTAIN DISTRICT
OWL CREEK MOUNTAINS
FREMONT COUNTY, WYOMING.

by
James Gliozzi
1966



Topography based on U.S. Geological Survey Map 1952

Index Map

Map Symbols

Lithologic Contacts
Definite or inferred. Where no line is present between adjacent rock types, the contact is either gradational, the unit is too thin to indicate separately, or the cover is too heavy to trace the unit any distance.

Fault Contacts-inferred

Brecciation Zones

Zones of Intense Shearing

65

Inclined; vertical bedding, S_1

65

Inclined; vertical foliation, S_2

65
48

Plunging lineations and mesoscopic folds, L

Explanation

Sedimentary Rocks

Eocene Undifferentiated

Cambrian Undifferentiated

Precambrian

Igneous Rocks

Pegmatite Dikes
Simple and complex types, steep and shallow dipping tabular bodies.

Granite
Two feldspar, homogeneous, and medium-grained.

Gneissic Granite
Fine to coarsely foliated, limited to granite roof pendant and contact of upper granite body.

Mafic Dikes
Foliated and non-foliated types. Diabases, andesites, basalts, orthoamphibolites and hornblende schists.

Hybrid Rocks

Banded-Augen-Granite Gneiss
Megascopic banding of lepidoblastic and granoblastic layers. Limited only to central part of roof pendant and adjacent contact of upper granite.

Migmatitc Rocks
Host rocks are generally amphibolites, however a wide range of other types are present. Vein composition is variable and consists mostly of quartz-epidote or quartz-feldspar types.

Metamorphic Rocks

Metasedimentary Sequence

Iron Formation
Banded iron formation.

Amphibolite and Amphibolite Schists
Ferroamphibolites, amphibole schists and chert beds.

Quartzo-Feldspathic Rocks
Characterized by massive quartzites and quartzo-feldspathic schists.

Pelitic Rocks
Marked by thin-bedded schists containing a variety of mineral assemblages. Most notable are sillimanite-kyanite, andalusite-garnet, sillimanite-garnet, and biotite-garnet schists.

Quartzo-Feldspathic Gneisses and Intercalated Mafic Rocks

This sequence contains thin unit of hornblende (or biotite)-quartz-plagioclase and granitoid gneisses and schists with intercalated amphibolites of rather uniform composition. This sequence appears to be older than the metasedimentary rocks.

Geology compiled during summers 1960-1961.

PLATE I