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Geology of a Portion of the Bull Mountain Range Jefferson County, Montana

Thomas A. Greene

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GEOLOGY OF A PORTION OF THE BULL MOUNTAIN RANGE

JEFFERSON COUNTY, MONTANA

By

Thomas A. Greene

Butte, Montana
January 23,1939

Dr. E.S.Perry
Dept. of Geology
Montana School of Mines
Butte, Montana

Dear Sir :

Being a candidate for the degree of Batchelor of Science in Mining Engineering in 1940, I present this report as part of the required course of study towards this degree.

I hope this report on the geology of a portion of the Bull Mountain Range, Jefferson County, Montana, will prove satisfactory in every respect.

Yours sincerely,

Thomas A. Greene

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INTRODUCTION

General Statement

This report is one of several made by Senior students of the Montana School of Mines. It is a portion of the course of study required of all students intending to graduate with a degree in Mining or Geological Engineering.

The geologic party consisted of 23 men. Three were instructors, twenty were students. The students were divided into groups of three and each group assigned part of the area to be mapped.

The members of the party were as follows :

Donald L. Archibald
John Buckvich
Arthur Connors
John Dougherty
Douglas M. Dowell
Conrad Lundgren
Royal A. McCready
Authur Mattila
Fredrick Pope
Cameron Rich
Roy Earhart
John A. Engstrum
Walter Everly
Fredrick Garbutt
Raymond Gilbert
Hossein Goudarzi
Ralph Hamblin
Henery Johnson
Max Rudin
Thomas A. Greene

Location And Nature of the Area

The total area mapped embraces the southerly slope of the Bull Mountain Range, part of the Rocky Mountain Range of Northwestern Montana. The region mapped is a crescent shaped area averaging three to six miles north of the town of Whitehall, Montana. The area is fairly rugged, especially in some sections. It is sparcely timbered, sagebrush and mesquite predominating, although


Kalispell
Shelby
Havre
Glasgow
Great Falls
Missoula
Lewistown
Butte
Whitehall
Billings
Dillon
Red Lodge

Fig. 1

cedar and yellow pine were encountered in the northernmost part. The region is drained by Whitetail Creek, which flows in a southeasterly direction, through the town of Whitehall, and eventially empties into the Jefferson River. About 30 miles east of Whitehall, at Three Forks, the Jefferson, Madison and Gallatin Rivers meet to form the Missouri River.

Dry farming in this area has been tried but prooved unsuccessful. There are many irrigated farms in the lowlands, the benchland being used for cattle grazing. There is considerable mining activity in the region, but only one large mine, the Sunlight mine. In the 1900's a small mining community called St. Paul was located at the head of a gulch about five miles northeast of Whitehall. Since then it has become one of Montana's numerous "Ghost Towns".

Two transcontinental railroads cross the valley, the Northern Pacific and the Chicago, Milwaukee, and St. Paul Railroads. Main highways connect Whitehall with Butte, Helena, Bozeman, and Dillon Montana, as well as with other towns. An airport is located west of Whitehall, where the Great-Falls-Salt lake and Butte-Billings routes of the Western Air Express Airway intersect.

Field Work and Acknowledgments

The area mapped by Mr. John Dougherty, Mr. Fred Garbutt, and the writer of this report, is shown by the small map, figure 4, and the report will be on this area only. No maps of the region were available prior to this report. The field work was carried out during the last two weeks of September, 1938.

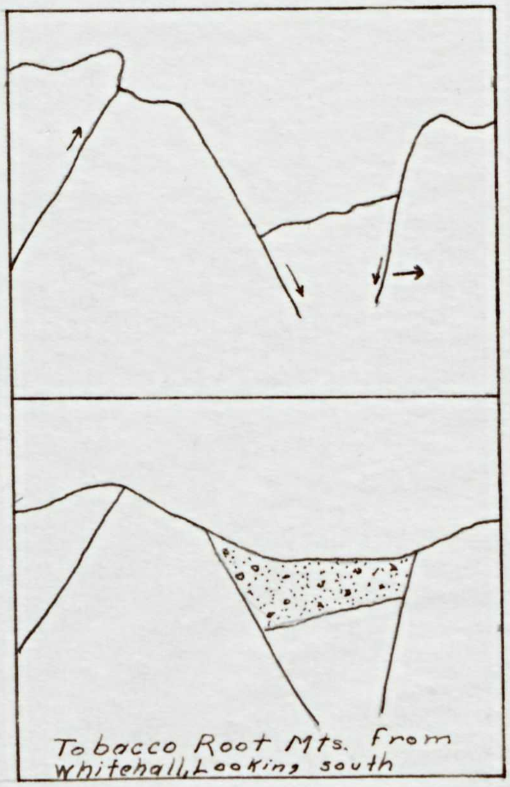
Work was first done on a known section, the South Boulder Section, in order to familiarize the student with the formations. Most of the area was mapped by plane table and telescopic alidade, general features being surveyed by automobile traverse and a pacing traverse.

The writer wished to acknowledge the assistance of Dr. E.S. Perry, head of the Department of Geology at the Montana School of Mines, under whose supervision the field work and office work was carried out; of Dr. G.F. Seager and Dr. L.L.Sloss, instructors in Geology who cooperated with the different partys in every way possible, both in the field and in compiling the maps; and of Mr. John Dougherty and Mr. Fred Garbutt, the other members of this particular "three man " crew.

GEOLOGY

General

Jefferson valley may have been formed and structurally controlled by block faulting, as shown by the diagram on this page.*



In Oligocene time there was much volcanic activity and land movements. At this period the Jefferson River flowed south into the Snake River in Idaho. It is possible that the lava flows and the warping of the land blocked the drainage and changed the course of the rivers. A lake built up, finally cutting a canyon to the west (Jefferson Canyon) and drained itself. The Bozeman Lake Beds could have been deposited during that period.

This region was not extensively glaciated, although remains of small regional glaciers may be seen in some of the mountain valleys.

*Classroom Lecture Notes, Professor Paul A. Schafer, 1936

The land slopes gently up to the mountains, typical Belt Series benchlands being formed. Practically all the rocks are sedimentary, small dykes and sills also are in evidence; the Livingston lavas and basalts being encountered in the northern part of the area.

Description of Rock Formations of South Boulder Canyon

The succession of geologic formations is shown on the columnar section of the South Boulder Area. (Fig. 3.)

PRE-CAMBRIAN

Pony Series*

Little work was done by the geologic party on the Pony Series. A general description of this series is as follows:

"The Pony Series is made up of both light and dark colored gneisses and schists. This series is well exposed in South Boulder Canyon, from its contact with the Paleozoic sediments to a point about 8 miles south.

These rocks are light-gray quartz-feldspar gneisses with subordinate hornblende and mica; hornblendic gneisses with minor ammounts of feldspar and quartz; black amphibolite schists composed almost entirely of hornblende; white quartz-feldspar gneiss having the appearance of metamorphosed pegmatite; several narrow bands of dark hornblendic-garnet schist,and a few thin bands of mica schist.

This gneiss and schist complex is literally cris-crossed by igneous injections of both Pre-Cambrian and later age. Rocks having the appearance of metamorphosed granites associated with pegmatites and quartz veins are numerous.

The Pony Group is faulted and folded in a complex manner. Schistose and gneissis structures have been caused by the tremendous pressures which crumpled the rock into a plexus of great

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*"A Geological Reconnaissance of the Tobacco Root Mountains, Madison County,Montana" by Wilfred Tansley & Paul A. Schafer, Memoir #9 Montana Bureau of Mines and Geology.

and minute contortions.

CAMBRIAN (Paleozoic)

Flathead Formation

As shown on the columnar section the Cherry Creek series and the Belt series are missing, the Flathead quartzite lying directly on the Pony gneiss. The formation was found to be about 100 feet thick in this locality. It is the basal member of the Cambrian series, is a conspicuous marker, and invariably stands up in bold outcrops. The rock is pinkish, brittle, and has a granular or sugary texture. It is composed of quartz grains cemented with silica. Near the base of the formation bands of angular or rounded milky quartz pebbles occur, and serve as a very definite marker for the base of the Cambrian. A shale horizon sometimes occurs between layers of the quartzite near the center of the formation.

Wolsey Formation

The Wolsey sahle lies comformably upon the Flathead formation. This shale has been called the Barker shale and the Flathead shale. The shale was found to be over 700 feet thick.

The most striking characteristics of the formation is its green-brown to gray-green color,* combined with its softness and fissility. Erosion of this soft shale has produced benches on the mountain sides, and sags on the ridges, either of which readity marks the position of the formation in most of the sections.

In general the formation displays a three-fold division.** The lower part consists of green-gray to green-brown sandy micaceous, fissile shales interbedded with numerous thin, ripple marked brown sandstones, that always carry on their upper surfaces numerous worn trails and borings. The middle part consists of more fissile

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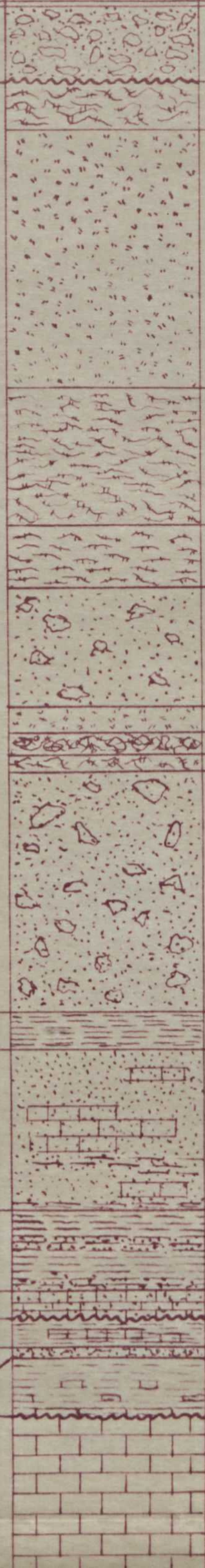
* ** Deiss, Chas. F., Paleozoic Formations of Northwestern Montana; Montana Bureau of Mines and Geology, Memoir No. 6

** Weed, W.H.; Geology of Little Belt Mountains, Montana; U.S.G.S. 20th Ann. report, 1899

Fig. 3

COLUMNAR SECTION OF SOUTH BOULDER AREA

Scale 1 = 1000



PERIOD	FORMATION NAME	COLUMN	THICKNESS	SYM.	CHARACTERISTICS
QUATERNARY	ALLUVIUM		?	Qal	Gravel & sand (unconformity)
UPPER CRETACEOUS	LIVINGSTON GROUP		?	Kl	Andesite Porphyry
			1420		Basalt Breccia
			715		Fine Andesite Porphyry
			350		Coarse Andesite Porphyry
			640		Agglomerates
			125		Basalt
			120		Vesicular Andesite
			80		Andesite
			1270		Agglomerates Pyroclastics
	COLORADO		210	Kc	Shale - fossilized
LOWER CRETACEOUS	KOOTENAI		875	Kk	Sandstone Shale Limestone
JURASSIC	MORRISON		423	Jm	Variegated Shales
	ELLIS		150	Je	Ls. - cherty (unconformity)
PERMIAN	PHOSPHORIA		155	Pp	Ls. - phosphate
PENNSYLVANIAN	QUADRANT		62	Pq	Quartzite - Ls.
	AMSDEN		296	Ma	Shale - Ls. (unconformity)

		120		Vesicular Andesite
		80		Andesite
		1270		Agglomerates Pyroclastics
	COLORADO	210	Kc	Shale - fossilized
LOWER CRETACEOUS	KOOTENAI	875	Kk	Sandstone Shale Limestone
JURASSIC	MORRISON	423	Jm	Variegated Shales
	ELLIS	150	Je	Ls. - cherty (unconformity)
PERMIAN	PHOSPHORIA	155	Pp	Ls. - phosphate
PENNSYLVANIAN	QUADRANT	62	Pq	Quartzite - Ls.
	AMSDEN	296	Ma	Shale - Ls. (unconformity)
MISSISS-IPPIAN	MADISON	2380	Mm	Massive Laminated Limestone
UPPER DEVONIAN	THREE FORKS	340	Dtf	Shale - limey
MIDDLE DEVONIAN	JEFFERSON	650	Dj	Cherty petriliferous Limestone (unconformity)
	DRY CREEK	100	€dc	Shale
	PILGRIM	720	€pi	Limestone Massive
MIDDLE CAMBRIAN	PARK	333	€pa	Shale - green
	MEAGHER	455	€m	Limestone - mottled
	WOLSEY	722	€w	Shale - green
	FLATHEAD	100	€f	Quartzite - pink (unconformity)
ARCHEAN	PONY	?	AR	Gneiss

and less micaceous green-gray shale, and locally, blackish-gray very finely bedded shale. Near the top numerous thin beds of crystalline limestone occur. These limestones carry fragments of trilobites very poorly preserved.

Meagher Formation

The contact between the Wolsey and the Meagher limestone is uneven and shaley. The formation was found to be 455 feet thick. It is a mottled limestone with a crystalline sugary texture. On fresh break it will give an odor of rotten eggs. This limestone is known as the "typical Montana black and gold", due to rust colored inclusions. An edgewise conglomerate was apparent near the base of the formation and seemed to be about one foot thick. Trilobite fragments were found at the base, A.C.Peel in the Three Forks folio (U.S.G.S. No. 24) called this the "Trilobite" limestone.

Park Formation

The Park shale is a fine grained green shale, about 330 feet thick. The outcrops are very obscure;most places the shale is covered with alluvium. It is a soft,easily eroded shale forming a valley between the Meagher and Pilgrim limestones. An undetermined species of Obolella is the only fissel regognized as coming from this horizon*.

Pilgrim Formation

This formation consists of 720 feet of massive limestone. It is a dark, mottled limestone forming ridges, and is fairly easily recognized wherever found, being recognized mainly by its position between the Park and Dry Creek shales.

Dry Creek Formation

In South Boulder Canyon the Dry Creek Shale was found to be 100 feet thick. It is a series of brown,yellow and red shales,

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* A.C.Peel; Three Forks Folio, United States Geological Survey, Folio No. 24.

and thin bedded sandstones. It lies conformable on the Pilgrim limestone, the contact being somewhat obscure. A limsetone horizon about 50 feet thick exists in the upper part of the formation.

DEVONIAN (Paleozoic)

Jefferson Formation

The Jefferson limestone is recognized as the base of the Devonian Period. In this region it rests unconformably upon the Dry Creek shales. It consists of 650 feet of black or mud colored limestone having a granular, sugary like texture, and is generally crystalline and magnesium from top to bottom.* It is non-fossiliferous in most localities, a few forms being obtained from the top of the formation. In this region this is a cliff and ridge forming limestone.

Three Forks Formation

The Three Forks shale rests conformably upon the Jefferson limestone, and is 340 feet thick. It is a limey shale which seems to be divisible into three parts. The lower part is a series of light brownish-red clayey shales about 125 feet thick. Next is a grayish brown limestone horizon about 40 feet thick. The upper part consists of black and greenish limey shales which are crowded with many Devonian fossils.

MISSISSIPPIAN (Paleozoic)

Madison Formation

The Madison formation consists entirely of laminated, massive limestone beds about 2300 feet thick. In this region it is a very prominent cliff forming limestone. The Madison is a greyish-white limestone with considerable cherty or jaspery"horizons" in the upper part of the series. This formation is easily recognized in this area, standing up in cliffs and ridges traceable for miles.

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* A.C.Peel; U.S.G.S. Folio No. 24;,

IDEAL CROSS SECTION
OF
SOUTH BOULDER AREA

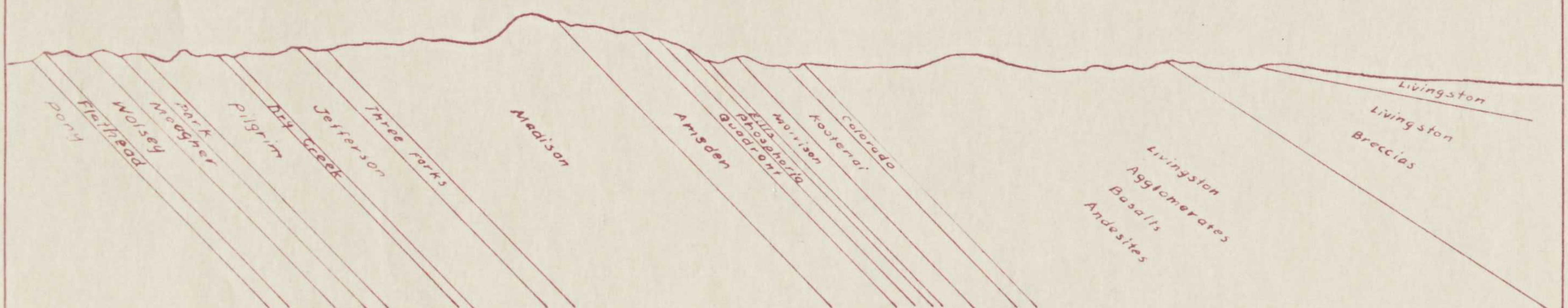

Fig. 2

Amsden Formation

The Amsden is a series of distinctive red shales and limestones about 300 feet thick, lying unconformable upon the Madison limestone. There has been some difference in opinion among geologists as to whether this is a separate formation or not. The formation appears to be a transitional stage between the top of the Madison and the Quadrant formation of the Pennsylvanian period. Basal shale

PENNSYLVANIAN

Quadrant

A.C.Peel in his Three Roeks Folio combines the Amsden and the Quadrant into one formation, the Quadrant quartzites and limestones. The Quadrant in this vicinity was found to be only 60 feet thick. It is a light-red colored formation capped by a prominent bed of quartzitic snadstone. Some fossels have been found in the sandy limestones which underlie the quartzite.

PERMIAN

Phosphoria Formation

This is a difficult to recognize formation containing a bed of oolitic phosphate rock about three feet wide. In this area the Phosphoria formation lies conformable upon the Quadrant and is about 155 feet thick. This formation contains nodules of black chert. The phosphate beds weather to a steel-gray color which helps to recognize the formation *

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* Wilfred Tansley and Paul A. Schafer; "A Geological Reconnaissance of the Tobacco Root Mountains, Madison County, Montana"; Memoir No. 9, Montana Bureau of Mines and Geology.

MESOZOIC

JURASSIC PERIOD

Ellis Formation

The Ellis consists of 150 feet of cherty limestones lying unconformable upon the Phosphoria formation. The chief distinguishing characteristic of this formation is the presence of oyster remains and star shaped crinoids.

Morrison Formation

The Morrison is a series of variegated shales and sandstones about 420 feet wide, lying conformable upon the Ellis formation. The red,purple and greenish shales are very susceptible to erosion and form a shallow vale.

LOWER CRETACEOUS

Kootenai Formation

The Kootenai consists of 875 feet of sandstones, shales, and limestones. A limestone horizon about in the middle of the formation contains fossils. There are beds of freshwater limestone in the formation, easily recognized by a light gray color, being thinly bedded, and by the presence of snails.

UPPER CRETACEOUS

Colorado Formation

The Colorado is a fine-grained soft, dark, shaley sandstone, sometimes called the salt and pepper sandstone, about 210 feet thick. It is badly weathered in this vicinity. A few worm trails were noticed, although no other fossils were found.

UPPER CRETACEOUS

Livingston Formation

The Livingston group consists of 4720 feet of basalts, porphyry, agglomerates, and other pyroclastics. It may be divided into eight sections.

The basal section consists of 1270 feet of agglomerates and pyroclastics. This group is massive, forming a prominent bluff. Igneous phenocrysts are present, and part of this section might be a mud flow. The rocks of this section are of a somber hue, being dark green and blackish-green.

The next section is about 80 feet wide and seems to consist of one lava flow. This series is composed of greenish amygdaloidal andesite, less massive than before. It grades into a reddish andesite at the top.

Another lava flow, but more vesicular than before, with inclusions of gypsum, follows. This lava flow consists of 125 feet of a basic rock which may be a basalt.

In the next series there is a sudden change in the character of the rock, a change from basalt to tuffs and agglomerates. This layer is one 600 feet thick. The rocks consist of a greenish to reddish agglomerate with well developed, oriented hornblende showing flow structure, and having an aphantic groundmass.

The next series is about 750 feet of basaltic porphyries. The lower part consists of about 330 feet of oatmeal rock and other coarse grained porphyries of feldspar in a fine grained aphantic basalt. The phenocrysts of fledspar are up to ½ inch in diameter, or about 1/3 rd the area. The rock weathers to a dark inconspicuous ridge. The upper part of this series consists of finer grained porphyries that are more andesitic than basaltic, and which possess parallel parting near the contact with the coarse grained porphyries. This rock is darker than that proceeding, and forms a fair sized high ridge.

Approaching the top of the series, a layer of basalt breccia about 1400 feet thick is found. The rock changes from an andesitic porphyry to a more basic non-porphyritic rock, this layer having about 30 feet of basal breccia at the proceeding contact. The top of the Livingston group consists of pinkish to brownish andesite porphyry of unknown thickness. This layer forms an outstanding ridge in this region.

GEOLOGY OF AREA MAPPED

The formations mapped in the area north of Whitehall (see fig. 4) include the Belt, Flathead, Wolsey, Meagher, Park, Pilgrim, Dry Creek, Jefferson, Three Forks, and Livingston.

The only formation mapped which has not previously been described is the Belt Formation of the Pre-Cambrian period.

This series varies in thickness from 2000 to 6000 feet.* The lower part of the formation consists of an alternation of coarse sandstones and conglomerates of arkosic character. They are of somber hue, dark green and steel gray colors predominating. In the central part of the series argillites and siliceous limestones are frequently found, and in the upper part sandstones again seem to predominate. The formation as far as examined, is non-fossiliferous.*

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* A.C.Peel, Three Forks Folio; Folio No. 24, U.S.G.S.

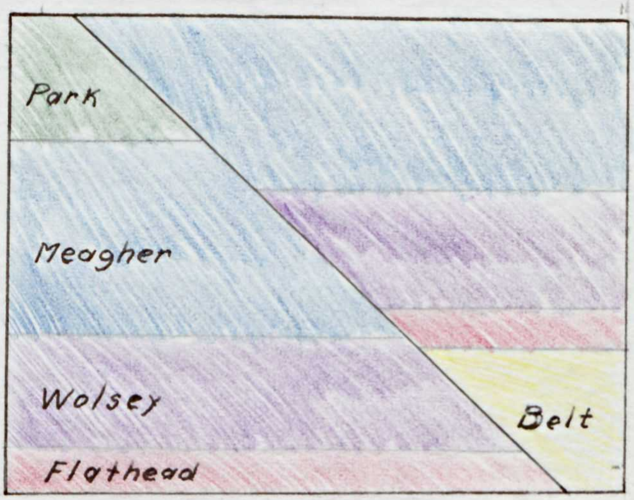
In the area north of Whitehall, the upper part of the Belt seems to consist of thin bedded shales exclusively, the shales being of lighter colors than Peel found in his survey.

The Quaternary alluvium in this area consists mostly of Bozeman Lake Bed deposits. These deposits grade from a disintegrated clayey or sandy shale to gravel. As seen from the map, figure 4, the formations gradually slope downward and disappear under the alluvium.

Included in the area mapped is a large hogback over 300 feet high. It is separated into three parts by gullies, as indicated on the map, figure 4. This hogback made it possible to map in the contacts as completely as shown. In the rear of the hogback (to the northeast) is a wide valley which slopes up to the mountains about one mile distant.

FAULTS AND SPECIAL CHARACTERISTICS

Several faults were encountered, two being very large. As seem from the map, one major fault in the southeast portion of the area throws the Flathead quartzite against the Meagher limestone, the northern part of the fault disappearing in the Park shales. The fault probably occurred as shown in the diagram, the direction of the slip being unknown. The other large fault lies at the extreme northern end of the map. This fault throws the Livingston formation against the Devonian Jefferson and Three Forks formations. This fault can be traced



for some distance and seems to have had great displacement. A smaller fault south of the one just mentioned is very interesting, as a beautiful example of a fault. It is easily seen from the striations and flutings that the movement was directly down the dip of the surface. A typical example of a "slickenside" has been formed, also a low fault scarp. The limestone has been hardened until it cannot be scratched with a knife near the fault zone. Considerable fault gouge is also present.

Three dikes were mapped, the dyke rock of all being of a syenitic nature. The limestone around these dikes is altered until it is practically unrecognizable. Most of the limestone is colored a brick red, or yellowish red. In one sample, taken near the large dike, wollastonite was believed to be present. Some of the samples taken were noted to have a breccia-like texture, the cause of this peculiar texture being unknown. Another sample taken near a prospect pit resembled a lump of black slag. It is very heavy and has a vitreous luster, and seems to have much iron in its composition.

ECONOMIC GEOLOGY

Considerable prospecting has been done over the southern part of this area, and one mine operated, traces of copper being found on the dump. The impure limestone around the dykes is, as was said before, greatly altered, making some of it almost unrecognizable. It is possible that contact metamorphic minerals may be formed, although it is not probable that ore deposits of any value would be formed.

Along the large north fault little prospecting has been done. Here too, the limestone is also greatly altered, and the area highly mineralized. This should warantee careful prospecting, especially for contact metamorphic or pneumatolytic minerals.

SUMMARY

Due to the fact that such a small ammount of work was done it is difficult to come to any definite conclusions about the area mapped. However, three things definitely have been accomplished.

1. Information obtained on an area for which no information was available proir to this report.
2. The work done will serve as a foundation for a more through examination of the Bull Mountain Range, particularly of the structural and petrographical characteristics of the region.
3. Experience gained by the party as to the proceedure followed in doing work of this type will proove very valuable to the undergraduate engineer.