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Bulletin 811—A

# THE NEW WORLD OR COOKE CITY MINING DISTRICT PARK COUNTY, MONTANA

BY

T. S. LOVERING

Contributions to economic geology, 1929, Part I
(Pages 1-87)

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1929

| | Feet |
|---|---|
| Gallatin formation—Continued. | |
| Massive gray limestone, cliff; rock is blue-gray medium-grained limestone, remarkably uniform but locally oölitic in texture and near the base composed largely of trilobite fragments. The weathered surface has a characteristic dark mottled appearance. Medium bedded at base | 135 |
| Gros Ventre formation: Flat-pebble conglomerate, flat limestone pebbles as much as 4 inches long and 0.3 inch thick in a limestone matrix | 1 |

Walcott[20] collected characteristic Upper Cambrian fossils from the upper part of the Gallatin limestone in the Yellowstone Park, and these are listed below.

Billingsella coloradoensis (Shumard).
Obolus (Lingulella) desideratus Walcott.
Dicellomus nanus (Meek and Hayden).
Orthis? remnicha Winchell.
Orthis? sandbergi Winchell.
Ptychoparia (Euloma?) affinis Walcott.
Ptychoparia llanoensis? Walcott.
Arionellus levis Walcott.
Ptychoparia sp.?

## ORDOVICIAN SYSTEM

### BIGHORN DOLOMITE

The rocks heretofore included in the Jefferson limestone in Yellowstone Park have been found to include both Ordovician and Devonian sediments. Peale[21] originally defined the formation in the Jefferson Mountains of Montana and gave its age as Devonian. A few years later Weed[22] described the Jefferson of the Yellowstone Park as Silurian, but after an exhaustive study by Kindle[23] the formation was shown to be Devonian, chiefly Middle Devonian but also including some Lower Devonian. According to more recent unpublished studies of Edward Kirk the Jefferson limestone is wholly of Middle Devonian age, and the Lower Devonian is, so far as known, absent in the Rocky Mountain region. The discovery by the writer in the New World mining district of Ordovician fossils in the beds overlying the Gallatin, previously included in the Jefferson, proves the presence of the Bighorn dolomite in this area.

About 3½ miles northwest of Cooke, on the north side of the steep divide that separates the Stillwater River from Sheep Creek, there is an excellent section of the post-Cambrian Paleozoic rocks. In the

[20] Op. cit., p. 441.
[21] Peale, A. C., The Paleozoic section of the vicinity of Three Forks, Mont.: U. S. Geol. Survey Bull. 110, pp. 25, 27, 1893.
[22] Weed, W. H., U. S. Geol. Survey Geol. Atlas, Yellowstone National Park folio (No. 30), 1896.
[23] Kindle, E. M., The fauna and stratigraphy of the Jefferson limestone in the northern Rocky Mountain region: Bull. Am. Paleontology, No. 20, pp. 4, 23–24, 1908.

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Big Blue claim 78



affected by contact metamorphism but is the favorite horizon for ore deposits of the vein and replacement type and contains the most promising lead-silver-zinc ores of the district. Locally it is known as the "Republic reef."

Resting on the cliff-forming member just described is a persistent bed of shale about 30 feet thick. Above this thin beds of limestone, flat-pebble conglomerate, and shale alternate for 200 feet. Some of the limestone has a marked columnar aspect when weathered, as shown in Plate 7, *C*. This is the result of a concentric texture suggesting the former presence of *Cryptozoon*. The individual beds range in thickness from a few inches to 10 feet; their average thickness is less than 5 feet. This upper shale member is affected by contact action at the north end of Red Mountain and strongly resembles metamorphosed upper Gros Ventre beds. Its areal distribution coincides with that of the lower member of the Gallatin.

A typical section of the formation is given below:

*Section of Gallatin formation on north flank of Republic Mountains, 1,800 feet S. 30° W. of Republic smelter*

| | Feet |
|---|---|
| Tertiary tuff. | |
| Bighorn dolomite; black fetid limestone, base of the Bighorn | 2 |
| Gallatin formation: | |
| Hard calcareous gray shale; pyrite nodules locally, many limestone lenses; contains beds of limestone conglomerate 1 to 2 feet thick, pebbles small and fairly well rounded; weathers brown. The uppermost bed 15 feet thick; weathers as a low cliff | 48 |
| Massive dense gray limestone; weathers with concentric marks suggestive of *Cryptozoon* | 4 |
| Thin-bedded shale and limestone, in beds less than 1 foot thick | 75 |
| Massive coarse-grained dark-gray limestone, speckled with brown, forming low cliff | 8 |
| Medium-bedded limestone and shale, with a few layers of flat limestone pebble conglomerate. Individual beds are from 1 foot to 2½ feet thick. The shale is green and calcareous and contains many elliptical limestone nodules. Much of the limestone weathers with a mottled surface but is dense blue-black on a fresh break | 50 |
| Thin-bedded green shale and limestone and flat-pebble conglomerate; average thickness about 1 inch, maximum thickness 6 inches. Limestone much less abundant than conglomerate | 18 |
| Dense dark-gray limestone, breaking with a conchoidal fracture, weathering in a markedly columnar fashion. (See pl. 7, *C*) | 12 |
| Green fissile shale containing a few thin layers of limestone | 30 |

underlying the Gallatin limestone in the Yellowstone National Park, which compose the beds later named Gros Ventre formation by Blackwelder. These fossils are listed below:

Haguia sphaerica Walcott.
Obolus (Lingulepis) acuminatus var. meeki Walcott.
Iphidea sculptilis Meek.
Acrotreta gemma Billings.
Platyceras primordialis Hall?
Hyolithes primordialis (Hall).
Agnostus bidens Meek.
Agnostus interstrictus White.
Agnostus tumidosus Hall and Whitfield.
Ptychoparia penfieldi Walcott.
Ptychoparia antiquata (Salter).
Crepicephalus texanus (Shumard).
Ptychoparia (Lonchocephalus) hamulus? Owen.
Ptychoparia (Lonchocephalus) wisconsensis Owen.
Ptychoparia? diademata (Hall).
Liostracus parvus Walcott.
Solenopleura? weedi.
Zacanthoides sp.?
Bathyuriscus? sp.?
Arionellus sp.?
Ptychoparia sp.?
Iphidea sp.?

### GALLATIN FORMATION

The Gallatin formation is classified by the United States Geological Survey as of Upper and Middle Cambrian age. It carries characteristic Upper Cambrian fossils in its upper part and contains representatives of beds to the north that carry Middle Cambrian fossils. In the New World district it consists of two distinct members, the lower member a massive oölitic limestone 130 to 150 feet thick, and the upper member, 250 to 300 feet thick, consisting of alternating beds of limestone and shale.

The lower member of the Gallatin is chiefly a massive gray oölitic limestone, very low in magnesia (see p. 38), commonly weathering in dark-colored cliffs. (See pl. 7, *A*.) The base of this member is a medium-bedded gray limestone which is locally rather sandy but more commonly is shaly and grades up into the massive oölitic limestone. This massive bed is nearly uniform from top to bottom and contains trilobite and brachiopod remains at many horizons. Its average thickness is a little over 100 feet. The limestone crops out as a cliff a few hundred feet above Soda Butte Creek and is also present on Miller Mountain and in the upper basin of the Stillwater River. Large xenoliths of the Gallatin are present on Red Mountain and Henderson Mountain. The massive lower limestone is little




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nearly white beds occur, and the uppermost limestone of this member (about 200 feet above the lower shale) is generally a black thin-bedded stratum which weathers into rough, irregular laminae.

The limestone is well exposed near Lower Hayden Falls, on Woody Mountain. Locally on Henderson Mountain it has been extensively marmarized, and magnetite, chlorite, actinolite, garnet, and other contact minerals have been developed.

*Upper shaly limestone member.*—Above the lower limestone member shale, limestone conglomerate, and thin-bedded limestone make their appearance. This uppermost member of the Gros Ventre formation is well exposed on the north slope of Republic Mountain about a mile west-southwest of Cooke.

Soft green shale containing a few thin limestone lenses overlies the black limestone bed for about 90 feet. This shale rarely crops out. At the top of this member limestone layers become abundant, and some flat-pebble conglomerate appears. The conglomerate is intraformational and consists of flat limestone pebbles in a limestone matrix. Above the green shale the Gros Ventre is made up of thin layers of limestone, flat-pebble conglomerate, and shale. These thin-bedded alternations persist nearly to the Gallatin limestone, 120 feet above the soft green shale. As the base of the Gallatin is approached, the limestone becomes more massive, the flat-pebble conglomerate disappears, and the shale becomes calcareous. In places a distinct break can be observed between the Gros Ventre and the unconformable Gallatin limestone, especially where the lower limestone of the Gallatin is sandy. More commonly there is no definite lithologic break between the two formations but rather a transitional zone covering 30 feet or more, in which the limestone beds become more and more massive.

The upper member of the Gros Ventre has been metamorphosed at several places near a monzonite stock, with the development of such characteristic contact minerals as garnet, epidote, chlorite, vesuvianite, tremolite, specularite, and magnetite. In one locality, on the southern slope of Henderson Mountain, marble containing much magnetite and chlorite has been formed. The shaly limestone of the Gros Ventre is a much better host for contact minerals than the purer limestone of the Gallatin. Selective action is especially notable at the Daisy mine, on Henderson Mountain, where the two rocks occur side by side. Here the Gros Ventre rocks have been completely changed to the contact minerals mentioned above, whereas the Gallatin has been but slightly affected, if at all.

More than 20 species of Middle Cambrian fossils were obtained by Walcott[19] from the strata overlying the Flathead quartzite and

[19] Walcott, C. D., The geology of the Yellowstone National Park: U. S. Geol. Survey Mon. 32, pt. 2, p. 440, 1899.

since Peale named it in 1893, and discarded the broader uses of the name Flathead. At the same time Gallatin limestone was adopted for the Cambrian beds above the base of the heavy mottled limestone member of Peal's 1893 classification. In central and southern Montana the beds intervening between the Flathead quartzite and the Gallatin limestone have been named Wolsey shale (at the bottom), Meagher limestone, and Park shales (at the top).[17] (See first column of pl. 6.) In the New World district the sequence of the beds below the Gallatin is strikingly similar to the Wolsey-Meagher-Park succession, although the beds differ in detail and in thickness, and it would be impossible to make an exact correlation.

As the beds of the New World district that overlie the Flathead quartzite and underlie the Gallatin limestone correspond in age, lithology, and stratigraphic position to Blackwelder's Gros Ventre formation [18] of northern Wyoming, they are considered equivalent and are herein mapped as the Gros Ventre formation.

The Gros Ventre formation is about 450 feet thick in the New World district and consists chiefly of shale and limestone. The limestone is medium to thin bedded and is not resistant to erosion; as a result the entire formation is soft and weathers in smooth slopes except where intrusive rocks have baked the shale or altered the limestone. Good exposures of the unaltered beds occur in the gorges of Republic and Woody Creeks south of Cooke, and good exposures of indurated Gros Ventre beds can be seen on Henderson Mountain, Sheep Mountain, and the upper slopes of Miller Mountain.

*Lower shale member.*—Overlying the Flathead quartzite is a persistent bed of green to chocolate-brown shale about 90 feet thick. This shale is laminated and micaceous and crumbles readily where it has not been indurated. At the top of Henderson Mountain it has been baked by intrusive monzonite into a dense, hard purple-brown rock resembling hornfels. This facies has been developed in a few other localities under similar conditions.

*Lower limestone member.*—Medium-bedded limestone 200 feet thick overlies the lower shale member. The beds are commonly about 10 feet thick, range in color from white through gray to black, and are interbedded with grayish-green shale. The limestone immediately above the lower shale is sandy in many places, and locally thin lenses of buff sandstone are present. Shale partings are abundant in the limestone, and seams of shale from 1 inch to 2 feet thick are common. The shale does not make up more than 20 per cent of this part of the section but effectually prevents the limestone from cropping out conspicuously. Most of the limestone is dense and dark gray, but some

[17] Weed, W. H., U. S. Geol. Survey Geol. Atlas, Little Belt Mountains folio (No. 56); Fort Benton folio (No. 55), 1898.

[18] Blackwelder, Eliot, op. cit., p. 418.

# CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1929

## PART I. METALS AND NONMETALS EXCEPT FUELS

## THE NEW WORLD OR COOKE CITY MINING DISTRICT, PARK COUNTY, MONTANA

By T. S. LOVERING

### INTRODUCTION

In the pioneer days of Montana the New World mining district was regarded as one of its most promising camps. In the early eighties Cooke had a population of over 2,000. Specimens of rich ore reputed to come from the vicinity of Cooke may be seen in many cities and camps remote from the district, but little information has hitherto been available as to the geology and mining. To supply this need the district was studied and mapped during the summers of 1922 and 1923.

### FIELD WORK AND ACKNOWLEDGMENTS

The writer was at Cooke from June 5 to September 10, 1922, and spent most of this time in making the topographic map that accompanies this report. The interval from June 10 to September 5, 1923, was devoted to a study of the geology of the district. About six weeks in July and August, 1925, was spent in completing the reconnaissance maps of the Goose Lake area and studying the recent mining developments. The writer was assisted by W. C. Werner in 1922 and by C. W. Gray in 1922, 1923, and 1925.

It is impossible to acknowledge adequately the assistance rendered by all those encountered during the field work, but the writer wishes to express his appreciation of the uniform courtesy, help, and consideration which he received from everyone with whom he came into contact in the New World mining district. Special mention should be made of Messrs. L. H. Brooks, N. J. Tredennick, F. C. Byrne, Harry Stinson, Gus Solomonson, and Jack Allen, who furnished

valuable information which is incorporated in this report. Thanks are also due to Mr. J. T. Pardee, of the United States Geological Survey, for the use of material which he gathered in 1918.

## BIBLIOGRAPHY

In the following bibliography the most comprehensive papers are marked with an asterisk.

### REFERENCES ON THE NEW WORLD MINING DISTRICT

*Brooks, L. H., New World mining district: Min. and Sci. Press, May 14, 1921, p. 682.

*Gardiner, E. D., Northwestern mining districts: Min. and Sci. Press, vol. 108, pp. 880–884, 1914.

*Hague, Arnold, and others, Geology of the Yellowstone National Park: U. S. Geol. Survey Mon. 32, pt. 2 and atlas, 1899.

Hayden, F. V., U. S. Geol. Survey Terr. Sixth Ann. Rept., p. 47, 1873.

Hill, J. M., The mining districts of the western United States: U. S. Geol. Survey Bull. 507, p. 117, 1912.

Raymond, R. W., Statistics of mines and mining in the States and Territories west of the Rocky Mountains for 1874, p. 324, 1875.

Swallow, G. C., Montana Min. Jour., Nov. 30, 1889; May 10, 1890.

U. S. Geol. Survey Mineral Resources, 1906, p. 283; 1908, pt. 1, p. 638; 1917, pt. 1, p. 359; 1918, pt. 1, p. 293; 1919, pt. 1, p. 525; 1920, pt. 1, p. 214; 1921, pt. 1, p. 301; 1922, pt. 1, p. 480; 1923, pt. 1, p. 471; 1924, pt. 1, p. 358.

### REFERENCES ON THE REGIONAL GEOLOGY

*Bevan, Arthur, Summary of the geology of the Beartooth Mountains, Mont.: Jour. Geology, vol. 31, pp. 441–465, 1923.

——— Rocky Mountain peneplains northeast of Yellowstone Park: Jour. Geology, vol. 33, pp. 563–587, 1925.

Condit, D. D., Relations of late Paleozoic and early Mesozoic formations of southwestern Montana and adjacent parts of Wyoming: U. S. Geol. Survey Prof. Paper 120, pp. 111–121, 1918.

Darton, N. H., Coals of Carbon County, Mont.: U. S. Geol. Survey Bull. 316, pp. 174–193, 1907.

Emmons, W. H., Geology of the Haystack stock, Cowles, Park County, Mont.: Jour. Geology, vol. 16, pp. 193–229, 1908.

Hague, Arnold, U. S. Geol. Survey Geol. Atlas, Absaroka folio (No. 52), 1899.

Iddings, J. P., U. S. Geol. Survey Geol. Atlas, Yellowstone National Park folio (No. 30), 1896.

——— and Weed, W. H., U. S. Geol. Survey Geol. Atlas, Livingston folio (No. 1), 1894.

Tomlinson, C. W., The middle Paleozoic stratigraphy of the central Rocky Mountain region: Jour. Geology, vol. 25, pp. 112–134, 244–257, 373–394, 1917.

Westgate, L. G., Deposits of chromite in Stillwater and Sweet Grass Counties, Mont.: U. S. Geol. Survey Bull. 725, pp. 67–84, 1921.

Woodruff, E. G., The Red Lodge coal field, Mont.: U. S. Geol. Survey Bull. 341, pp. 92–107, 1909.



ously. The lower part of the Gallatin formation is a remarkably persistent cliff-forming member and can be seen on both sides of Soda Butte Creek from Cooke to the western limits of the area mapped. The Gallatin formation is classified by the United States Geological Survey as Middle and Upper Cambrian.

### FLATHEAD QUARTZITE

The basal quartzite bed of the Flathead quartzite is well exposed on Sheep Mountain, the west side of Red Mountain, and the north side of Scotch Bonnet Mountain, where it forms conspicuous reddish ledges. Good exposures can also be seen near Cooke, on Republic Creek 1,000 feet above its mouth. The upper sandstone member is exposed on the Daisy Pass road half a mile due north of Cooke.

*Generalized section of the Flathead quartzite*

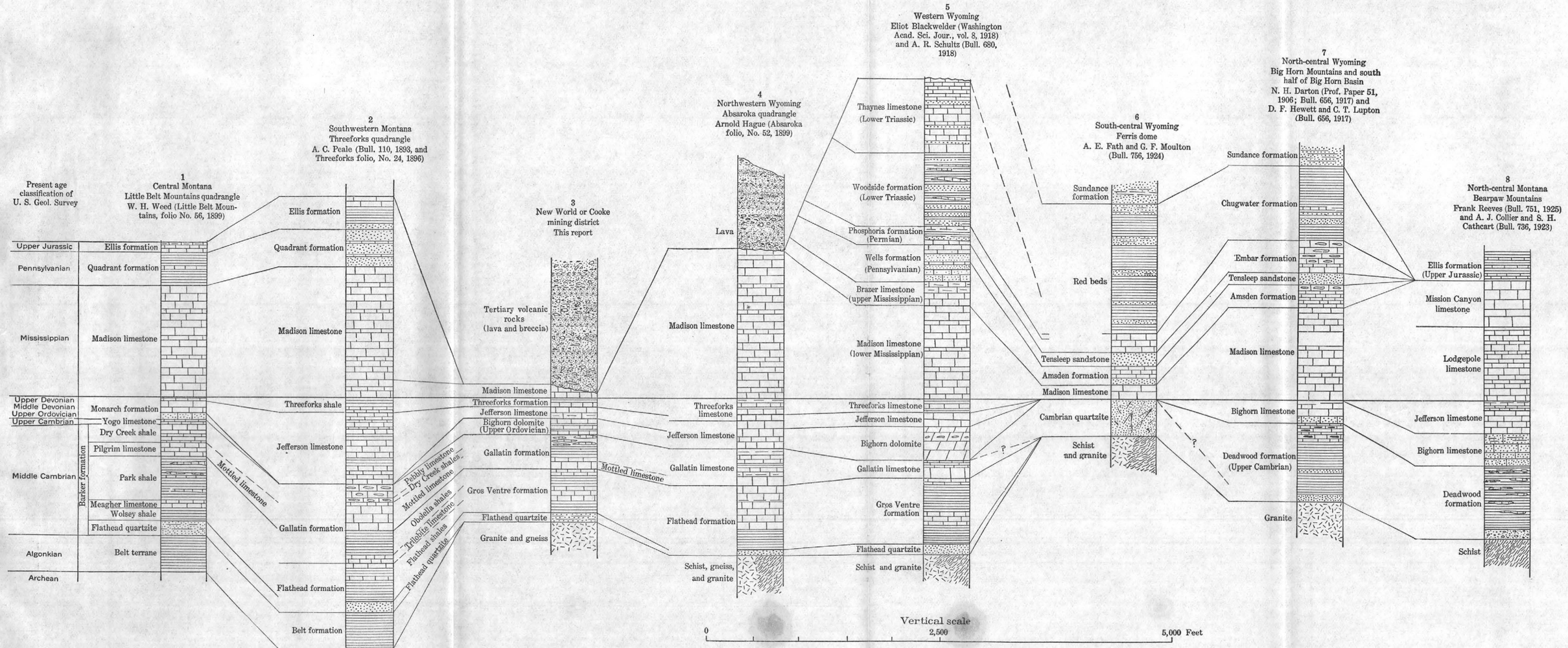
| | Feet |
|---|---|
| Flathead quartzite: | |
| Brown glauconitic sandstone | 35 |
| Gray quartzitic sandstone | 10 |
| Green fossiliferous glauconitic sandy shale | 1 |
| Gray basal quartzite | 50 |
| Conglomerate | 2 |
| Archean granite. | |

The Flathead quartzite is the oldest recognizable sedimentary rock in the district. Its base is light colored, ranging from white through pink to gray, and grades near the top into a chocolate-brown sandstone. Locally a basal conglomerate of granite, white quartz, and schist pebbles occurs, but more commonly the base is a coarsely cross-bedded arkose as illustrated in Plate 7, *B*. The overlying quartzite member consists of quartz with small amounts of feldspar and muscovite well cemented by silica. About 50 feet from the base a thin fossiliferous bed of sandy glauconitic shale occurs. Immediately above this member is a light-colored quartzitic sandstone, but a little higher it grades into brownish glauconitic sandstone, which becomes shaly as the Gros Ventre formation is approached.

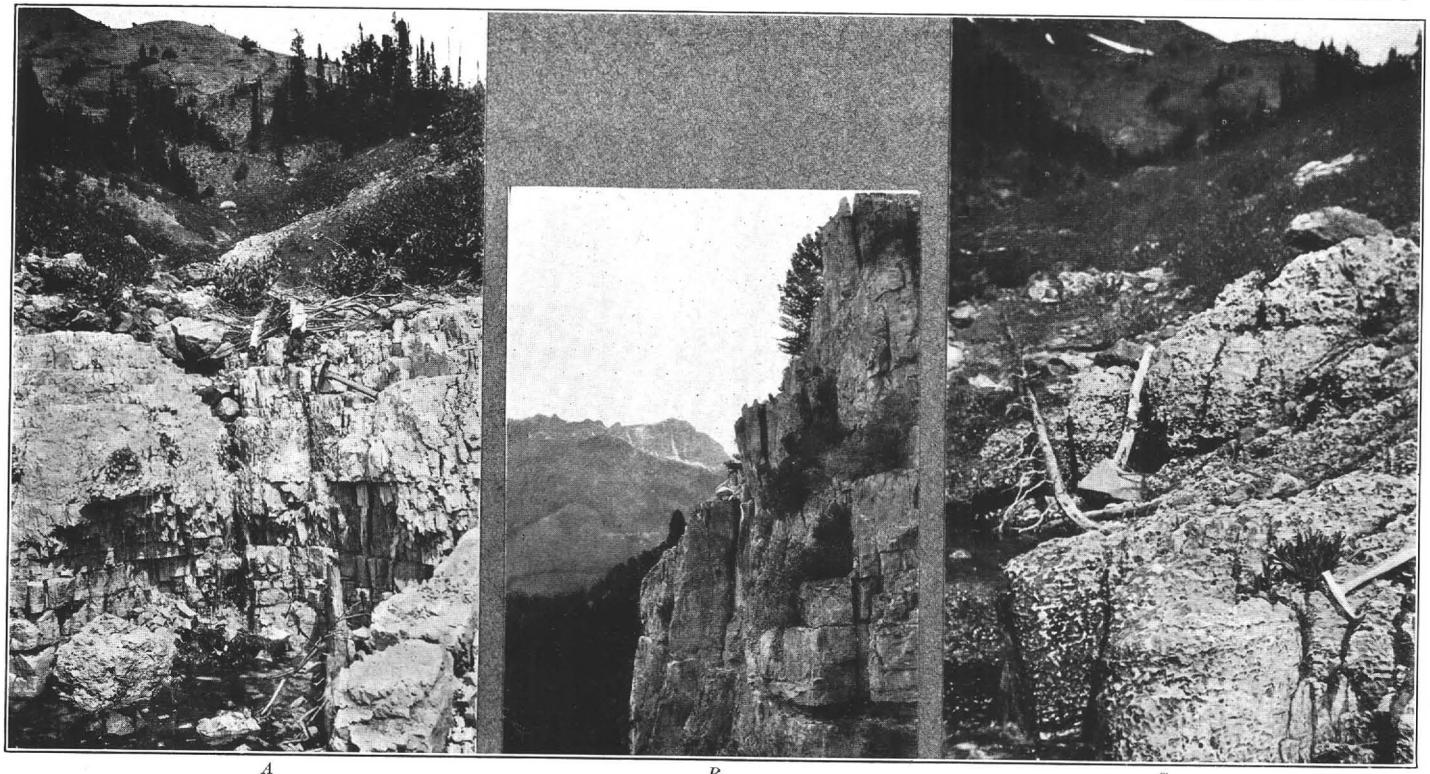
### GROS VENTRE FORMATION

Near Three Forks Peale[16] originally divided the Cambrian into the units shown in section 2 of Plate 6. Since that time the names Gallatin and Flathead have been used in different senses by various writers. In 1912 the United States Geological Survey adopted the term Flathead quartzite, the name by which the basal Cambrian quartzite of this region (of Middle Cambrian age) had been known

[16] Peale, A. C., The Paleozoic section in the vicinity of Three Forks, Mont.: U. S. Geol. Survey Bull. 110, p. 20, 1893.

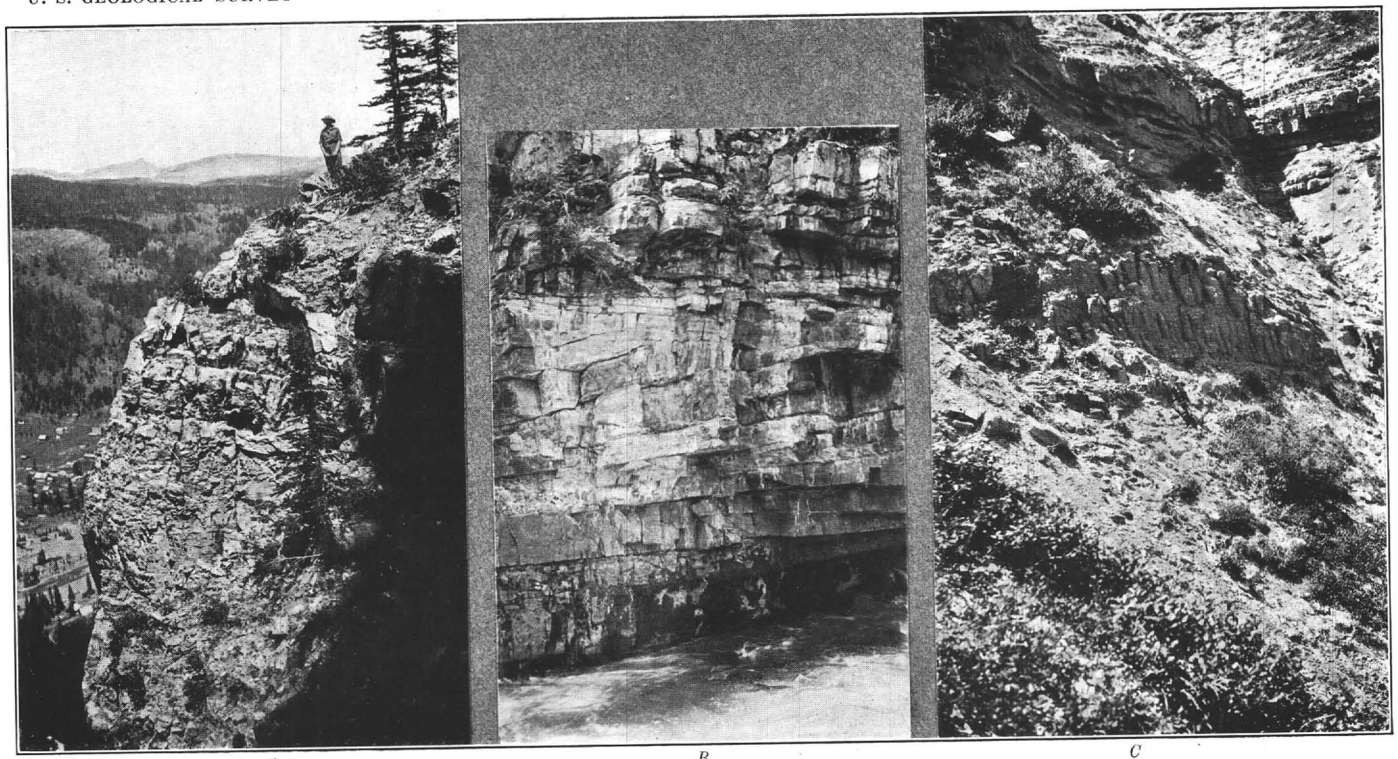



CORRELATION DIAGRAM OF THE NEW WORLD MINING DISTRICT AND SURROUNDING REGION



A B C

A. WHITE CRACKLED LIMESTONE MEMBER OF THE BIGHORN DOLOMITE, SHEEP CREEK BASIN, MONT.
B. TYPICAL EXPOSURE OF THE DARK MASSIVE CLIFF-FORMING LOWER PART OF THE BIGHORN DOLOMITE, SILVER MOUNTAIN, MONT.
C. CHARACTERISTIC EXPOSURE OF THE MASSIVE BUFF ROUGH-SURFACED MEMBER OF THE BIGHORN DOLOMITE



A B C

A. CROSS-BEDDED FLATHEAD QUARTZITE ON REPUBLIC CREEK, MONT.
B. MOTTLED LIMESTONE, THE LOWER MASSIVE CLIFF-FORMING MEMBER OF THE GALLATIN FORMATION
C. COLUMNAR WEATHERING OF LIMESTONE IN THE UPPER MEMBER OF THE GALLATIN FORMATION ON REPUBLIC MOUNTAIN, MONT.

the Paleozoic formations can be seen from the vicinity of Cooke to points in the valley of Soda Butte Creek, where detailed sections were made by Weed.[13] In mapping the Paleozoic sediments the lithologic units which had been used in mapping the adjacent quadrangles were adopted with two exceptions. The "Flathead formation" and the Jefferson limestone of Hague and his associates have both been subdivided in the New World district. Following Blackwelder,[14] the writer has mapped the formation overlying the basal Flathead quartzite and underlying the mottled limestone member of the Gallatin limestone as the Gros Ventre formation. The Jefferson limestone of the Yellowstone Park and Absaroka folios includes Ordovician as well as Devonian rocks.[15] It is almost certain that the lower part of Weed's Jefferson limestone in the detailed sections referred to above should be correlated with the Bighorn dolomite of Wyoming, and that the upper part of his Jefferson and some of the lower members of his Threeforks formation correspond to the Jefferson of the type locality in western Montana. Accordingly, the continuation of the rocks mapped as Jefferson in the northeastern part of the Yellowstone National Park is subdivided into Bighorn dolomite and Jefferson limestone in the New World district. A generalized columnar section is shown in Figure 2, and a correlation diagram of the region near by is given in Plate 6.

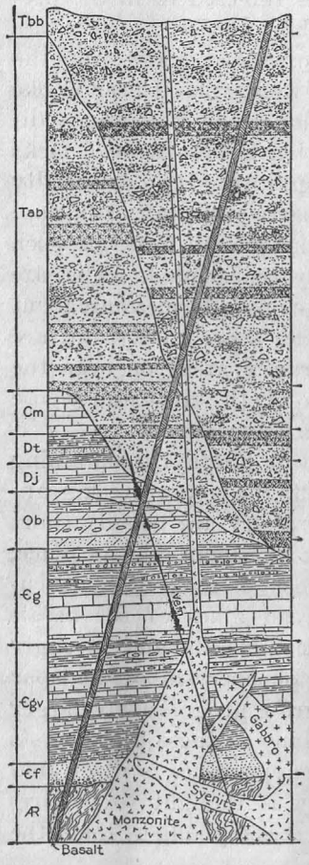



FIGURE 2.—Columnar section of the New World mining district

### CAMBRIAN SYSTEM

Both Middle and Upper Cambrian beds are present in the New World district and have a thickness of approximately 1,000 feet. The Flathead quartzite (Middle Cambrian) consists chiefly of quartzite and sandstone, but the overlying Gros Ventre formation (also Middle Cambrian) is very shaly and rarely crops out conspicu-

[13] U. S. Geol. Survey Mon. 32, pt. 2, pp. 212–213, 1899.

[14] Blackwelder, Eliot, New geological formations in western Wyoming: Washington Acad. Sci. Jour., vol. 8, pp. 417–426, 1918.

[15] Tomlinson, C. W., The middle Paleozoic stratigraphy of the central Rocky Mountain region: Jour. Geology, vol. 25, pp. 112–134, 244–257, 373–394, 1917.



The articles by Gardiner and Brooks give a very good summary of the history of mining and the conditions of mining operations up to 1921. They also contain brief descriptions of the general geology of the New World mining district and are the best accounts which have thus far appeared. Bevan's paper on the Beartooth Mountains is one of the best descriptions of the regional geology and also contains a good bibliography.

## LOCATION AND MEANS OF ACCESS

The New World mining district is in Park County, Mont., in the mountainous country northeast of the Yellowstone National Park. As shown in Figure 1 the intersection of the 45th parallel and the 110th meridian makes its southwest corner. It is reached by way of Gardiner, Mont., from which it lies about 40 miles due east, or 57 miles by road. The district has an extent of about 10 miles from north to south and 5 miles from east to west. The only settlement is the small mining town of Cooke, which lies in the valley of Soda Butte Creek, in the southern part of the district, at an altitude of about 7,600 feet. As illustrated by Plate 2, Cooke is in the heart of a beautiful mountain region. At present the population ranges from about 75 in the winter to over 200 in the summer. Summer tourists and miners who have claims upon which assessment work must be done make up most of the summer population.

All supplies are freighted from Gardiner. Red Lodge, Mont., is closer to Cooke by air line, but some of the highest and most rugged mountains of Montana separate them, and there is no direct road between the two places. An automobile road is under construction which will eventually permit communication between them and provide Cooke with another outlet. A proposed route leads north from Cooke to Columbus, Mont., by way of the Stillwater River, but although the survey has been made and a railroad promised, construction work started at Columbus has been prosecuted in a desultory manner, and little progress has been made. Thus in 1925 the only practicable means of communication between Cooke and a railroad was by teams or automobile truck over the stage road to Gardiner. Freighting to Gardiner costs about 1 cent a pound, a rate that prohibits the shipping of any but high-grade ore.

Sporadic attempts have been made from time to time to run smelters near Cooke, but as the nearest coal fields are at Red Lodge, a long haul is now necessary to bring the coal from the mines to Cooke. If transportation should become available between these two towns, it might be possible to smelt ores economically in the district, but in 1922 coke cost $40 a ton at Cooke, and this price was prohibitive. In the early history of the camp charcoal was used, but cut-

ting and burning of timber for this purpose has been forbidden by State law for a number of years.

## GEOGRAPHY

### REGIONAL GEOGRAPHY

The New World district lies in the vast area included in the Cordilleran Rocky Mountain system, in the physiographic province known as the northern Rocky Mountains. (See fig. 1.) The Yellowstone River, gathering volume from many divergent tributaries in the Yellowstone National Park, flows north through a wide intermontane valley separating the Gallatin Mountains on the west from the Snowy Mountains on the east. Near Livingston, Mont., 60 miles north of the park, the stream turns eastward around the north flanks of the Snowy Mountains. In the vicinity of Billings, augmented from the south by the waters of Clark Fork of the Yellowstone, it bends slightly to the north and follows a northeasterly course to the Missouri River through the Great Plains of eastern Montana and western North Dakota. The broad, rugged uplift delimited on the west and north by the Yellowstone River and on the east by Clark Fork of the Yellowstone is the northward continuation of the Absaroka Range of Wyoming. The steep eastern edge of the range is known as the Beartooth Mountains; the western part is called the Snowy Mountains. A high granite plateau, deeply carved by canyons, forms the backbone of the range and is termed the Beartooth Plateau. This plateau lies chiefly to the east of the center line of the uplift and contains the highest mountain country in Montana. Granite Peak, 12,850 feet above sea level, is the highest peak in the State and lies about 15 miles northeast of the Yellowstone National Park and a few miles northeast of the region mapped in this report. The Beartooth Plateau was formerly covered by an extensive ice sheet, which drained into the surrounding country through many valley glaciers. The tongues of ice radiating from the ice cap trenched valleys thousands of feet below the mountain tops. Hanging valleys, gemlike mountain lakes, polished granite ledges (roches moutonnées), and deeply scarred cirques mutely attest the tremendous sculpturing of the ice. A few glaciers still linger in the high country. The New World mining district lies in this region of rugged and inspiring beauty, where the Snowy Mountains merge eastward into the Beartooth Plateau and southward into the Absaroka Range of Wyoming.

### TOPOGRAPHY AND DRAINAGE

The area discussed in this report is entirely mountainous. The valley floors range in altitude from 7,500 to 9,000 feet and some of the neighboring peaks reach more than 11,000 feet.



*Gabbro gneiss.*—The north end of Mount Fox is made up of a gabbro gneiss which apparently is younger than the Goose Creek granite. This is the only locality in the New World district where this rock is found. It has a striking appearance, consisting of coarse-grained hornblende and plagioclase that weather dark green and white respectively. The structure of the mass suggests an ancient plug or small stock, and the schistose dikes referred to in the preceding paragraph may be related to this gabbro gneiss.

*Cooke granite.*—An ancient but unmetamorphosed granite cuts the Goose Creek granite at many places. It is well exposed near Cooke and apparently extends to the southwest under the Paleozoic sediments. The Cooke granite, as this formation is here named, lacks the gneissic structure of the Goose Creek granite. It is essentially a medium-grained pink granite in which quartz and pink orthoclase make up the bulk of the rock, and the ferromagnesian minerals, such as biotite and hornblende, are but sparingly represented. The size of the crystals varies but little, and the grains usually measure about 3 millimeters in diameter. Pegmatitic facies occur rarely and are usually found within the Goose Creek granite areas or near the borders of the Cooke granite. Inclusions of both schist and Goose Creek granite have been observed but are very uncommon.

*Basalt porphyry.*—A fresh-appearing basalt porphyry containing feldspar phenocrysts 3 inches in diameter cuts the Goose Creek granite in a few places. The dikes of this porphyry are usually short and irregular, and for this reason the rock is seldom seen in place, but the great size of the light-colored phenocrysts make it conspicuous in stream débris. The borders of broad dikes of the basalt porphyry are practically free from black minerals and strongly resemble fine-grained anorthosite. Small phenocrysts of feldspar appear a few inches from the sides and grow progressively larger as the center of the dike is approached. Many of these phenocrysts are 4 inches in diameter, and their striking appearance is illustrated in Plate 5, *B*. The age of the porphyry is thought to be pre-Cambrian, as it was not found cutting rocks younger than the Archean at any point in the district.

## PALEOZOIC ROCKS

### GENERAL FEATURES

Sedimentary rocks of Paleozoic age cover about one-third of the district, and their distribution is shown on Plate 1. They include formations of Cambrian, Ordovician, Devonian, and Mississippian age, which are readily correlated with the formations of the Yellowstone National Park, where careful work has been done by W. H. Weed, J. P. Iddings, and others. Nearly continuous exposures of

vertical it may have been accompanied by a slight tilting to the west. It renewed the erosional activity of streams, and valleys were rapidly carved in the newly formed plateaus. Probably glaciers were formed in the higher part of the range very soon after the uplift occurred.

A deep mantle of snow and ice covered the New World district in Pleistocene time, and the more conspicuous topographic features now observed have been produced by heavy glaciation. Since this comparatively recent ice action streams have been at work cutting narrow gorges in the old U-shaped ice channels and otherwise modifying the glacial topography.

## ARCHEAN ROCKS

Half of the bedrock mapped in the New World district is of pre-Cambrian age, but this proportion would be diminished to about one-fifth if the Goose Lake area were excluded. These rocks unconformably underlie the Flathead quartzite, the oldest Cambrian formation in the region. The period in which they were formed is not certainly established, although they are mapped as Archean in adjoining regions and are believed to be of that age. They are therefore herein classified as Archean.

The pre-Cambrian rocks mapped are all of igneous origin, unless the scattered schist inclusions in the granite should prove to be fragments of greatly metamorphosed sediments. Granitic rocks make up the bulk of the Archean rocks exposed and occupy extensive areas to the east and north of the district. They cover practically all of the Goose Lake country and appear along the eastern and northern edges of the New World district.

*Goose Creek granite.*—The oldest rock is a gneissic gray granite, locally carrying inclusions of biotite or hornblende schist. It is most widely exposed in the northern part of the district, and as Goose Creek flows over this rock for practically its entire length, it is here named the Goose Creek granite. In metamorphic texture the rock ranges from a strongly banded biotite gneiss to a granite distinguished by granulated feldspar. The usual gray color is in places masked by an abundance of garnet, which makes it superficially resemble the younger pink granite. Mineralogically the Goose Creek granite commonly consists of about 65 per cent of gray feldspar (oligoclase and orthoclase), 20 per cent of quartz, and about 15 per cent of biotite. Medium to coarse grained textures predominate, and fine-grained facies are rare.

Narrow masses of hornblende and chlorite schists cut the gneiss near Mount Fox and probably represent early basic intrusive rocks which were rendered schistose by the same agency that gave the gneissic structure to the granite.



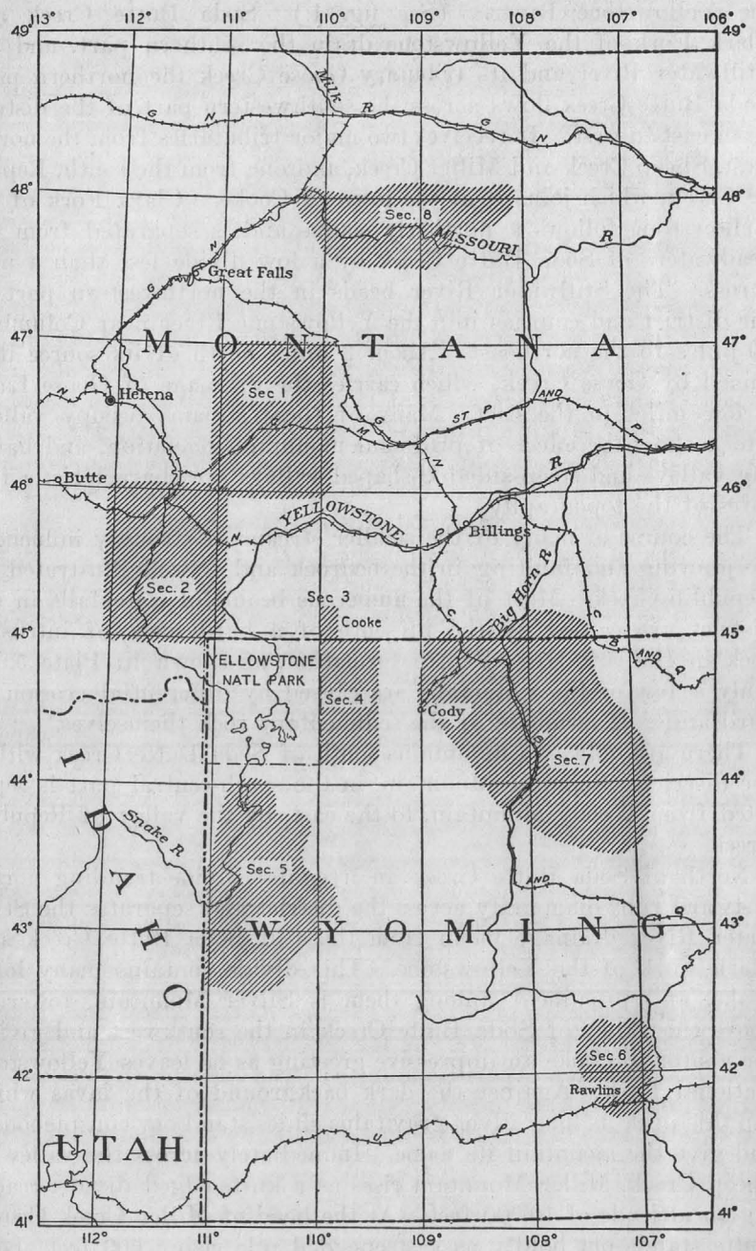



FIGURE 1.—Index map showing location of New World mining district, Montana. Shading indicates areas represented by sections in Plate 6

The district is drained by the headwaters of three tributaries of the Yellowstone River. (See fig. 1.) Soda Butte Creek and Clark Fork of the Yellowstone drain the southern part, and the Stillwater River and its tributary Goose Creek the northern part. Soda Butte Creek flows across the southwestern part of the district from east to west. It receives two major tributaries from the northwest, Sheep Creek and Miller Creek, and one from the south, Republic Creek, which joins it at the town of Cooke. Clark Fork of the Yellowstone follows a northerly course and is separated from the headwaters of Soda Butte Creek by a low divide less than a mile across. The Stillwater River heads in the northwestern part of the district and empties into the Yellowstone River near Columbus, 60 miles to the northeast. About 3 miles north of its source it is joined by Goose Creek, which carries the drainage of Goose Lake, a few miles to the east. Many of these streams occupy valleys which show the effect of profound mountain glaciation, and hanging valleys and steep-sided U-shaped valleys are characteristic features of the topography.

The course of many of the smaller streams is strongly influenced by jointing and faulting in the bedrock and is well illustrated by Republic Creek. Most of the numerous beautiful waterfalls in the district are caused by the presence of a hard mass of intrusive rock in the soft Gros Ventre formation, as shown in Plate 5, *A*. Only a few of the waterfalls are caused by differential erosion of hard and soft members of the sedimentary rock themselves.

There are only two mountains south of Soda Butte Creek within the district. Republic Mountain, in the south-central part is separated from Woody Mountain, to the east, by the valley of Republic Creek.

North of Soda Butte Creek an irregular divide trending northeastward runs diagonally across the district and separates the Stillwater River drainage basin from those of Soda Butte Creek and Clark Fork of the Yellowstone. This divide contains many lofty peaks, and prominent among them is Silver Mountain, towering above the valley of Soda Butte Creek in the southwest and giving the visitor to Cooke an impressive greeting as he leaves Yellowstone National Park. Against the dark background of the lavas which cap this peak its long silver-gray talus slides stand out conspicuously and give the mountain its name. Immediately across the valley of Sheep Creek, Miller Mountain rises as a knife-edged divide, reaching an altitude of 10,500 feet. At the head of Miller Creek Crown Butte stands out boldly as a steep-sided pile rising 600 feet above Daisy Pass. Henderson Mountain, between Miller Creek and the valley of Clark Fork of the Yellowstone, has a gentle western slope



period the land was again submerged, and marine sandstone, shale, and limestone preserve an incomplete record of the Jurassic deposition.

In Cretaceous time—when Mesozoic seas had their maximum extent in North America—sediments thousands of feet in thickness accumulated in Montana. This system is predominantly marine shale and sandstone, with minor amounts of limestone and chalk. Toward the end of this period volcanic activity commenced, and thick beds of andesitic tuff occur in the Livingston formation, forecasting the great igneous activity of the Tertiary period. During late Cretaceous or early Tertiary time a pronounced uplift of the region caused the final withdrawal of the seas from this part of North America. The anticline in which the New World district is situated probably had its birth in these early movements of the Rocky Mountain revolution.

From that time to the present erosion has been active, and early in Tertiary time it had completely removed Cretaceous, Jurassic, Triassic, and late Carboniferous rocks from the New World mining district, developing a land surface of moderately strong relief.

The first result of the volcanic activity that characterized the Tertiary period is found in the early acidic breccia, of Eocene age.[9] This material probably represents a volcanic outburst of great magnitude, although the beds in the vicinity of Cooke are not extensive.

Erosion cut away the greater portion of this early lava in Oligocene time and reduced the range to a nearly featureless peneplain.[10] This surface was then uplifted about 2,000 feet and tilted slightly to the southwest, and remnants of the ancient peneplain can be seen to-day in the smooth, gently inclined granite summits of the Beartooth Mountains.

During Miocene time there was an extrusion of more basic lava,[11] which was accompanied by the intrusion of numerous dikes and sills. Nearly contemporaneous with the basic lava were intrusions of gabbro, and later granodiorite and related rocks appeared. Faulting, fracturing, and mineralization attended this igneous activity. Some time during the later part (Pliocene?) of the Tertiary period basalt dikes were intruded, cutting all the rocks previously mentioned.

A second epoch of peneplanation began in the Pliocene epoch, but long before its completion it was interrupted by an uplift of great magnitude. This last movement, according to Bevan,[12] occurred in early Quaternary (Pleistocene) time, and although nearly

[9] Hague, Arnold, The age of the igneous rocks of the Yellowstone National Park: Am. Jour. Sci., 4th ser., vol. 1, p. 450, 1896.

[10] Bevan, Arthur, Rocky Mountain peneplains northeast of Yellowstone Park: Jour. Geology, vol. 33, pp. 563–587, 1925.

[11] Iddings, J. P., U. S. Geol. Survey Geol. Atlas, Yellowstone National Park folio (No. 30), 1896.

[12] Bevan, Arthur, op, cit., p. 587.

ments, removing nearly all the beds overlying the massive siliceous member of the Bighorn dolomite.

Only slight differences of relief existed when the Devonian sea advanced and covered this erosional surface, and the base of the Jefferson limestone, the lowest Devonian formation, is a subangular limestone breccia. Warm, clear water must have existed for some time, as the Jefferson limestone is thick and uniform and shows no conformable sandstone or shale at its base. Later in the Devonian period the water shoaled, and light-colored sandy limestone was formed, constituting the lower part of the Threeforks formation. This sandy limestone is overlain by alternate layers of green and red shale and a few thin beds of purple limestone. The predominant red or pink color is presumably due to the iron oxide washed from the Devonian shore.

The transition from the Upper Devonian (Threeforks) to the Mississippian epoch was very quiet, and no evidence of uplift marks the passage from one to the other. It is probable that the land surface which supplied the clastic sediments lay practically awash in late Devonian time, and at the end of the period deposition was slight. Conditions favorable to extensive limestone deposits again returned, and the uppermost shale of the Devonian is decidedly limy, foreshadowing the great thickness of limestone which was formed in the Mississippian epoch.

Limestone was deposited upon a sinking bottom in the Mississippian sea, and over 1,500 feet of calcareous material (Madison limestone) was laid down before a decided change in the conditions of deposition took place. The shoaling of the sea toward the end of the Paleozoic era is indicated in neighboring regions by quartzite, sandstone, reddish shale, and a little impure limestone formed during Pennsylvanian and Permian time.

If the geologic history were to be interpreted solely from the evidence in the New World district the formations overlying the Paleozoic sediments would bespeak volcanic activity after sufficient time had elapsed to allow erosion to etch a fairly rugged topography in the uplifted sediments, but no clue would be given to the history represented by the unconformity between the volcanic rocks and the sediments. South of Cooke Tertiary fossils have been found in volcanic ash that rests on Mississippian beds, showing that Mesozoic rocks are lacking here. Study of the surrounding region indicates that beds thousands of feet thick were eroded in this district before Tertiary volcanic activity began. Reconstruction of the history of this interval from evidence obtained in the surrounding country shows that thin Triassic beds of red shale and sandstone were formed—presumably as arid continental deposits—after the uplift that marked the end of Paleozoic time. During the succeeding



that presents a marked contrast to its precipitous eastern side. Red Mountain lies north of Henderson Mountain and derives its name from its iron-stained flanks. Scotch Bonnet Mountain, reaching an altitude of 10,485 feet, stands at the head of the valley of Clark Fork of the Yellowstone. East of it, Sheep Mountain rises to an altitude of 10,700 feet, and here again we find a gentle western slope and a very precipitous cliff-like slope on the east.

From the top of Sheep Mountain the region to the east and north presents a great contrast to that which lies to the south, southwest, and west. The granite country to the northeast was formerly covered by a great ice sheet and presents the knob and kettle topography so characteristic of glaciated surfaces. Scattered over this area are 15 or 20 small lakes, and to the west and southwest there is a wide expanse of rugged mountain peaks, sharp, deep valleys, and sparkling streams. Plates 3 and 4, *A*, well illustrate the characteristics of the heavily glaciated region. On a clear day the Grand Tetons may be seen, a hundred miles to the southwest.

Goose Creek occupies a canyon whose walls rise 1,000 feet above the stream. It has a steep gradient, for it heads in Goose Lake at an altitude of nearly 10,000 feet and empties into the Stillwater River, 4 miles to the southwest, at an altitude of less than 7,900 feet. Goose Lake is surrounded by the highest mountains of the district. Mount Fox, to the west, attains an altitude of 11,250 feet. The Sawtooth Mountains, to the north, rise to 11,600 feet, and Mount Zimmer, to the east, reaches 11,680 feet. Northeast of the lake, across Glacier Divide, is Grasshopper Glacier. This glacier, famous for the entombed grasshoppers which it contains, drains northeastward into East Rosebud Creek.

## CLIMATE

Many of the mountains are snow capped the entire year, but the snow melts from the valleys in June, and automobile traffic between Cooke and Gardiner starts late in May. During June, July, August, and September the climate is ideal. Snowstorms may occur in any month of the year, but the snow seldom comes to stay until late in the fall, and automobile stage service with Gardiner sometimes continues until December. December, January, February, and March are the only months that bring much snow, but by spring drifts in the passes often attain a depth of 75 feet. Through this season mail service is maintained once a week by means of horses, dog teams, and snowshoes. There is seldom at any season of the year a distance of more than 8 miles which can not be traversed by horses. As the snows melt in April and May, these are the months of the spring floods, and during this time the snow disappears with great rapidity

and makes travel of any sort very difficult. Mute evidence of the heavy winter snowfall is given by the snowslide scars illustrated in Plate 4, *B*.

### VEGETATION

The southern part of the district is heavily forested, but toward the granite country, to the north, timber becomes noticeably less abundant, and north of Goose Creek it is practically absent. Close to the streams a heavy growth of willow and black alder is common, and the lower slopes of the mountains carry spruce, balsam, fir, lodgepole pine, and a small amount of cedar. The higher slopes support juniper and limber pine. The district lies in the Beartooth National Forest, and thus the timber is well guarded by competent rangers, and an adequate supply of lumber for mining operations is available.

Grass is abundant in the valleys and in many open, parklike spaces in the mountains, providing abundant forage for horses and for the wild game that abounds in the district, and these areas are also thickly carpeted with wild flowers.

### INDUSTRIES

Ever since the early settlement of Cooke it has been an outfitting center for prospectors, and in recent years it has furnished supplies for the stock raisers, who yearly take advantage of the excellent summer forage found in the mountain valleys near by. Although mining has been the most important industry carried on for a great many years, in some seasons the revenue derived from the tourist camp erected in 1921 exceeds that coming from the mines in their semidormant state. Trapping is carried on to some extent in the winter.

## REGIONAL GEOLOGY

The front ranges of the Rocky Mountains are in general broad arches or anticlinal folds along whose eastern and western fronts the formations have been tilted at very steep angles. Fracturing frequently accompanies such severe deformation, and along the borders of the mountains some of the folds pass into faults many miles in length. In these ranges erosion has stripped the cover most rapidly from the centers of the anticlines and exposed ovate areas of pre-Cambrian rocks girdled by Paleozoic and Mesozoic sediments. Igneous activity frequently but not invariably accompanied the formation of the front ranges; and in the Beartooth Range, in which the New World mining district lies, folding, faulting, intrusion, and extrusion have all played their part.



Stocks and other intrusive rocks of Tertiary age are well developed in the center of the district, and numerous dikes and sills attest intrusive activity in the southern part. Faulting took place in Tertiary time, and four main systems of faults and related fissures are recognized. In their probable chronologic order from oldest to youngest, these trend east, N. 20° W., N. 55° E., and N. 30° E. The stresses that produced these faults have also produced joints parallel to the corresponding faults in the more competent beds.

Extensive mineralization has taken place. Contact metamorphism has developed gold and copper deposits in the vicinity of Henderson Mountain, and in the surrounding region lead-silver-zinc ores commonly occur as replacement deposits and veins. At Goose Lake, in the northern part of the district, there is a deposit of chalcopyrite formed by magmatic segregation which carries appreciable quantities of platinum. The region near this deposit has not been thoroughly prospected but is known to contain some promising lead-silver veins.

### GEOLOGIC HISTORY

In pre-Cambrian time the country suffered intense regional metamorphism and the intrusion of many different granite magmas. An enormous period of time elapsed during which erosion cut this district to a nearly featureless peneplain exposing these acidic plutonic rocks to a great depth. Early in Paleozoic time subsidence took place, and basal conglomerates and sandstones (Flathead quartzite) were deposited in the shallow Middle Cambrian sea. As the waters deepened the deposits became argillaceous, and evidence of offshore deposition is found in the interbedded limestone and shale that make up the Gros Ventre formation. A slight oscillation in the sea bottom toward the end of the Gros Ventre epoch lifted the sea floor, so that Cambrian limestone was exposed to the wave action and limestone conglomerate was formed. In Upper Cambrian time the waters again advanced, and during a long period in which conditions were nearly uniform the massive lower member of the Gallatin limestone was deposited. Successive beds of shale, flat-pebble conglomerate, and thin limestone and sandstone above the thick limestone member indicate varying conditions of deposition during late Cambrian time.

After the Cambrian period sedimentation ceased until Upper Ordovician time, when the Bighorn dolomite was deposited. The oldest part of this formation was a siliceous dolomite, and above it sandy and shaly limestones were laid down, indicating the advance of the sea and its later shoaling.

It is probable that this region emerged from the sea in the Silurian period but without appreciable tilting. Erosion cut into the sedi-

Boulder, New World, and Sunlight mining districts and 40 miles farther to the southeast in the Kirwin district. The occurrence of the ore in these localities goes hand in hand with the presence of intrusive rocks, but such ores usually occur in or near stocks of essentially even-grained rocks that include gabbro, diorite, and syenite. This mode of occurrence is typical of the ore deposits of Montana and other Northwestern States, where most of the metallization is related to granites or granitoid rocks, whereas intrusive rocks that have dense or porphyritic instead of granular texture, even though large and of cross-breaking form, are usually accompanied by metallization on only a moderate or minor scale. In Montana ore deposits are rarely found in or near porphyries except where the porphyries are cut by younger bodies of granular rock, but the region under discussion is an exception to this general rule. In the Emigrant mining district, on the east side of the Yellowstone Valley north of Gardiner, at a few points near the west side of the Livingston quadrangle, and in the New World district there are ore deposits closely associated with cross-breaking masses of rocks belonging in the acidic porphyrite group of Iddings. In the New World district the rock of this group is a monzonite porphyry. Ore deposits associated with monzonite porphyries are fairly common in the Southwest but unusual in this part of the Rocky Mountains.

## GEOLOGY OF THE DISTRICT

### OUTLINE OF THE GEOLOGY

The bedrocks over about half of the New World district are of pre-Cambrian age. Paleozoic sedimentary rocks cover about one-third of the district. Mesozoic sediments are lacking. Some water-laid tuffs of Tertiary age are present in the volcanic breccias. A thin mantle of glacial drift covers the older rocks in many places but has not been mapped except where doubt exists as to the distribution of the bedrock formations which it hides. Landslides are abundant, and alluvial deposits are present in most of the stream valleys.

The Snowy Mountains, in which the New World mining district lies, are due to a broad anticlinal Laramide uplift that trends northwest. As the region is slightly to the west of the axis of this uplift the pre-Tertiary sediments have a general dip to the southwest. The rocks present include pre-Cambrian schist, gneiss, and granite, Paleozoic sedimentary rocks, Tertiary volcanic and intrusive rocks, and Quaternary deposits. Erosion has removed the Paleozoic and younger formations from the northeastern part of the district, exposing the Archean complex, but in the southwest the pre-Cambrian is not uncovered.



The Beartooth and Snowy Mountains constitute an elongated dome which rises in northern Wyoming near the canyon of Clark Fork of the Yellowstone River and extends northwestward to the valley of the Yellowstone near Livingston, Mont. Along the axis of this anticline there is an extensive belt of pre-Cambrian crystalline rocks 20 to 25 miles wide, bounded on both sides by sedimentary rocks that partake of the anticlinal structure.[1] Along the northeastern flank the whole Paleozoic and Mesozoic section is exposed, but on the opposite side the Mesozoic formations are mostly hidden by volcanic rocks of Tertiary age except at the ends of the long anticline.

The Paleozoic strata of the region are usually divisible into eight formations and include rocks of Cambrian, Ordovician, Devonian, Mississippian, and Pennsylvanian age. These formations consist predominantly of limestone and have a total thickness of 2,000 to 3,500 feet. Mesozoic rocks are lacking in the New World mining district but are well shown on the northeast side of the great uplift, where they consist largely of shale and sandstone and attain a thickness of over 5,000 feet. Both Paleozoic and Mesozoic beds formerly extended across the pre-Cambrian area, from which they have been removed by erosion since the upthrusting of the broad anticline near the end of Mesozoic time. Where the sedimentary rocks are now exposed they exhibit a very rugged surface, and it was upon similar topography that a thick series of Tertiary lava was spread in Eocene and Miocene time.

The New World mining district lies on the southwest flank of the great Beartooth-Snowy Mountain anticline, within the region where erosion has bitten deeply into the uplift and exposed both Paleozoic sediments and rocks of the crystalline complex. Thick accumulations of effusive volcanic rocks rest with marked unconformity upon the earlier formations. In the Yellowstone National Park six sets of extrusive rocks have been distinguished.[2] Only two of these, the early acidic breccia and the early basic breccia, are generally present in the northeastern border of the volcanic plateau region of the park, although basalt flows representing a third set occur in the high mountains immediately southeast of Cooke. On the basis of fossil plants occurring in tuffs and intercalated sediments an Eocene age has been assigned to the early acidic breccia.[3] Neither the original nor the present extent of this formation can be determined, as it had been deeply eroded before the extrusion of the basic breccia began, and it is widely buried by younger effusive rocks, which in many

[1] Bevan, Arthur, Jour. Geology, vol. 31, pp. 448, 457, 1923.
[2] Iddings, J. P., U. S. Geol. Survey Geol. Atlas, Yellowstone National Park folio (No. 30), 1896.
[3] Idem, p. 2.

places rest on formations older than the early acidic breccia. The early acidic breccia is exposed only where formerly buried masses, some of which are of mountainous proportions, have been exhumed by the stripping and trenching of the younger volcanic rocks. The flora found in the early basic breccia at Specimen Ridge was first assigned to late Miocene time,[4] but recent work by Knowlton [5] suggests that it may be much earlier, although it probably should still be classed as Miocene. A discussion of its probable age will be found on page 31. Valleys that were several thousand feet deep were filled by the Miocene breccias and basalts, and the volcanic activity of this time completely obliterated the preexisting topography.

The source or sources of the volcanic rocks is an interesting problem to the volcanologist. At three localities in the Crandall quadrangle, south of the New World district—in the Sunlight mining district, at Hurricane Mesa, and at Sunlight Basin—composite bodies of gabbro, diorite, and syenite occur with the form of typical stocks and are thought to be the volcanic conduits of the early basic breccias near by. The localities named are about 15 miles apart and they define a triangle so oriented that the apex at Hurricane Mesa is directed toward the New World district, 15 miles distant to the northwest. Near Cooke gabbro stocks and other intrusive masses occur along the pre-Cambrian and Paleozoic boundary, and near Goose Lake, 7 miles farther north, there are stocks of three sorts of granular rocks cutting pre-Cambrian granite. At Haystack Peak, 12 miles northwest of Cooke, a stock composed of gabbro, diorite, and related rocks occurs at the edge of the pre-Cambrian terrain, just where the ancient rocks are overlapped by the acidic breccia that constitutes the base of the volcanic series.

The bodies of granular rocks in the Crandall quadrangle break through several thousand feet of rudely bedded basic breccia, and, as shown by Iddings,[6] the stocks occupy the pipes of volcanoes that were active during the later part of the basic breccia epoch. The stocks at the three localities to the northwest, though more deeply eroded, are believed to be volcanic necks belonging to the same general period.

Southeast of the New World district for many miles the Paleozoic formations exposed along the border of the pre-Cambrian terrain are not invaded by bodies of igneous rock other than narrow dikes. From the locality of Cooke northwestward as far as the valley of Yellowstone River the pre-Tertiary sediments, especially those making up the lower part of the section, have been intruded in many places by sills of basalt, dacite, or andesite. In a few places along this border, in addition to dikes and sills, there are large masses of the same or closely related rocks, some of which are irregular laccoliths, and others break directly across the sedimentary bedding planes.

[4] Hague, Arnold, The age of the igneous rocks of the Yellowstone Park: Am. Jour. Sci., 4th ser., vol. 1, pp. 451–452, 1896.

[5] Knowlton, F. H., Flora of the Latah formation of Spokane, Wash., and Coeur d'Alene, Idaho: U. S. Geol. Survey Prof. Paper 140, p. 17, 1926.

[6] Iddings, J. P., Geology of the Yellowstone National Park: U. S. Geol. Survey Mon. 32, pt. 2, p. 232, 1899.



Emmons regards the andesite-dacite sills that invade the Cambrian sandstone, shale, and limestone in the vicinity of Haystack Mountain as the oldest Tertiary intrusive rocks of this district,[7] but he makes no definite statement concerning the relative age of the stocklike bodies of similar rock that occur east and south of the Haystack stock of gabbro and diorite.

At Emigrant Gulch, on the east side of the Yellowstone Valley a few miles north of Gardiner, a large mass of dacite-andesite porphyry associated with monzonite porphyry breaks through the early basic breccia,[8] and some of the large bodies of similar rocks occurring in the southeastern part of the Livingston quadrangle west of the New World district probably exhibit the same relation.

In the New World district a large mass of porphyritic monzonite which breaks through the Paleozoic formations is known to be younger than part of the basic breccia from the fact that the lower beds of the volcanic formation, though not actually in contact with the igneous rock, are found to be considerably metamorphosed in its vicinity. Where gabbro and porphyritic monzonite (belonging to the acidic porphyrite group) are in contact, the monzonite is believed to be younger than the gabbro. Elsewhere rocks of the granular and porphyritic groups are not known to come together.

All the formations that have been mentioned are cut by narrow dikes of many varieties of basic rocks. Such dikes are especially numerous near some of the old volcanic vents, and from this fact it appears that they represent the latest extrusions from these centers of igneous activity.

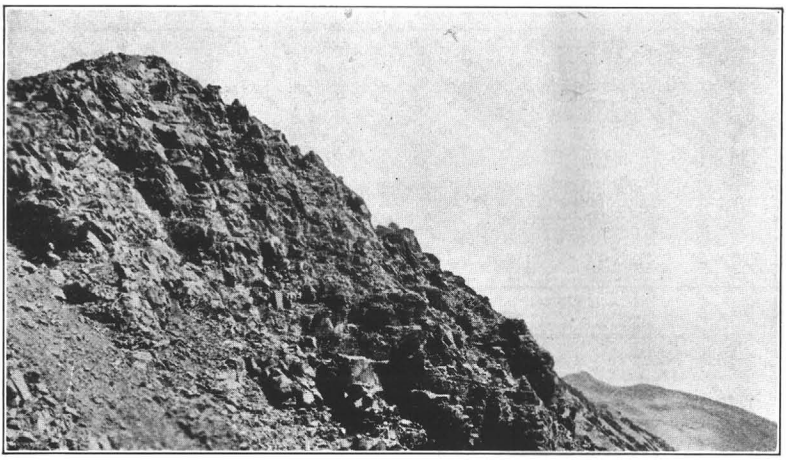
Close to the igneous intrusions the country rocks are more or less indurated and metamorphosed, the degree of alteration varying with the physical and chemical character of the invaded rocks, on the one hand, and with the form, size, and composition of the invading masses, on the other. Within the major uplifts of this part of the Rocky Mountains mineral deposits containing sulphides of iron, copper, lead, and zinc with or without noteworthy amounts of silver and gold occur mainly in or close to those large intrusive masses of stocklike character. This association is illustrated in the

[7] Emmons, W. H., Geology of the Haystack stock, Cowles, Park County, Mont.: Jour. Geology, vol. 16, p. 201, 1908.

[8] Iddings, J. P., Geol. Soc. London Quart. Jour., vol. 52, p. 612, 1896.

*A.* POIKILITIC INTERGROWTH OF BIOTITE AND LABRADORITE IN BIOTITE GABBRO

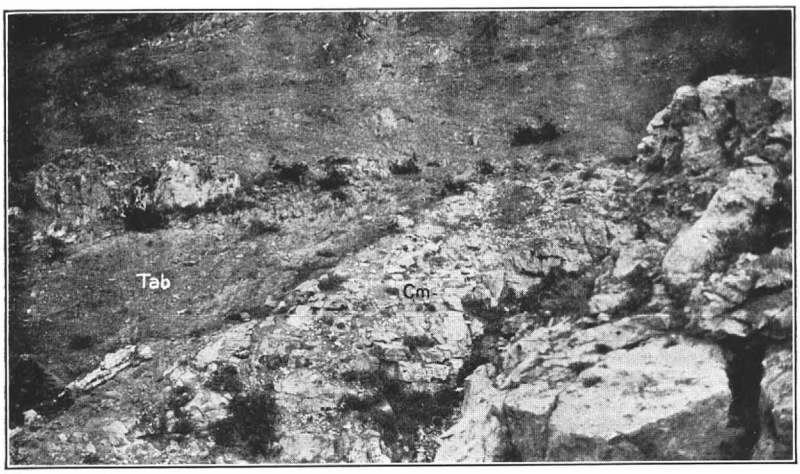
Specimen from prospect on Miller Creek 200 yards east of bench mark at Cooke



*B.* HORIZONTAL SHEETING DEVELOPED IN THE BIOTITE GABBRO FORMING THE TOP OF SCOTCH BONNET MOUNTAIN, MONT.

*A.* WOODY MOUNTAIN, MONT.

The cliff is the brown sandy limestone member of the Threeforks formation, and the man is standing on a sill of Pliocene basalt that is an offshoot from the dike seen on the right




*B.* UNCONFORMITY BETWEEN MADISON LIMESTONE (Cm) AND EOCENE EARLY ACIDIC BRECCIA (Tab), WEST SIDE OF WOODY MOUNTAIN

The picture clearly indicates the rugged character of the early Tertiary topography upon which the volcanic tuffs and breccias were deposited

Jefferson limestone. Medium or thin-bedded gray limestone 35 feet thick rests on the cherty member and is overlain by a dense white crackled limestone whose weathered surface has a distinctly soapy texture and feeling. This member is a good horizon marker, and its appearance is well shown in Plate 8, *A*. The massive rough-surfaced buff dolomite shown in Plate 8, *C*, intervenes between the bed just described and a thin-bedded whitish limestone of shaly texture. The 35-foot layer of massive buff dolomite overlying the shaly limestone forms the top of the Bighorn formation and is covered by rocks of Devonian age. A vertical section is given below:

*Section of Bighorn dolomite on north side of Sheep Creek-Stillwater River divide 3½ miles northwest of Cooke*

| | Feet |
|---|---|
| Jefferson limestone: Chocolate-brown fetid-smelling granular limestone | 10 |
| Bighorn dolomite: | |
| Rough-surface massive dolomite, weathering buff; fresh surface medium grained, light colored but blotched with gray | 35 |
| Thin-bedded, somewhat shaly whitish limestone; contains many thin layers of darker color; fossiliferous | 25 |
| Massive dolomite, weathering dark buff with rough, reticulated surface; rather coarse grained; contains some chert and many calcite nodules | 15 |
| White crackled limestone; weathers with a dull-white smooth, soapy-feeling surface; fresh surface white and dense | 20 |
| Brecciated limestone, massive; weathers gray; fresh surface shows light-gray fine-grained matrix containing dark blue-gray, irregularly rounded fragments | 5 |
| Massive banded limestone; bands of dark blue-gray fine-grained limestone alternate with bands of light blue-gray; the bands range from half an inch to 1 inch in thickness | 10 |
| Thin-bedded earthy-textured light-gray limestone, weathers back in slope | 5 |
| Massive limestone; weathers light gray to buff with rough, irregularly pitted surface; on fresh fracture the surface is brownish gray and has a somewhat brecciated appearance | 10 |
| Massive dark-gray dolomitic limestone, containing an abundance of black chert nodules 2 to 5 inches in diameter | 10 |
| Massive dolomitic limestone; weathers with rough dark bluish-gray deeply pitted surface; fetid smelling on fresh fracture and showing medium-grained dark-buff dolomitic patches in a finer-grained dark brownish-gray matrix; fossiliferous; covered by talus | 25 |
| Gallatin limestone (float) | 10 |

beds overlying the Gallatin formation here the writer found a few fossils which Prof. A. A. Stoyanow has kindly identified. They include *Platystrophia lynx* Eichwald, *Halysites catenulatus* Linnaeus, *Raphistoma* sp.?, and *Orthoceras* sp.? This fauna is pronounced by Kirk to indicate the western facies of the latest Upper Ordovician or Richmond fauna, which is characteristic of the Bighorn dolomite. A marked lithologic change also occurs 175 feet above the base of the rocks previously included in the Jefferson, and at this horizon *Atrypa reticularis* Linnaeus was discovered. The chocolate-brown fetid limestone carrying this post-Ordovician fossil is believed to be the base of the true Jefferson limestone. Near by, in beds lithologically resembling the Bighorn of the New World district, Tomlinson[24] has found the following fossils:

Receptaculites oweni Hall.
Lichenaria cf. L. typa Winchell and Schuchert.
Columnaria alveolata Goldfuss.
Halysites gracilis Hall.
Streptolasma corniculum Hall.
Zygospira sp.?
Clinoceras sp.?

The rocks ascribed to the Ordovician in the New World district are lithologically similar to the Bighorn dolomite of Wyoming. The meager fauna found indicates that the age is the same, and accordingly the Ordovician beds in the region near Cooke are designated Bighorn dolomite.

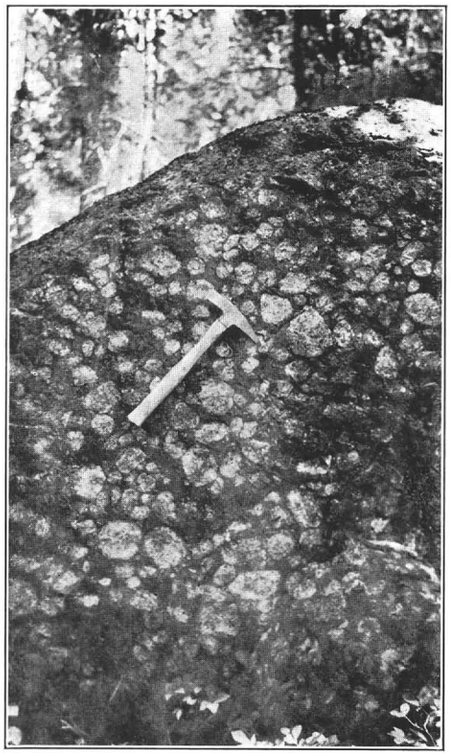
The lower limestone member of the Bighorn forms a bold cliff on the south side of Silver Mountain, high above Soda Butte Creek. (See pl. 8, *B*.) It girdles Miller Mountain as a dark cliff just below the lava and can be seen at many points on Woody and Republic Mountains, where the hills of a pre-Tertiary topography are exposed beneath a great thickness of volcanic rocks. Good sections of the entire formation can be made on the north side of the Sheep Creek divide and on Woody Mountain 2,000 feet southeast of the Irma mine.

The thickness of the Bighorn rocks in the district is commonly about 175 feet, but locally the upper part of the Bighorn is missing and the Jefferson limestone is separated from the Gallatin by only 50 feet of the dark-colored Bighorn limestone. The basal bed of the Bighorn is a dark fetid-smelling limestone. About 40 feet above the Cambrian-Ordovician contact is a gray limestone carrying large nodules of black chert. Above this horizon the formation lacks the fetid odor which Hague[25] mentions as characteristic of the

[24] Tomlinson, C. W., op. cit., p. 130.
[25] Hague, Arnold, U. S. Geol. Survey Geol. Atlas, Yellowstone National Park folio (No. 30), 1896.

*A.* HAYDEN FALLS, WOODY CREEK, MONT.

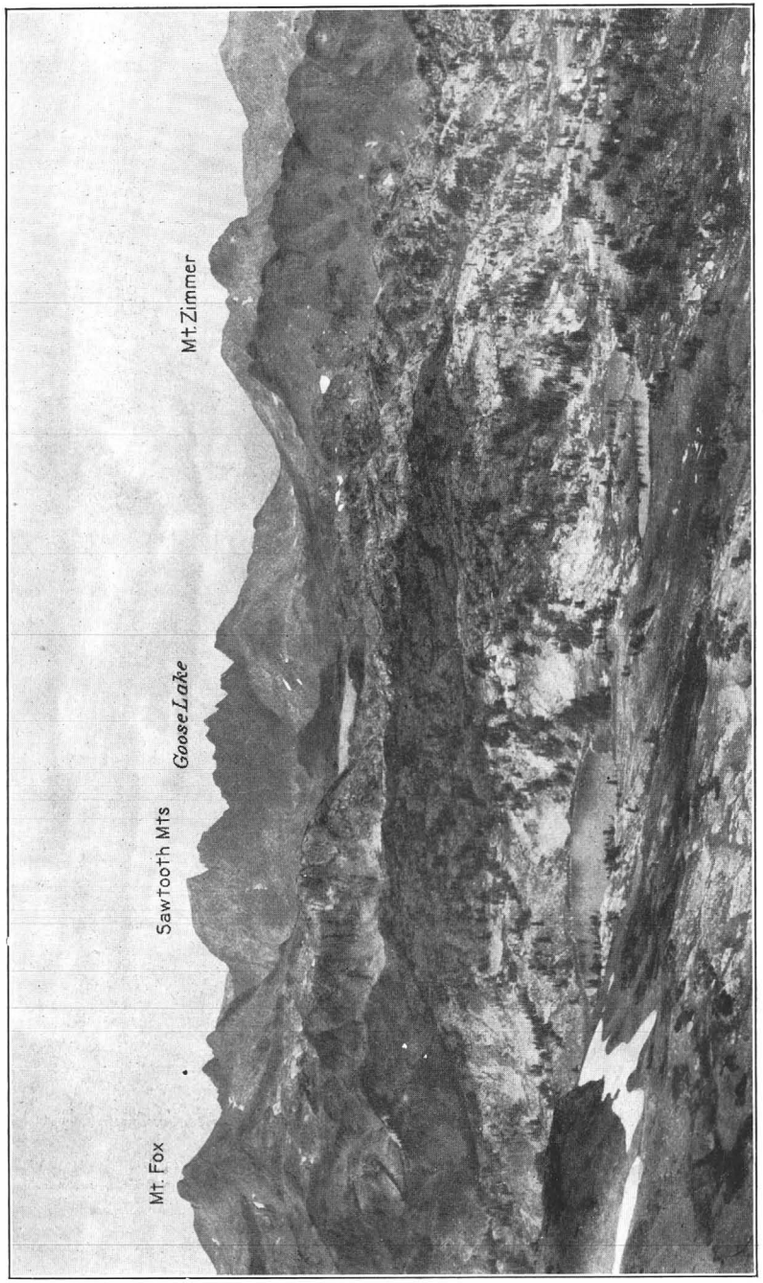
The falls are caused by a thick sill of potassic andesite porphyry in the soft Gros Ventre shales



*B.* COARSE-TEXTURED ARCHEAN BASALT PORPHYRY NEAR COOKE, MONT.

COOKE, MONT.

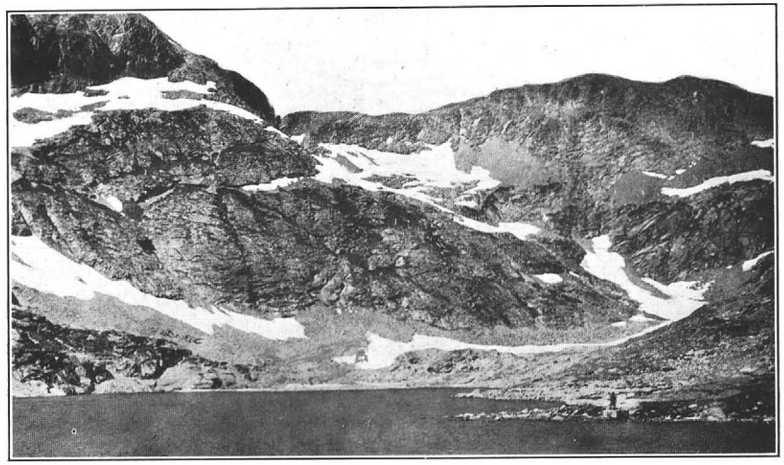
View looking east from north slope of Republic Mountain. A cliff of early acidic breccia stands in right foreground




VIEW LOOKING NORTH FROM THE TOP OF SHEEP MOUNTAIN, MONT.

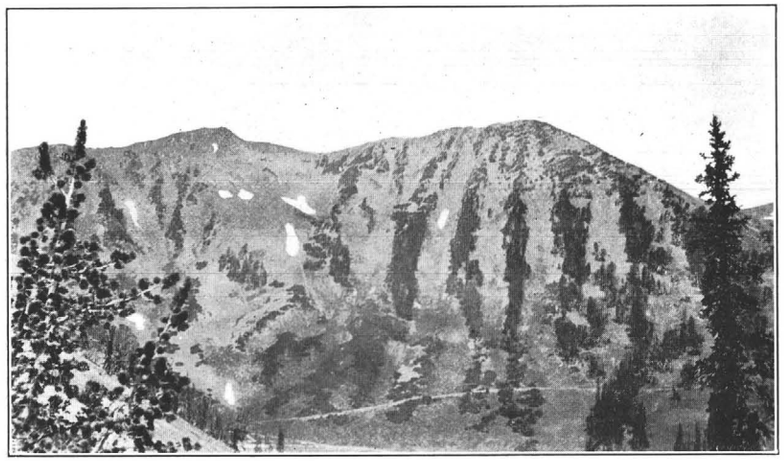
The rugged topography is typical of the heavily glaciated granite area





*A.* CORINNES LAKE, A STEEP-WALLED TARN NEAR GRASSHOPPER GLACIER, MONT.

This recent cirque shows the effect of vigorous glacial sapping. Iceberg Peak in left background. The man in right foreground indicates the scale



*B.* SCOTCH BONNET MOUNTAIN, MONT.

View looking north from Henderson Mountain. The course of recent snowslides is clearly shown

The minerals of group 1 are nearly contemporaneous. The pyrite is earlier than the major part of the chalcopyrite, which was the second sulphide to form. A very small amount of the chalcopyrite is contemporaneous with the pyrite, but most of it appeared at a much later stage. Where arsenopyrite is present its relation to chalcopyrite is obscure, but it is easily seen that pyrite is earlier than the arsenopyrite, whereas the galena is distinctly later. Galena, the third sulphide to be deposited in noteworthy amounts, closely followed the chalcopyrite. Next the bulk of the sphalerite was deposited. Later a second generation of galena appeared and in most places was followed by or contemporaneous with a second generation of sphalerite. Argentite was probably deposited with the second generation of galena. Some tetrahedrite and freibergite are later than the first generation of sphalerite and earlier than the second.

In the ore deposits south of Soda Butte Creek evidence is found of two stages in the period of mineralization. A reversal of the usual order of deposition is obvious, for veinlets of quartz and arsenopyrite cut all the other hypogene minerals. These facts suggest another wave of metallization or a mingling of the first solutions with those from a different source. The usual order of paragenesis given above holds for the first period of mineralization but is masked by the effects of the second period.

Only two deposits of any economic importance are now known that are related to the intrusive rocks at Goose Lake; one of these is due to magmatic segregation, and the other is a lode deposit formed at moderate temperature and pressures. (See pp. 59 and 72.) The paragenesis indicated for these deposits is chalcopyrite, quartz, pyrite, sphalerite, galena, antimonides (boulangerite), and carbonates.

*Source.*—All the field evidence in the New World district points to a magmatic source for the ores. The age of the ores (their formation closely followed the intrusion of the monzonite), the intensity of hydrothermal action on the monzonite porphyry of Henderson Mountain, the rude zonal arrangement of ores about the Henderson Mountain stock, the common occurrence of ore deposits close to other intrusions of this nature, and the lack of spatial and age relationship between other kinds of igneous rock and the ore deposits—all suggest a genetic relation between the metallization of the district and the magma from which the monzonitic intrusions were derived.

*Character of the mineralizing solutions.*—The probable character of the mineralizing solutions is indicated by the replacements that have been made. As each replacement means the loss of some constituents from the solutions and the addition of others, the change in the character of the moving solutions must be taken into account.



### MADISON LIMESTONE

The Madison limestone can be seen at the localities previously described as exposing good sections of the Jefferson limestone. The thickness of the Madison in surrounding regions reaches 1,500 feet, but in the New World district a tenth of this figure is the maximum observed. Its contact with the underlying Threeforks formation is not sharp. The base of the Madison, as nearly as can be ascertained, consists of a medium-bedded dark-gray limestone which has a slight fetid odor. It weathers light gray, is much jointed, and contains many thin calcite stringers. The limestone becomes massive a short distance above its base and is highly fossiliferous. At the few localities near Cooke where it occurs it stands out as light-colored cliffs strongly contrasting with the dark lavas that cap them. The marked unconformity between the Madison and the Tertiary lavas is shown in Plate 9, *B*.

An abundant Mississippian fauna containing 79 species has been identified by Girty[28] from the Madison limestone of the Yellowstone National Park.

## CENOZOIC ROCKS

### TERTIARY SYSTEM

No Mesozoic rocks exist in the New World district, and Tertiary volcanic rocks lie unconformably upon the Paleozoic sediments. The Tertiary lavas of the district are readily correlated with similar rocks in the Yellowstone National Park. Two sets of extrusive rocks, both containing interlayered tuffs and tuffaceous sediments, and a variety of intrusive rocks occur within the New World district. The age of all the igneous rocks other than the pre-Cambrian discussed on pages 16 and 17 is believed to be Tertiary. Some of the salient features of the igneous geology are discussed under "Regional geology" on pages 8 to 10, but a brief summary showing the age relations of the important rock families is given below.

Pliocene: Basalt dikes and sills.
Miocene:
- Syenite stocks.
- Intrusive breccia (pyroclastic facies of the monzonite porphyry).
- Monzonitic intrusive rocks, including quartz monzonite, granodiorite, monzonite, and diorite families; usually porphyritic, in part fine grained, rarely coarse grained.
- Early basic breccia (augite andesite breccias, tuffs, and basalt flows). Cut by andesite dikes.
- Gabbro stocks.

Eocene: Early acidic breccia (augite and hornblende andesite breccias, tuffs, and basalt flows). Cut by hornblende andesite dikes.

[28] Op. cit., pp. 484–496, 507–578.

### EFFUSIVE ROCKS

Two periods of extrusive activity are represented. The evidence of the first, in Eocene time, is nearly obliterated, and only a small remnant of the early volcanic material is present. The activity of the second period resulted in the formation of the Miocene tuffs and breccias that now cap Miller Mountain, as well as the neighboring peaks farther to the south and west. These rocks have been extensively indurated near the large bodies of intrusive monzonite.

*Early acidic breccia.*—The early acidic breccia is of Eocene age, and Hague [29] believed that it should be correlated with the Fort Union formation. Hewett [30] has later evidence indicating that its age is more probably Wasatch. It consists chiefly of light-colored hornblende andesite, latite, and dacite fragments of variable size, rudely stratified and interbedded with andesite flows. The thickness of this breccia on Miller Mountain is not more than 150 to 200 feet, but it probably once covered the whole region to a much greater depth, as it reaches a thickness of 2,000 feet on Republic Mountain. This great variation in thickness is traceable to the long interval of quiet that followed the accumulation of the volcanic beds, for during this time most of the Eocene breccia disappeared under the attack of erosion. The vents from which the early acidic breccia came are not known.

Some dikes of hornblende andesite cut the early acidic breccia but are older than the early basic breccia.

*Early basic breccia.*—The early basic breccia is of Miocene age and has a maximum thickness of 2,000 feet in this region. It forms the steep upper flanks of Miller and Silver Mountains and weathers in dark-brown precipitous slopes, giving a somber-colored wall-like appearance to the mountains which it caps. It consists of andesite flows, basalt flows, and basic tuffs and breccias.

An abundant fossil flora was found in the lower part of the early basic breccia by Hague and his associates near the junction of the Lamar River and Soda Butte Creek. This material was correlated by Knowlton with the auriferous gravels of California,[31] which were then believed to be of late Miocene age. Accordingly, the many events recorded in the formations older than the Pliocene Tower Creek conglomerate were supposed to have been crowded into late Miocene time. During this interval at least 5,000 feet of early basic breccia slowly accumulated in the Yellowstone Park and was capped by the early basalt flows; both of these formations were intruded by

[29] Hague, Arnold, The age of the igneous rocks in the Yellowstone National Park: Am. Jour. Sci., 4th ser., vol. 1, p. 450, 1896.

[30] Hewett, D. F., Geology and coal and oil resources of the Oregon Basin, Meeteetse, and Grass Creek Basin quadrangles, Wyo.: U. S. Geol. Survey Prof. Paper 145, p. 62, 1926.

[31] Hague, Arnold, The geology of the Yellowstone National Park: U. S. Geol. Survey Mon. 32, pt. 2, p. 790, 1899.



## MINERALOGY

In the following table the occurrence and relative abundance of the economically important minerals are summarized. The three groups of deposits listed are (1) contact-metamorphic deposits; (2) high-temperature deposits, including the pyritic copper lodes, the gold quartz veins, and a deposit formed by magmatic segregation; (3) moderate-temperature deposits, including copper-lead lodes, the complex lead-zinc-silver group, and carbonate silver veins.

*Ore and gangue minerals of the New World mining district*

[A, Abundant; D, dominant; S, sparingly present; R, rare; p, primary; s, secondary (supergene)]

| Mineral | Contact-metamorphic | High temperature | Moderate temperature | Comments |
|---|---|---|---|---|
| Actinolite | Sp | | | |
| Ankerite | Rp | Sp | Dp | |
| Anglesite | | | Ss | At Morning Star mine. |
| Argentite | | | Sp, Ss | |
| Arsenopyrite | | Sp | Sp | |
| Azurite | Rs | Rs | Rs | |
| Biotite | | Rp | | |
| Bornite | Ss | Rp, Ss | Rs | |
| Boulangerite | | | Sp | Abundant near Goose Lake. |
| Calamine | | | Rs | |
| Calcite | Rp | Rp | Rp, Rs | |
| Cerusite | | | Ss | |
| Chalcopyrite | Ap | Ap | Sp, Ss | |
| Chalcocite | Rs | Ss | Ss | |
| Chlorite | Sp | | | |
| Covellite | | | Rs | |
| Cuprite | | | Rs | |
| Dolomite | Rp | Rp | Rp | |
| Epidote | Dp | | | |
| Freibergite | | | Sp | |
| Galena | Sp | Sp | Ap | |
| Garnet | Ap | | | |
| Gold | Rp | Rp | | |
| Gypsum | | | Ss | |
| Limonite | As | As | As | |
| Magnetite | Ap | Sp | | Longstreet claim. |
| Malachite | Ss | Ss | Ss | |
| Marcasite | | | Ss | |
| Platinum | Pp | | | At Copper King mine. |
| Polybasite | | | Ss, ?p | |
| Proustite | | | Ss | |
| Pyrargyrite | | | Ss | |
| Pyrite | Ap | Dp | | |
| Quartz | Ap | Dp | Ap, Ss | |
| Silver | | | Rs | |
| Specularite | Dp | Rp | | |
| Smithsonite | | | | Not observed but probably present. |
| Sphalerite | Rp | Rp | Ap | |
| Tetrahedrite | | | Sp | |
| Vesuvianite | Rp | | | |

## GENESIS

*Paragenesis.*—The paragenesis indicated for the ores related to the Henderson Mountain stock is as follows:

1. Quartz, sericite, magnetite, hematite.
2. Pyrite.
3. Chalcopyrite, arsenopyrite.
4. Small amounts of sphalerite.
5. Galena, freibergite, tetrahedrite.
6. Sphalerite.
7. Argentite and small amounts of galena and blende.
8. Ankerite and small amounts of quartz.

mineral is a carbonate (manganiferous ankerite), but fine-grained quartz is present in varying quantities. Galena and blende are by far the most plentiful of the sulphides. Chalcopyrite, pyrite, and silver are present in small amounts.

Some of the complex lead-silver-zinc ore bodies have been extensively enriched, and the black manganese-stained outcrops that form the characteristic gossan in such deposits are prominent in many localities. Cerusite and anglesite are abundant in the upper portion of the secondary zone, giving way in depth to galena, zinc blende, and secondary silver antimonides, such as pyrargyrite and polybasite. Native silver is encountered at several places some distance from the surface and is the deepest of the secondary ore minerals.

Texturally the ore bodies of this class are for the most part very friable, and their loose texture has been a great aid to the enrichment, which is prominent at the Republic and Irma mines.

*Carbonate silver veins.*—Veins consisting almost wholly of sideritic calcite containing small amounts of manganese and magnesium are found near Woody and Silver Mountains and in the Stillwater Basin and probably represent the outermost zone in which metalliferous deposits occur. A little silicification has occurred. The carbonate is much higher in iron than the gangues found in deposits of the preceding classes and resembles coarse-grained siderite.

Very small amounts of sulphides are present in these veins. A little pyrite has been noted but may be of supergene origin. Galena and blende are generally absent. The veins assay as much as 5 ounces to the ton in silver at the surface, and this metal may be present as the carbonate. Many of the veins are strong and well defined and may be traced for considerable distances.

Either brown or black manganese oxides are formed on weathering. Thiel,[38] who has made an exhaustive study of the conditions of deposition of secondary manganese oxides, reached the conclusion that the brown manganese oxide is the first secondary mineral to be formed and may indicate the upper portion of a vein. The darker oxide indicates downward migration of manganese.

The veins of this class have been little worked. It would be of great practical and theoretical interest to know the change in tenor of the vein with increasing depth, but no data are available on this point.

### SURFICIAL DEPOSITS

Some small deposits of bog iron, bog copper, and placer gold occur in this district but are of minor economic importance. They are discussed in detail on pages 85 and 86.

[38] Thiel, G. A., The manganese minerals: Econ. Geology, vol. 19, p. 131, 1924.



stocks and dikes (the Sunlight intrusives) and then subjected to severe erosion. During the period of degradation the early basic breccia was completely removed in many places before a second stage of volcanic activity began. A thick mantle of the late acidic breccia was spread over the region and was soon covered with other volcanic formations—the late basic breccia, the late basalt flows, and the late andesite flows. The end of this period of volcanic activity was marked by the intrusion of many stocks and dikes, such as the Ishawooa intrusives, the Sherman diorite, and the Electric Peak intrusives. Subsequent to these events the Tower Creek conglomerate was deposited. Its age is well established by the bones of a Pliocene horse which it contained.

It was difficult to reconcile the length of time suggested by the events summarized above with the time interval apparently established by Knowlton, but no other course was open until recently. In 1926 Knowlton stated that the auriferous gravels of California probably indicate a much longer time interval than was formerly supposed and probably represent a phase of sedimentation extending from the upper Eocene well into and possibly through the Miocene, although the localities most frequently mentioned still fall within the Miocene.[32] This is equivalent to withdrawing the auriferous gravels from the late Miocene, and as a consequence the contemporaneous flora of Lamar Valley in the Yellowstone National Park becomes merely Miocene, instead of late Miocene. This shift in age makes it possible to assign ample time for the volcanic events that occurred after the burial of the Lamar flora and prior to the deposition of the Pliocene conglomerate on Tower Creek. It seems probable to the writer that the early acidic breccia, the early basalts, and the Sunlight intrusives represent early Miocene time, and that the erosion which followed occurred during the middle Miocene.

It is plausible to assume that the upper Miocene was ushered in by the volcanic activity that caused the formation of the late acidic breccia, the late basic breccia, the andesite flows, and the late basalt flows and ended with the intrusion of the Ishawooa intrusives, the Sherman Peak diorite, and the Electric Peak intrusives.

The predominant rock of the early basic breccia in the Cooke district is an augite andesite, but hornblende-augite andesite and basalt are common, and the breccia also contains fragments of the early acidic breccias and of the sedimentary formations. Large angular fragments of limestone, quartzite, and granite have been noted by the writer at the head of Sheep Creek. The breccia is rudely bedded and of subaerial origin. Its former thickness was probably very great. The materials of which it is composed may have come from

[32] Knowlton, F. H., Flora of the Latah formation of Spokane, Wash., and Coeur d'Alene, Idaho: U. S. Geol. Survey Prof. Paper 140, p. 19, 1926.

the Crandall volcano, 15 miles to the south, where, according to an estimate by Iddings,[33] this lava was formerly 13,000 feet in thick ness. The amount remaining in this district thus represents only a part of Miocene volcanic activity. This lava rests unconformably upon the Paleozoic sediments of the region.

A few dikes of augite andesite occur in the district, and as none of them cut rocks younger than the early basic breccia, they are believed to be the intrusive representatives of this epoch of volcanic activity.

### INTRUSIVE ROCKS

The Tertiary intrusive rocks range in composition from gabbro to granite. As indicated in the table on page 29 they have been subdivided into four groups, exclusive of the andesites described briefly above, and have been mapped as gabbro, monzonite and related rocks, syenite, and basalt. This subdivision is made primarily on the basis of age relation, and though the composition of all the rocks in a group is very similar, the textural varieties may include coarse-grained rocks, porphyries, and felsites. Only a few of the many intrusive rocks in the lavas are mapped, as the time required for detailed work was not available. From the work of Hague[34] it seems probable that basalt is the only intrusive rock of post-Miocene age near Cooke and that all the other cross-breaking rocks represent a period of intense volcanism in the Miocene.

#### GABBRO

*Distribution, form, and age.*—Gabbro has a scanty distribution compared with that of the monzonite family but is well represented at a number of localities. A large mass of biotite gabbro crops out north of Cooke, in the hill locally known as Fairview, and Scotch Bonnet Mountain is almost wholly composed of similar rock. On the south side of Henderson Mountain there is an area of about 50 acres made up of gabbro. North of Goose Lake a conspicuous outcrop of coarse-grained gabbro runs from the Copper King mine across the Glacier Divide and out of the district.

The gabbro usually occurs in the form of a stock, less commonly in dikes, and a few sills have been mapped which were believed to be its finer-grained facies.

The mass of gabbro that makes up Scotch Bonnet Mountain is a uniform, medium-grained rock lacking any evidence suggestive of movement during its crystallization. The pronounced horizontal sheeting near the top of the mountain shown in Plate 10, *B*, may indicate solidification under a horizontal roof. The presence of

[33] Iddings, J. P., U. S. Geol. Survey Mon. 32, pt. 2, p. 236, 1899.
[34] Hague, Arnold, U. S. Geol. Survey Mon. 32, pt. 2, pp. 1–59, 1899.



Enrichment has made but little progress in the veins belonging to this class that were visited by the writer. Copper carbonates and superficial coatings of lead carbonate and lead sulphate may be noted at many places, but the primary ore is much more abundant than the secondary ore. Thin streaks of oxidized material along fractures may be found to depths of 50 to 100 feet, and they have a much higher content of silver than the unoxidized ore. None of the prospects have been worked for silver alone, however.

*Lead-silver deposits.*—Partly oxidized lead-silver ores, low in zinc, occur on the southern and southwestern flanks of Miller Mountain. Sulphides of lead and silver intermixed with cerusite made up the major portion of the zinc-free ore sought by the smelter in 1885–86 for admixture with the complex ore from the Republic mine. Most of the mines that supplied the demand have long been abandoned and caved, but information from men who mined the deposits of Miller Mountain suggests that the ore bodies were formed by replacement of Gallatin and Bighorn limestones. The ore was found either in nearly horizontal deposits or in nearly vertical pipelike masses. Cross sections of any ore body varied greatly, even in one deposit.

All the sedimentary rocks observed in Miller Mountain dip south or southwest. Postmineral movement has partly shattered the formations over large areas and greatly expedited the movement of meteoric water down the dip of the sediments into the valley of Soda Butte Creek. It is probable that large amounts of sphalerite and pyrite were removed through the active circulation of the ground water. Abundant lead carbonates and a low content of zinc would be expected in leached lead ores of this kind.

*Complex lead-zinc-silver ores.*—Deposits of lead-zinc-silver ore usually occur at some distance from the large intrusive masses and the mines now operating in the complex ores are south of Soda Butte Creek on Republic Mountain and Woody Mountain. Some promising prospects of the same class were seen in the Stillwater Basin. Large ore bodies have been developed at the Republic mine, and it is probable that there are other extensive deposits of this class. As there are no concentrating mills in the district, the present shippers send only their high-grade ores to market, either throwing away lower-grade lead ores and mixed lead-zinc ores or piling them for future use.

The complex ores are chiefly medium to fine grained replacement deposits in the lower limestone of the Gallatin formation, where the bed is cut by mineralized fissures. The fine-grained phases of the ore are in many places dense, siliceous, and zincky, but the coarser-grained ore commonly consists of friable fractured masses of galena, high in silver and lead and low in zinc. The most abundant gangue

highly silicified xenoliths of Gros Ventre limestone lends support to this supposition. From the evidence at hand it seems improbable that this body was a volcanic pipe.

Study of the large irregular basic intrusive mass north of Goose Lake leads to a different conclusion. There the rock is very coarse grained and seamed with basic pegmatites, but near the contact of the gabbro and granite a porphyritic border facies exists. Phenocrysts 2 inches across are common in a medium-grained groundmass. The horizontal sheeting noted at Scotch Bonnet Mountain is not evident here. It is quite possible that the intrusive mass represents an ancient volcanic conduit.

Gabbro cutting sedimentary rock was observed in only a few places, but upon the crest of Scotch Bonnet Mountain some xenoliths of metamorphosed Cambrian limestone were found. The Cambrian sediments in contact with the gabbro on the top of Scotch Bonnet Mountain are only slightly metamorphosed. Epidotization and silicification have occurred, but it may be safely said that the gabbro exercised only a feeble contact action on the rocks which it invaded.

The gabbro is intruded by monzonite dikes, so that its age is later than Cambrian and earlier than the monzonite. The earliest known post-Cambrian volcanic activity in this part of Montana occurred in the Livingston epoch (Upper Cretaceous and Eocene), and the postgabbro monzonite is probably late Miocene. Thus there is little doubt that the gabbro is of Tertiary age. It seems reasonable to correlate the gabbro intrusion with one of the periods of volcanic and intrusive activity in the Yellowstone National Park. In composition the gabbro corresponds most closely with the early basic breccia, and so the suggestion is put forward that the gabbro is the intrusive representative of Hague's early basic breccia and should be considered Miocene, possibly early Miocene. (See discussion of early basic breccia on p. 30.)

*Lithologic character.*—Most of the gabbro consists essentially of labradorite, biotite, augite, and magnetite. In a few thin sections of the rock olivine was observed, and in some others quartz and orthoclase are present as accessory minerals. A characteristic but unusual feature of much of the gabbro is the poikilitic intergrowth of labradorite and brown biotite, which gives it a diabasic appearance. (See pl. 10, *A*.) In hand specimens it is commonly a very dark medium-grained granitoid, slightly diabasic rock in which small flecks of biotite may be seen. The amount of biotite present is variable, and some specimens are nearly free from this mineral. The basic intrusive mass near Goose Lake contains practically no mesgascopic biotite, except in pegmatitic dikes and seams. Magnetite is much more abundant here than in the intrusive bodies of a similar character farther south.

The basic intrusive rocks are usually much fresher in appearance than the monzonite, and the gabbro has suffered little hydrothermal alteration except near monzonitic rocks and along its contacts with other rocks, where it is in places heavily chloritized and sericitized.

About 40 per cent of the rock is composed of labradorite, which is present in interlocking laths from 0.3 to 1 centimeter in length but mostly about 0.5 centimeter. In the larger crystals zonal growth is common, the zones invariably being less basic at the margins. A few crystals in contact with balsam were observed to have the same index as balsam at their margins and a much higher index at their centers. This indicates that some of the plagioclase crystals consist of a labradorite core and oligoclase shell. Albite, Carlsbad, and pericline twinning are common. Much of the feldspar was earlier than the augite, which contains small inclusions of labradorite.

It is probable that two generations of pyroxene are represented, as a few small crystals of augite were observed in some of the larger crystals of plagioclase. The augite shows zonal growth, and in much of it three cleavages are visible. Two distinct types of crystals were noticed. In one the crystals of augite were large and nearly euhedral; in the other the crystals were small and subhedral to anhedral. Augite makes up about 15 per cent of the fresh rock.

The amount of biotite varies greatly but may make up 20 per cent of the thin section. The large grains are remarkable for the poikilitic intergrowth with the labradorite, which gives the rock a diabasic appearance.

Hornblende occurs in euhedral to subhedral crystals that vary greatly in size. The small crystals commonly occur in the interstitial spaces between the large feldspar laths. Hornblende is a minor constituent, as a rule not making more than 3 or 4 per cent of the fresh specimen. Magnetite is an abundant accessory mineral.

Some of the thin sections show small amounts of quartz, orthoclase, and albite, which are usually interstitial between labradorite laths. In one section a distinct fragment of granite which measured only 1 by 1.5 centimeters was noticed. At the contact of the fragment and the gabbro carbonate, talc, hornblende, and chlorite were developed. The specimen from which this slide was made appeared to be fresh unaltered rock, and the rest of the slide shows little evidence of alteration by hydrothermal action. This suggests that other crystals of quartz, orthoclase, and albite may be small fragments derived from the acidic rocks intruded by the gabbro.

The probable order of crystallization in the gabbro is as follows: The earliest minerals to crystallize were magnetite and apatite. These were followed by a part of the augite (the euhedral crystals). Plagioclase then crystallized, and later the remaining augite and the biotite. Quartz, albite, orthoclase, and hornblende formed still later.

zinc blende are associated with it. Silver is rarely present, and the gold content runs from $5 to $15 a ton in the better class of primary ore. The intensity of hydrothermal action, the character of the ore, and the close spatial relation to large intrusive bodies indicate the deep-seated conditions prevailing at the time of deposition. Where these ores are partly oxidized the copper and gold content is markedly greater, and typical secondary copper minerals have been developed. The completely oxidized portions of the pyritic gold ores can be profitably cyanided, but the tonnage of such ore is small, and cyanidation of the sulphides in the past has been utterly unsuccessful. No other method of treating the ore has been tried, and it may be that with the introduction of modern methods of milling and concentration these deposits will prove a source of revenue.

Some rich pockets of gold-bearing quartz have been discovered in a few places close to and within the large intrusive masses of monzonite. As these deposits were mined out rapidly, the writer has not seen any in the field. Specimens of the ore, however, show coarse comb quartz of a vuggy character, with a small amount of pyrite and free gold. These veins, from the nature of their gangue and their areal distribution, are thought to have been formed at high temperature under great pressure.

### MODERATE-TEMPERATURE VEINS

*Copper-lead deposits.*—Copper-lead veins containing little zinc are found in Miller Mountain and to a less extent in Sheep and Red Mountains and north of Scotch Bonnet Mountain. Most of these deposits appear small, but it is difficult to judge of their extent because of the meager development work. These veins were an important source of silver and lead in the early days of the camp and supplied much of the zinc-free ore that was used to run the Republic smelter during the fall of 1886.

The gangue minerals consist of manganiferous ankerite and a small amount of fine-grained quartz. Sericite and chlorite are developed to some extent in the wall rocks, but hydrothermal alteration is not as extensive as in the deposits that have already been described. Characteristic ore from veins in this group contains an abundance of coarse-grained galena and a small amount of chalcopyrite. Arsenopyrite is found locally. Zinc blende and tetrahedrite occur locally but usually in small amounts. Pyrite is of subordinate importance, and the amount present varies greatly.

These veins are typical fissure fillings, and extensive replacement of the wall rock occurs at very few places, even where they cut the pure, massive, lower limestone of the Gallatin formation.

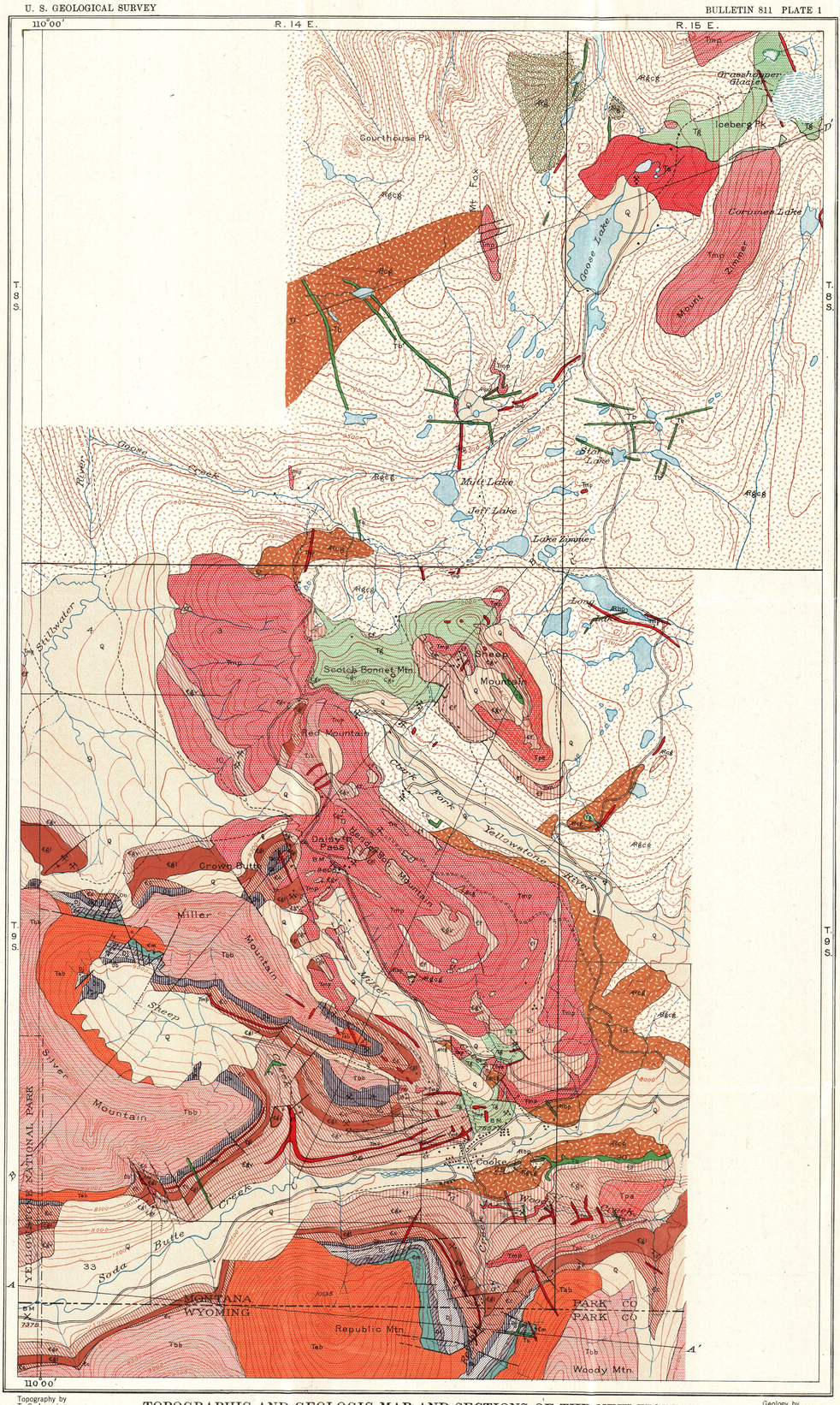
and up to 1925 no paying ore bodies had been developed. Rich gold ores of contact-metamorphic origin were worked in the late eighties, but none are exposed to-day. Specimens showing wire gold in galena were seen and are said to be typical of the rich ore. The gold-bearing galena occurred in irregular masses intermixed with typical contact-metamorphic minerals such as garnet and specularite and showed no depth relation to the surface. On this somewhat meager evidence the gold ores are regarded as primary.

The most common sulphide of the contact-metamorphic deposits is pyrite. Second in abundance is chalcopyrite. Some galena and blende are occasionally found, but are not economically important. Specularite is abundant at a number of localities, but, contrary to the opinion of many of the prospectors, it does not indicate the presence of copper ore. Magnetite is much less abundant than hematite and is found in quantity only in the south end of Henderson Mountain. The nonmetallic minerals consist largely of quartz, epidote, and ankerite, which are suggestive of mild metamorphic activity. Where metamorphism has been intense garnet and tremolite are also developed, and more rarely vesuvianite and muscovite.

During the replacement of limestone, which is the country rock of these deposits, iron, silica, manganese, sulphur, and copper have been added and carbon dioxide, calcium, and magnesium have been subtracted. These deposits are resistant to weathering, except where they are traversed by fracture zones. In such localities the rocks are kaolinized and heavily stained with iron and manganese oxides. Some gold is close to the surface and is believed to be secondary, as it is associated with manganese-stained quartz. Secondary copper of commercial importance is not known, although copper carbonates, as well as some secondary sulphides, have been observed in these deposits. The fresh ores are for the most part dense, homogeneous masses, although vugs lined with quartz and containing some gold are occasionally found.

### HIGH-TEMPERATURE VEINS

Pyritic gold-copper deposits are very numerous in the district, and many of them have been mined. Up to 1923 little of the ore mined from them had yielded any profit, but this may be due largely to the lack of proper beneficiation. The deposits are found in the neighborhood of large intrusive masses, such as the gabbro of Scotch Bonnet Mountain or the monzonite stock of Henderson Mountain. Quartz is the most abundant gangue mineral. The wall rocks are in places intensely altered by hydrothermal action, with the development of sericite, chlorite, and other minerals. Pyrite forms the chief sulphide, and smaller quantities of chalcopyrite, galena, and




Topography by T. S. Lovering, Surveyed in 1922 and 1923

Geology by T. S. Lovering, 1923 and 1925

## EXPLANATION

**QUAT.**

- Q — Slope wash, landslides, alluvium, and glacial deposits

**TERTIARY**

UNCONFORMITY

- Basic dikes (*Fine-grained basalt and andesite. Some of the dikes in the pre-Cambrian areas may be older than Pliocene*) — Pliocene?
- Ts — Syenite (*Stocklike mass of coarse-grained perthitic syenite; locally carries syngenetic chalcopyrite*) — Miocene
- Tim — Intrusive breccia (*Pyroclastic facies of monzonite porphyry, in places highly sericitized*) — Miocene
- Tm — Monzonite porphyry (*Stocks, sills, and dikes of monzonite porphyry, latite, and granite porphyry*) — Miocene
- Tp — Potassic andesite (*Dikes and sills belonging to the basic group of the monzonite family*) — Miocene
- Tg — Gabbro (*Stocklike masses of gabbro containing in places abundant biotite*) — Miocene
- Tbb — Early basic breccia (*Augite and hornblende andesite breccias, tuffs, and basalt flows*) — Eocene
- Tab — Early acidic breccia (*Augite and hornblende andesite breccias, tuffs, and basalt flows*) — Eocene

UNCONFORMITY

**CARBONIFEROUS**

- Cm — Madison limestone (*Massive light-colored fossiliferous limestone*) — Mississippian

**DEVONIAN**

- Dj — Threeforks formation (*Interbedded limestone and red and green shale*) — Upper Devonian
- Dt — Jefferson limestone (*Dark-gray massive fetid-smelling limestone*) — Middle Devonian

UNCONFORMITY

**ORDOVICIAN**

- Ob — Bighorn dolomite (*Dark-colored fetid-smelling cliff-forming dolomite grading up into interbedded sandy dolomite and shaly limestone*) — Upper Ordovician

**CAMBRIAN**

- Gallatin formation (*Upper part, Gc, interbedded shale, limestone, and flat-pebble limestone conglomerate; lower part, Cg, massive cliff-forming gray limestone—the common source of silver-lead-zinc ore*) — Upper Cambrian
- Cg — Gros Ventre formation (*Interbedded shale, limestone, and flat-pebble limestone conglomerate*) — Middle Cambrian
- Cf — Flathead quartzite (*Quartzite grading up into glauconitic sandstone; locally conglomeratic at base*) — Middle Cambrian

UNCONFORMITY

**ARCHEAN**

- Basalt porphyry (*Dikes; rock contains plagioclase phenocrysts 3 inches in diameter*)
- Acg — Cooke granite (*Medium-grained pink granite*)
- Agb — Gabbro gneiss (*Mottled green and gray rock containing hornblende and plagioclase*)
- Agcg — Goose Creek granite (*Gneissic gray granite locally carrying schist inclusions*)

Fault (*Shows downthrown side; dashed where location is uncertain, dotted where covered by later deposits*)

12° Strike and dip of rocks

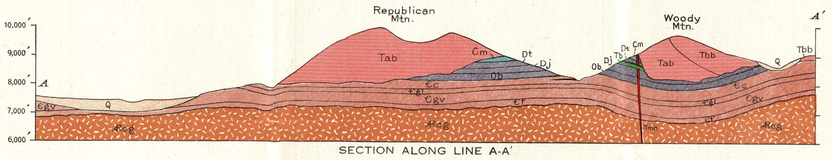
Mine

# TOPOGRAPHIC AND GEOLOGIC MAP AND SECTIONS OF THE NEW WORLD MINING DISTRICT, MONT.—WYO.

Scale $\frac{1}{31,680}$ 0 — 1 — 2 Miles

Contour interval 100 feet

1929

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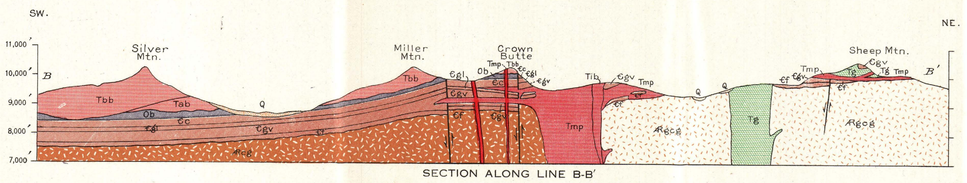


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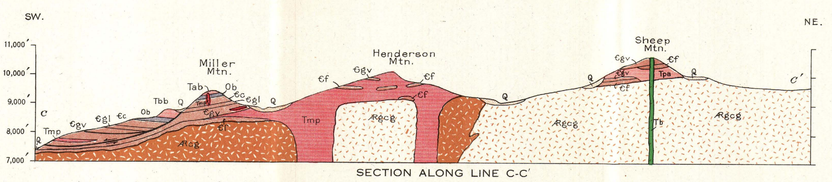


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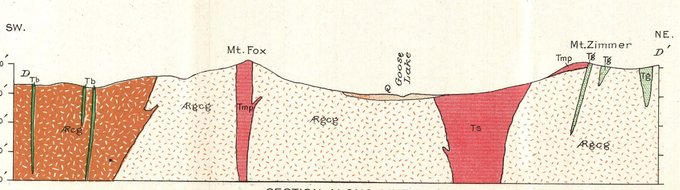


SECTION ALONG LINE D-D′

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