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Geological Report of Conrow Wood Creek Area 8 Miles N.E. of Whitehall, Montana

Kenneth M. Judd

MONTANA SCHOOL OF MINES

Butte, Montana

GEOLOGIC REPORT

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SUBMITTED TO

DEPARTMENT OF GEOLOGY

by

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ILLUSTRATIONS

Kahla Judd Wilson Rolfe

ACKNOWLEDGEMENTS

The author would like to take this opportunity to acknowledge the help that was provided by Dr. Perry, in working out the geology of this district, and the many helpfull suggestions that he forwarded, that aided us in our field work. Mr. Hanson's aid as our field instructor was also appreciated, and the congenial cooperation of the author's associates, Bill Kahla, Dave Wilson, and Bill Rolfe, made the work in the field enjoyable and instructive.

GEOLOGIC REPORT OF THE AREA EIGHT MILES N.E. OF WHITEHALL, MONTANA

by Kenneth M. Judd

INTRODUCTION

The contents of this report, composed of the geologic field work done by the senior Mining, Geological, and Petroleum Engineering students at the Montana School of Mines, deal with the regions of the South Boulder Area, and the area eight miles N.E. of Whitehall, Montana.

This field work is required of all seniors who will be candidates for a degree in Mining, Geological, or Petroleum Engineering at the following commencement. The purpose of this trip is to acquaint the student with field problems that are encountered geologic exploration and mapping. Special attention is given to detailed and reconnaisance mapping of a given area, andthe study of geologic formations as they occur in Montana.

Plane table and pacing methods were used in the mapping of the individual areas, but an automobile traverse was used to tie the independent areas into a composite group that would be useful for the entire zone. All land marks, section corners, roads, fence lines, drainage, and geologic features were plotted in the field and later transferred to a master map.

The entire group that partook in this field trip met at the campus of the Montana School of Mines on Tuesday Morning, September 7, 1948, at 8 AM, and proceeded by automobile to Whitehall, Montana, thirty miles southeast of Butte,

on U.S. Highway No. 10 South. Headquarters for the trip were established at the Green and White Cabins, where the students lived for two weeks.

Students doing the field work were:

1. Anders Augustson
2. Dare Boulter
3. Charles Christman
4. Frank Colbert
5. Hugh Coyle
6. Logan Davis
7. Alvin Ek
8. Bruce Emerson
9. Jean Hardesty
10. Frank Hitchcock
11. Gordon Irving
12. Kenneth Judd
13. William Kahla
14. Herbert Keen
15. Gordon Lanouette
16. Richard Lenz
17. Russell Maurer
18. Russell Rockwell
19. William Rolfe
20. Howard Waldron
21. David Walker
22. Norman Warberg
23. Higbee Williams
24. David Wilson

This group was under the direct supervision of Drs. Eugene S. Perry, Forbes Robertson, Alvin Hanson, and John Buckvich, faculty of the Montana School of Mines.

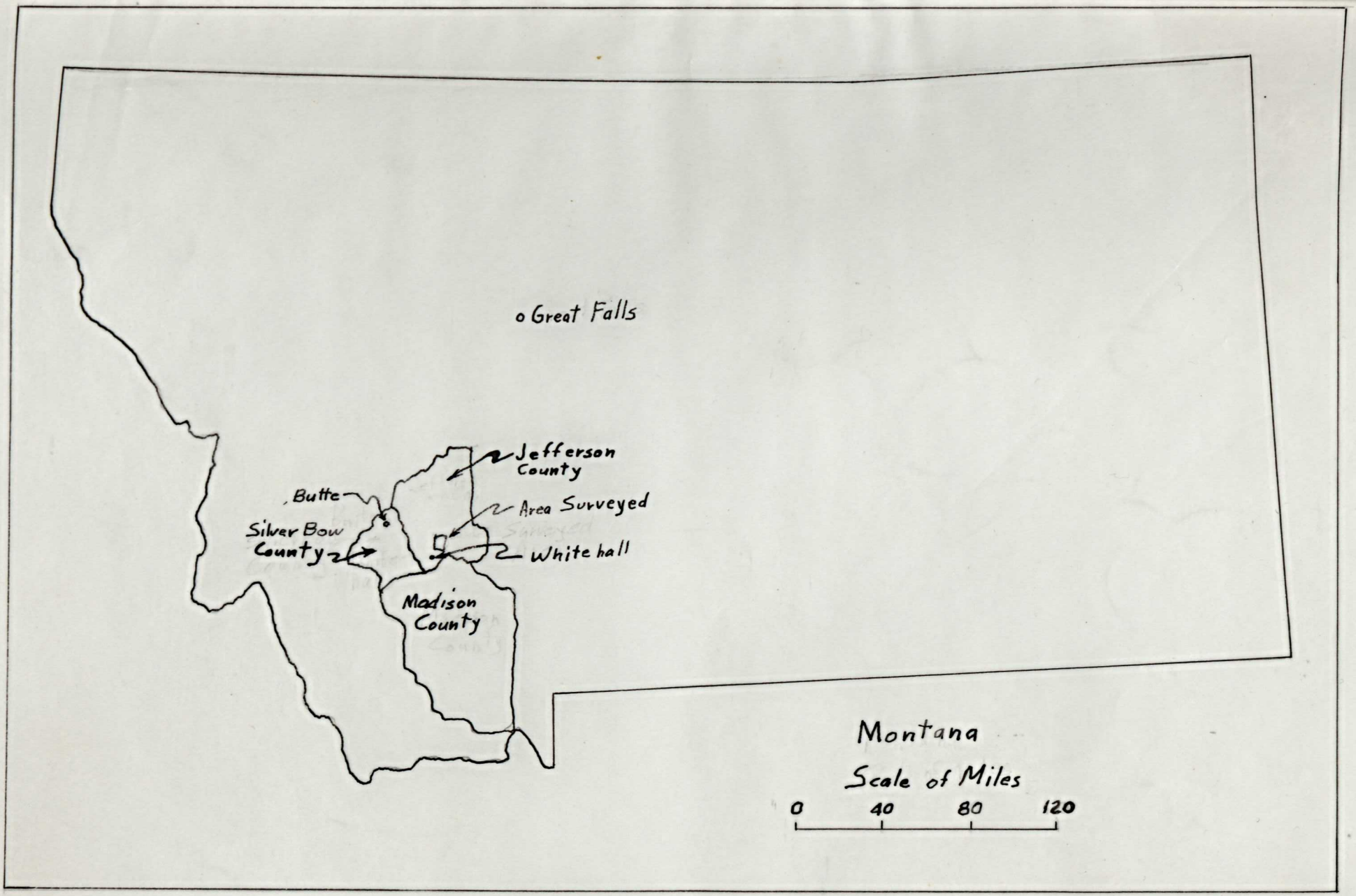
The afternoon of the first day was spent in reviewing the geologic column for Montana and in practicing with the plane table by runninga closed traverse within the limits of Whitehall.

Early the next morning, the entire group started a two day preliminary study of the stratigraphy of the South Boulder Canyon, where the geologic column from pre-Cambrian to Tertiary is exposed. Notes on the character of the beds were taken for future reference, as some of the formations encountered in the field work would be the same.

After the preliminary work, the students were divided into six groups of four men each. Mr. Hanson was in charge of the two groups that did the Conrow Wood Creek Area.

Dr. Perry directed the automobile survey, in which all the men took part.

Mapping and field work continued in this area until September 18th, when the field work was halted and the class returned to Butte to do the necessary office work and draw the final maps. Six days were spent in drawing maps and making preparations for this report from data collected in the field. In all, eleven days were spent in the field mapping, and six days were spent in office work, during the period from September 7 to September 25, 1948.


o Great Falls
Jefferson County
Butte
Area Surveyed
Silver Bow County
White hall
Madison County
Montana
Scale of Miles
0
40
80
120

GEOLOGY OF THE SOUTH BOULDER AREA

PHYSIOGRAPHY:

South Boulder Canyon is in Madison County and is reached by following the county road leading south from U.S. Highway No. 10 South, through Jefferson Island for a distance of ten miles. This road is the old highway to Bozeman. The locality is representative of the Montana Column and hence, was chosen for the preliminary work. Sediments from the Paleozoic to the Cenozoic are conformably deposited in this area. Subsequent orogenic movement during Cretaceous time have tilted these beds, so that they now dip northward at an angle of 45 . Pleistocene glaciation is evident in the South Boulder Canyon area. The glaciation can be traced at right angles to the strike of the beds and runs northward down the dip. Small creeks have cut ravines along the strike of the strata. By studying the topography and applying the technique of physical geology it is possible to infer the physical characteristics of the formations themselves. Some beds are resistant and form ridges of "hog backs", while others are easily eroded and form valleys or deep ravines. The degree of resistance of the respective formations will be discussed in the stratigraphy of the section.

CLIMATE AND VEGETATION

The climate in the South Boulder area is semi-temperate. The temperature range is about 140°F, the maximum being 100°F in the summer and the minimum -40°F in the winter. The late fall days give the most variable temperature, as the days will be warm, and the nights will cool off to a near freezing temperature, thus affording good spalling action on the rocks.

Snow piles up in the winter to depths of 3-6 feet and in the spring there are heavy runoffs which have a certain amount of erosional force, thus causing the wearing down of the high points and deposition in the low spots. Flash rains in the summer accomplish the same ends. The annual rainfall for this region is approximately 14.07 inches per year.

Vegetation in this area is both natural and artificial, the artificial being the crops planted by the farmers of the region.

Sagebrush and greasewood grow on the most rugged peaks and hills, while the slopes are covered with buffalo grass. The valley bottoms give ample subsistance to brush and willows. On the slopes are found stands of pine, and in the more rugged areas, stands of firs. The more level portions of the area are used as farming tracts, planted with such crops as hay, grain, potatoes and apples.

GEOLOGIC COLUMN

SOUTH BOULDER CREEK AREA

SEPTEMBER 1948

PERIOD	FORMATION	SYMBOL	THICKNESS	DESCRIPTION
Tertiary	Lake Beds	Tlb	Tlb	Unconsolidated Sediments. Silt, sand.
Cretaceous	Livingston	Klv	Klv	Lava sand, agglomerate, andesite and basalt porphyry. Varying shades of gray and green. Result of wide spread volcanicvectivity.
Cretaceous	Colorado	Kc	Kc	Greenish blue to black shale. Narrow coal seam at base. "Salt and pepper" sandstone of medium grain size.
Cretaceous	Kootenai	Kk	Kk	Limestone containing gastropods near top.
Jurassic	Morrison	Jm	Jm	Red, green, and yellow sandstones and shales. Contain calcareous nodules.
Jurassic	Ellis	Je	Je	Gray ls, gr,br,bl, shale, sandstone.
Permian	Phosphoria	Pp	Pp	Oolitic black and white phosphate rock
Pennsylvanian	Quadrant	Pq	Pq	Massive tan quartzite.
Mississippian	Amsden	Ma	Ma	Red hshale at botton, with a bed of white limestone at top.
Mississippian	(Mission Canyon) Madison	Mmc	Mmc	Massive limestone with poor bedding, containing black chert bands.
Mississippian	Madison (Lodgepole)	Mlp	Mlp	Limestone. Light colored on weathered surface, gray to black on fresh fracture. Fine grained and fossiliferous.
Devonian	Three Forks	Dtf	Dtf	Green shale, thin bedded, with limestone near center. Fossiliferous.
Devonian	Jefferson	Dj	Dj	Limestone with fetid oror. Mottled dark gray color with white streaks. Fine grained and contains walnut sized quartz geodes.
Cambrian	Dry Creek	Cdc	ϵ_{dc}	Gray to red and black shales.
Cambrian	Pilgrim	Cp	ϵ_{pg}	Mottled two tone gray limestone. Thin bedded, becoming massive at top.
Cambrian	Park	Cpk	ϵ_{pr}	Green shale
Cambrian	Meagher	Cm	ϵ_m	"Black and gold" limestone. Fine grained, oolitic near center. Some cross bedding.
Cambrian	Wolsey	Cw	ϵ_w	Gray-green thin bedded shale. Sandy and calcareous. Worm trails characteristic. Contains trilobites.
Cambrian	Flathead	Cf	ϵ_{Fl}	Pink iron-stained quartzite.
Pre Cambrian	Pony Gneiss	APp	APp	Feldspar gneiss containing some pink orthoclase. Some mica gneiss present. Mostly dark in color, becoming lighter in upper portion.

STRATIGRAPHY OF THE SOUTH BOULDER AREA

ARCHEOZOIC (pre-Cambrian)

PONY: The Pony formation in this area is a reddish, banded, hornblende gneiss, with alternating bands of pink feldspar and quartz, the quartz has black streaks of hornblende and garnet minerals. It has been highly metamorphosed and may be of either sedimentary or igneous origin. The gneiss is not really exposed in this area, but the soil resulting from its decomposition may be identified by the presence of numerous shiny biotite flakes and quartz particles. There are several high temperature pegmatite veins cutting the gneiss.

CAMBRIAN

FLATHEAD: The Flathead formation which forms the basal member of the Cambrian series in Montana is a pink, limonite-stained, sugary quartzite. It overlies the Pony gneiss and the lower part is a breccia-quartzite. Cross bedding occurs above the basal contact and makes it possible to distinguish between the upper and lower surfaces. It is very hard and resistant, forming ridges, and when weathered, breaks into large blocks. The total thickness of the formation is approximately 190 feet.

WOLSEY: The Wolsey formation lies conformably on the Flathead. It is a soft, variegated, green, micaceous, thin-bedded shale. Because it is a soft shale it does not commonly crop out, but can usually be found in valleys. Diagnostic worm tracks are the most important key of this formation. It is also thin-bedded at the base with limestone in the center. In this region the Wolsey shale is about 400 feet thick.

MEAGHER: The Meagher formation is a dense, massive, blue limestone which lies on top of the Wolsey shale. It is locally known as "black and gold limestone", from the mottled appearance it has on the weathered surface. It has an oolitic horizon in the center of the formation. Middle-Cambrian trilobites may be found in the limy upper surface. It is nearly 350 feet thick in this region and forms resistant cliffs and outcrops.

PARK: The Park shale, which is about 170 feet thick, is a fine-grained, "greasy", green shale, and is very easily eroded, forming valleys. It lies conformably on the Meagher formation.

PILGRIM: The Pilgrim formation is a dolomitic, sugary-grained limestone with mottled grey, and yellowish streaks. It is characteristically thin and slabby at the base and blocky at the top. When exposed to erosion it takes on a fluted appearance, tending in a vertical direction. The Pilgrim formation is very resistant and forms ridges and high cliffs. It is about 250 feet thick, and overlies the Park shale.

DRY CREEK: The Dry Creek formation, which lies on top of the Pilgrim formation, is a reddish-brown shale grading from a sandstone into a shale into a limestone and even into a quartzite. The base consists of variegated shales and thin bedded, brownish, sandstones. This is overlain by 90 feet of light-colored laminated limestone. The total thickness of the formation is about 115 feet.

DEVONIAN

Note: Since neither the Ordovician nor the Silurian periods are represented in this section of Montana, the Devonian beds lie unconformably on the Cambrian sediments.

JEFFERSON: The Jefferson overlies the Dry Creek formation. It is a black, fetid (oily smell), fine, sugary grained limestone. It is characterized by quartzy, cherty geodes, and is quite dolomitic. It is very thick, reaching a maximum of about 1320 feet in this locality. Bryozoans are characteristic fossils. As Montana's climate is helpful in making limestones resistant to erosion, this formation is a ridge former where exposed.

THREE FORKS: This formation is found above the Jefferson and is a green, grayish, greasy shale with a limestone horizon in the center of the formation. The shale "arrowheads" found in it are typical of the formation and serve as a key. Bryozoa and brachiopods are very abundant and are found in a good state of preservation. The formation is about 340 feet thick in this section.

MISSISSIPPIAN

MADISON: The Madison formation consists of two members:

1) The Lodgepole limestone at the base, and 2) the Mission Canyon limestone at the top.

The Lodgepole limestone, which overlies the Three Forks shale, consists of about 1070 feet of dark colored, laminated limestones, somewhat resembling a basalt, and contains many fossils. There has been a further subdivision of this member into the Paine and Woodhurst formations. The lower part (Paine) is thin slabs of limestone interbedded with limy shales. The (Wood hurst) upper section is blocky.

The Mission Canyon is a massive limestone with indefinite bedding, and is characterized by cherty corals. Index fossils of the Mission Canyon are pipe-organ corals. Crinoid stems are also abundant at the top portion of the formation. This division of the Madison limestone is about 1180 feet thick, making the entire Madison formation about 2200 feet thick.

AMSDEN: The Amsden formation, which overlies the Mission Canyon, is about 300 feet thick. It is the first real red bed in the column, thick reddish shales at the base, and the remainder a buff colored limestone. The base is easily eroded; the upper part is resistant and forms ridges.

PENNSYLVANIAN

QUADRANT: Overlying the Amsden is the Quadrant formation, which consists of a fine-grained, tan colored quartzite which resembles a sandstone. In this section it is approximately 190 feet thick, and is one of the most resistant formations in the column.

PERMIAN

PHOSPHORIA: The Phosphoria formation is about 105 feet thick, and consists of conglomerate at the base, also some black, chert, and grading into a series of this order: "black chert, oolitic phosphate, paper shales". Locally, bone fragments are found. The formation is soft and poorly exposed. The phosphate rock forms commercial deposits in several different localities in Montana.

JURASSIC

Note: Because there is no Triassic sediment deposited in this section of Montana, Jurassic sediments lie unconformably on the Permian formations. "In the Southeast section of Montana the Chugwater sandstone is deposited."

ELLIS: The Ellis, lowermost Jurassic formation, overlies the Phosphoria formation. In this section it is 100 feet thick and is a massive grey limestone, consisting of grey, brown, black, sandstones and shales. Star-shaped crinoid stems are the index fossils of this formation, and oyster shells are in abundance.

MORRISON: The Morrison formation has at its base, a sandstone, and the upper portion is composed of a red, green, and yellow shale. The total thickness is about 350 feet.

Stratigraphic Column of Montana, M.S.M.

CRETACEOUS

KOOTENAI: The Kootenai formation is about 490 feet thick, and is separated from the Morrison by a six inch coal seam. The Kootenai is a sandstone, shale, limestone formation. It has very predominant deltaic cross-bedding. Black chert fragments are found in the sandstone. This same chert is mixed with a grey, sugary sandstone, to form what is known as "salt and pepper sandstone". At the top is a deposit of fresh-water limestone 30 feet thick which contains many gastropods. According to Dr. Perry, "this formation is the Cat Creek oil horizon".

COLORADO: On top of the Kootenai lies the Colorado formation which is locally 320 feet thick. It is a dirty, greasy, greenish-blue shale, that is not very well exposed, being covered with much weathered material.

Dr. Perry: Statement made on geology trip.

LIVINGSTON: The Livingston formation is at the top of the Cretaceous series. It is the result of far-flung volcanic activity, and is composed of lava, sand, agglomerate, andesite and porphyry. It has a very great width, some 2000 feet being exposed in this area. Agglomerates and clastics are found between the individual flows. The top is a basalt porphyry containing many phenocrysts (5-10mm in length), which are irregularly place in a fine, bluish-grey, aphanitic groundmass.

QUATERNARY

The Valley floor is covered with a thin deposit of alluvium. This is water borne from the beds adjacent to the valley. The upper portion of the area is covered with detritus of a gravelly nature in varying degrees of thickness.

STRUCTURE OF THE SOUTH BOULDER AREA

The topography and the dip of the beds in the South Boulder area indicates that there has been intense folding and faulting in this region. The area as a whole can be considered to be a part of the Tobacco Root Mountains.

By careful study, local folding may be seen along the road in many places.

The great stresses created by folding have caused faulting to accompany the folding in the region. In the South Boulder area a fault is found, that has moved the Pilgrim and Dry Creek beds of Cambrian age, and the Jefferson formation of Devonian age up over the Jefferson.

Both intrusive and extrusive rocks are found in the area. The Livingston formation makes up the extrusive, which forms a blanket of about 2000 feet.

The intrusives are mostly dikes and sills, and are found in many places. They are mostly basic, with a few high temperature veins being found. It is probable that the center of the Tobacco Root Mountains underlies this area, which serves as a reservoir and feeder for the intrusives. Since they traverse all the formations, they can geologically be called the youngest beds.

The Pony gneiss gives evidence of a great amount of metamorphism.

16.

STRUCTURE

The area is one of rather uniform uplift. There are very few faults in this area and the beds all tend to have a uniform dip. The general dip is 55 to 60 SE and the strike runs SW.

Lake beds and volcanics cover the beds in many places and it is assumed that series is uninterrupted beneath them.

Erosion has acted on much of the outcrops and only the most resistant have survived as outcrops.

STRATIGRAPHY

The stratigraphy of the area follows the stratigraphy of the South Boulder Canyon. Rock composition and color is hte same as in South Boulder, also.

GEOLOGIC HISTORY

There are no pre-cambrian rocks in this area.

CAMBRIAN

This is very definitely established in this area, many of the outcrops being represented and many fossil remains being discovered.

DEVONIAN

Most of the North American Continent was a low lying plain with narrow seas in the Appalachian and Cordilleran geosynclines. In Montana the Jefferson limestone and Threeforks shale make up a considerable thickness of the Devonian sediments. The Threeforks shale contains amny fossils in this area.

CARBONIFEROUS

Limestone is the predominant sediment of this time and the Madison is the predominant outcrop in this section. The Amsden red beds are an indicitive feature of this time.

CRETACEOUS

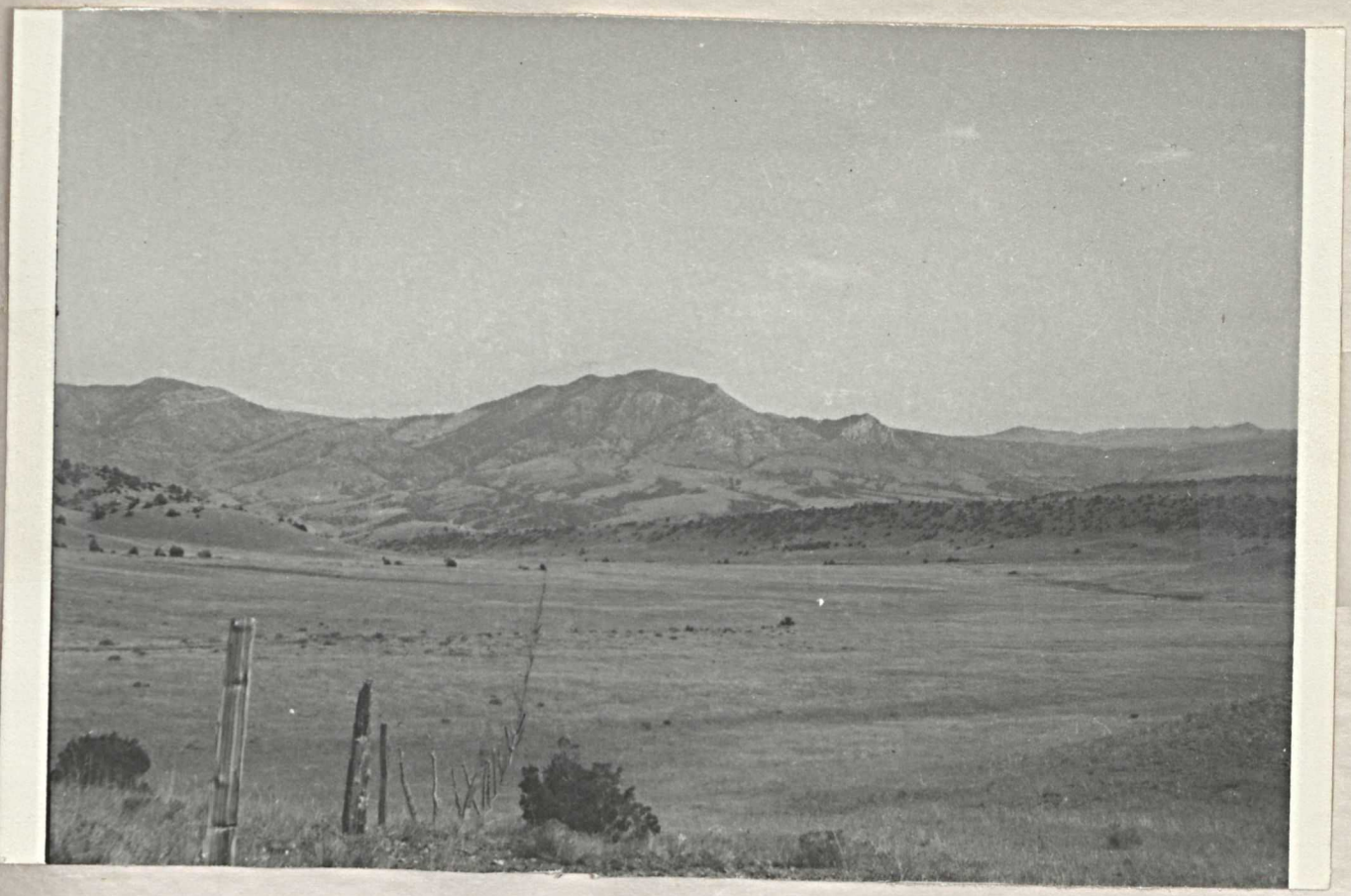
The Cretaceous period is established in this area, by the presence of the Livingston volcanics.

TERTIARY

The Bozeman lake beds, lying in the intermountain valleys, represent this period.

Pilgrim Outcrop in Southeast Part of Area

Pilgrim Outcrop with Madison in Background



Pilgrim Outcrop Behind Eastern Portion of Area

Madison Outcrop Intersecting Livingston Volcanics at Right

ECONOMIC GEOLOGY

The only prospect found in this area, was established by the Golden-Sunlighte Mining Company, but appeared unimportant. There were many iron outcropings, but they were the result of springs and not gossans.

The grazing of cattle was the most important economic feature of the area.

AREA EAST OF SOUTH BOULDER CREEK

The area surveyed on the last day in the field, is one of many folds and faults. Although the smaller folds do not appear on the map, they are easily seen in the field and form a geologist's paradise.

The series start with the Belt and progress through the Meagher. There are many sills and dikes that cover the beds, and many faults, which make the geology very jumbled.

The only economic possibilities seen for the area was the grazing land present.

Not much time was spent in this area, so further details must be omitted.

CONCLUSION

In conclusion, I would like to say that a great deal of experience and professional polish was acquired in the compilation of this report. The theories taught in the classroom were well correlated with the field work and thus the trip gave me an understanding of the importance of the theory taught at the School of Mines.