GEOLOGY OF PART OF THE TENDOY-MEDICINE LODGE AREA, BEAVERHEAD COUNTY, MONTANA

by

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ABSTRACT

The Tendoy-Medicine Lodge area is located in the extreme southwestern part of Montana. The sedimentary rocks exposed in the area are Upper Paleozoic, Mesozoic, and Tertiary in age. Volcanism is represented by baslatic flows and breccias. There has been intrusive activity. The intrusion is acid, and has been tentatively dated Upper Cretaceous or Early Tertiary. The two major periods of orogeny are Laramide and Mid-Tertiary. Early Laramide deformation produced northeastward trending folds. Deposition of the Red Rock conglomerate followed in Paleocene (?) time. In late Paleocene or early Eocene time Laramide thrusting from the west produced the Beaverhead thrust which overlies the Red Rock conglomerate. Erosion then followed, and the Basin beds were deposited. This deposition was accompanied by volcanic activity. Mid-Tertiary structures are represented by high angle faults, the Red Rock fault, East and West Muddy Creek faults, and an unnamed fault in the north east part of the area. This faulting is of the horst and graben type. The Tendoy Mountains are formed by a horst block and Muddy Creek Basin is a graben. Three erosional surfaces are found in the area. They are believed to correlate with surfaces described by Blackwelder in Wyoming, and have tentatively been called the Black Rock, Circle and present surfaces.

INTRODUCTION

Location of the area

The Tendoy-Medicine Lodge area is located in Beaverhead County in the southwestern corner of Montana. The main portion of the area lies within Townships 12 and 13 South, and Ranges 10 and 11 West. See index map, plate 3 . The area mapped is bounded on the east by a line that is approximately two miles west of U.S. Highway 91 and parallel to it. To the north the area is defined by the northern limit of Township 12 South. The southern boundary extends up Big Sheep Creek to Township 13 South and thence westward to Medicine Lodge Creek. The western boundary is determined by Medicine Lodge Creek.

Description of the area

The Tendoy-Medicine Lodge area has an extent of about 150 square miles and has a relief of approximately 3,800 feet. The lowest part of the area is near the mouth of Big Sheep Creek Canyon. Here the elevation is approximately 6,300 feet above sea level. The highest peaks in the area are Dixon Mountain and Ellis peak which rise over 10,000 feet above sea level. These peaks, as well as numerous others in the area, are capped with Quadrant quartzite. The resulting slopes are characterized by their dark appearance due to the growth of black lichens. Those hills that do not have the Quadrant as a capping rock tend to be less rugged.

The area is drained by Big Sheep Creek and Medicine Lodge Creek whose waters subsequently flow into the Red Rock River. These creeks are part of the headwaters of the Missouri River drainage system.

The area is reached from U.S. Highway 91. Big Sheep Creek Road at the southern limit of the area is passable in all types of weather. The road connects with the Cabin Creek Road that joins the North Medicine Lodge Road which bounds the western limit of the area. This part of the area also may be reached by turning west at Armstead from Highway 91, and continuing westward to Medicine Lodge, and thence southward up Medicine Lodge Creek. The road which runs up Muddy Creek Basin allows easy access to the center of the area in dry weather, but it is impassible in rainy weather. There are a few wagon trails, some of which may be traveled by automobile in dry weather.

The area has an arid climate with an annual average precipitation of 9.27 inches. The January average temperature is 16.3° F. The July average temperature is 62.9° F. The annual mean temperature is 39.3° F. These data have been taken from "Climate of the States, Montana", Agriculture Yearbook, Separate number 1844, Washington, 1941, and are obtained from observations by the U. S. Weather Bureau at Lima, Montana. Vegetation however indicates that there is considerably more rainfall in the higher portions of the area. The dominant vegetation is sage brush; however, conifers are present on the higher slopes. The valleys are used for grazing cattle, and where sufficient alluvium is present hay is grown.

Previous work and study

Prior to 1946 very little work was done in this area. E. S. Perry and Uuno M. Sahinen of the Montana School of Mines made a reconnaissance map during the summer of 1946 that includes the Tendoy-Medicine Lodge area. Part of the area was mapped in detail during the same summer by W. Lowell, but the result of this work is not available. W. D. Kupsch, Robert Scholten, H. H. Krusekopf, S. R. Wallace, E. G. Lipp, and Robert Becker of the University of Michigan did detailed mapping in surrounding areas during the summer of 1947. This work was done in preparation of Master's theses by the previously mentioned persons.

Acknowledgments

This report is based on field work done by the author during the summer of 1948, under the direction of Dr. A. J. Eardley, Professor of Geology at the University of Michigan. The author is also indebted to Professor Eardley for his assistance in compiling the accompanying

geologic map and the writing of this report. The writer had as a field associate, Dean L. Cummins, with whom he also collaborated in making the geologic map. Additional assistance was given the author and his associate by Walter O. Kupsch within whose Ph. D. area the Tendoy-Medicine Lodge area is located.

The work of S. R. Wallace and H. H. Krusekopf, who mapped an area to the south, has been included, with some changes, in the accompanying geologic map. Several instances of misidentification of formations were noted by the writer and his associates. This erroneous identification resulted in a faulty structural picture. At the suggestion of Dr. Eardley, this area, appropriate changes having been made, was included in the map. It comprises approximately the southwest quarter of the Tendoy-Medicine Lodge area.

STRATIGRAPHY

Stratigraphic column

A fairly complete stratigraphic column is present in the Tendoy-Medicine Lodge area with all but the pre-Mississippian periods being represented. Brief descriptions and approximations of thicknesses of these pre-Mississippian formations as they have been described in adjacent areas are being included even though they are not to be found in the locality immediately concerned with this report.

TABLE 1

STRATIGRAPHIC COLUMN

Age	Formation	Thickness
Quaternary	Alluvium	Unknown
Quaternary	Landslide	Unknown
Quaternary	Terrace gravels	50' ±
Pleistocene	High terrace gravels	Unknown
Upper Eocene (?)	Basin beds	Unknown
Paleocene (?)	Red Rock conglomerate	2,000' ±
Lower Cretaceous	Kootenai formation	1,200' ±
Jurassic	Rierdon formation	116'
Jurassic	Sawtooth formation	252'
Triassic	Thaynes formation	791'
Triassic	Woodside formation	353'
Triassic	Dinwoody formation	553'
Permian	Phosphoria formation	802'
Pennsylvanian	Quadrant quartzite	3,319'
Pennsylvanian and Mississippian (?)	Amsden formation	2,022'
Mississippian	Madison limestone	3,000' ±

During the summer of 1947 detailed stratigraphic work was done in this region by the previously mentioned graduate students of the University of Michigan. Since the work was done in the immediate area and in adjacent districts it was felt by the writer that repetition was unnecessary, and the detailed stratigraphic columns appearing herein are those measured in 1947.

Pre-Mississippian system

Flathead quartzite. There are no pre-Mississippian rocks exposed in the area. The following descriptions are of exposures in the Beaverhead Mountains 20 miles to the west, which is the nearest exposure of the formation. The Flathead quartzite was named by A. C. Peale (1893, p. 20-21) from exposures in Flathead Pass in the northeast corner of the Three Forks quadrangle, Montana. Originally the formation was considered to be of Lower Cambrian age, but has since been placed in the Middle Cambrian, and is believed to rest unconformable on the pre-Cambrian rocks.

The Flathead quartzite is reddish brown to maroon in color. It is well bedded, and in some places cross-bedded. At several horizons flat-pebble conglomerates are present.

The minimum thickness of the Flathead quartzite has been estimated to be 900 feet from exposures in Trail Creek Canyon and along the west side of Nicholia Creek Canyon (Kupsch, 1948, p. 13).

<u>Kinnikinic quartzite</u>. The Upper Ordovician Kinnikinic quartzite was named by C. P. Ross (1934, p. 947) for exposures along Kinnikinic Creek at Clayton, Custer County, Idaho. This formation has never been seen by the writer, but has been described by Kupsch (1948, p. 15) as being white to light gray in color. Iron stains locally give it a pink to light yellow color. There is no bedding evident and this along with color are excellent guides in distinguishing the Kinnikinic from the underlying Flathead quartzite. There is a conglomeratic layer at the base in some exposures. This layer, however, is not present in all localities. The thickness was estimated to be 800 feet.

<u>Threeforks formation</u>. The Threeforks formation was named by A. C. Peale (1893, p. 29) for outcrops at the junction of the three forks of the Missouri River near Threeforks, Montana. The age of this formation is Upper Devonian. The formation is not resistant to erosion, and for this reason it is very difficult to obtain complete lithologic descriptions and accurate measurements of thickness. Where the Three forks formation is exposed it usually forms gentle concealed slopes, and the definite formational boundaries are difficult to find. W. O. Kupsch (1948, p. 17) describes the formation as being made up of yellow and gray calcareous shales containing lumpy, brown inclusions.

The lower part contains a cherty shale, purplish in color. The upper beds become increasingly calcareous, and contain thinly bedded limestones with chert layers. The thickness of the formation is roughly 600 feet, but this is not considered accurate since accurate dips are difficult to obtain.

Mississippian system

Madison limestone. The Madison limestone of Lower Mississippian age was named by A. C. Peale (1893, p. 33-39) for exposures in the Madison Range, Montana. According to L. L. Sloss and R. H. Hamblin (1942, p. 313) no satisfactory section is exposed in the Madison Range, and they describe a section at Logan, Montana, which they propose as the type locality. Originally the Madison was considered a formation, but now it is considered a group, being divided into the Lodgepole and Mission Canyon formations. This division is mage largely on lithologic grounds. The outstanding difference is the thinly bedded nature of the Lodgepole and the massive character of the Mission Canyon. Both members were recognized in the Tendoy-Medicine Lodge area, but no attempt was made to map them as separate units.

The Madison limestone has an extensive area of outcrop in the locality mapped by the writer. The majority of outcroppings noted were characterized by cliffs of massive gray limestone, some of which contained chert inclusions. Fresh surfaces yield a fetid odor, and effervesce freely in cold, dilute HCl. A brecciated horizon was observed along McBride Creek in Section 34, T. 12 S., R. 11 W. The Madison also contains a dense gray limestone with calcite veins and a thinly bedded limestone at the bottom. Shale beds and arenaceous limestones are also present. In the area mapped no fossil horizons were noted; however, several cup corals in a poor state of preservation were found. These corals were considered unidentifiable by the author and his associate.

No Madison section was measured in the area since the base of the formation is not exposed. Upwards of 3,000 feet is believed to be present at the head of Nicholia Creek.

The following section measured by Scholten and Kupsch (1948, p. 21) is only a part of the total section. The minimum thickness is estimated by them as being 3,000 feet. This is in keeping with the 3,500 feet of Mississippian rocks found in Idaho by Shenon (1928, p. 7).

Madison formation measured in sections
7, 8, 9, 17, T. 17 S., R. 10 W.

12. Limestone, medium to dark gray, thin bedded, bands of dark chert, cliff-forming...............350'

11. Limestone, dark gray, weathers differentially in light gray and tan, laminated in gray colors, bedding of intermediate thickness, scattered chert-nodules, crinoid stems and large cupcorals, bryozoa, gastropods. The crinoids decrease, corals increase in quantity in higher parts of unit .... 200'

10.	Limestone, light to medium gray, massive, strongly jointed, almost entirely built up of fossils, mainly crinoids, calcite veins, chert layers	160'
9.	Limestone, medium gray, weathers tan and light gray to white, bedding of intermediate thickness, strongly jointed, calcite veins, chert layers, few fossils	30'
8.	Limestone, light gray, weathers white, massive, no chert, completely built up of crinoid stems	30'
7.	Limestone, light gray, laminations in gray colors, cliff-forming, calcite veins, chert, very fossiliferous, crinoid stems, corals, bryozoa brachiopods	50'
6.	Limestone, gray, thin-bedded, slope-forming chert nodules, calcite veins	15'
5.	Limestone, dark gray to black, fan-like laminations, breccia layers, regular chert beds, calcite veins, fossiliferous	100'
4.	Limestone, gray, weathering pink, laminations in brown and red colors, massive, chert nodules, calcite veins, corals	30'
3.	Limestone, dark gray, thin bedded, chert and calcite, fossiliferous	25'
2.	Shale, brown and sandstone, violet-pink	30'
1.	Limestone, dark gray, breccia with sandstone fragments, rusty brown, few fossils, some lenses of recrystallized crinoid stems	60'
	Total thickness	980'

Pennsylvanian system

<u>Amsden formation</u>. The Amsden was named by N. H. Darton (1904, p. 398-401) for exposures along the Amsden Branch of the Tongue River in Wyoming. The exact age of the Amsden is still a matter of debate.

It has been proved by paleontological evidence that the lower part in places is of Mississippian age, and the upper part is of Pennsylvanian age; however, a definite line between the two periods is not established. The lower part (Mississippian) of the Amsden has been called the Sacajawea by C. P. Branson (1936, p. 391-392). This division, however, is not in favor since it is not a mappable unit. Ruth Brachrach (1945, p. 67) proposes that all units below the Darwin sandstone be considered Mississippian, and the remaining higher units be considered Pennsylvanian. Since the largest portion of the Amsden is considered Pennsylvanian the formation is treated here as such, and no attempt is made to map its separate units.

The formation is represented in the area by interbedded limestone and thinly bedded calcareous shales. These are gray to buff in color and weather to lighter shades. Some of the limestones have a strong petroliferous odor on breaking. A red chert layer near the top is believed to be present because of much of the material in the float near the Quadrant quartzite contact. In all places where the upper part of the Amsden was observed the contact was covered by Quadrant talus. None of the gypsum beds that are common in the northwestern part of Wyoming were seen, but according to W. L. Adam and R. W. Benner, graduate students at the University of Michigan, who mapped the Lima Peaks area to the south, gypsum beds are present there. A gypsum mine is located in the Lima Peaks area in Section 1, T. 15 S., R. 9 W. from which commercial amounts of gypsum have been produced (personal communication).

Throughout the area the Amsden forms gentle slopes and the upper part is usually covered by Quadrant talus.

Parts of the formation are very fossiliferous containing numerous pelecepods, productids, and bryozoa. Some crinoid fragments have been found.

The thickness is over 2,000 feet.

The following section was measured in the northwest quarter, Sec. 36, T. 13 S., R. 10 W. by H. H. Krusekopf and S. R. Wallace (1947).

29.	Limestone, dark gray weathering to light gray, fine grained	2.0'
28.	Sandstone, light tan, friable	6.0'
27.	Limestone, dark gray weathering to light gray, fine grained	8.0'
26.	Covered interval	58.0'
25.	Limestone, dark gray weathering to light gray, massive, dense	10.0'
24.	Covered interval	139.0'
23.	Limestone, dark gray weathering to buff color, crystalline, well bedded: contains numerous thin bands of chert	43.0'
22.	Shale, gray: grades upward into brown shales, upper part of bed covered	389.0'

21.	Sandstone, light brown, thin bedded, calcareous, well bedded, but the thickness of individual beds varies considerably, in places weathers a reddish purple color	120.0'
20.	Sandstone, tan, weathers to rusty brown, massive, friable	24.0'
19.	Covered interval- covered by Quadrant quartzite talus	269.0'
18.	Limestone, dark gray, finely crystalline, contains numerous organic fragments	12.0'
17.	Limestone, dark gray weathering to buff, argillaceous, thin bedded with some interbedded chert	38.0'
16.	Limestone, gray brown weathering to buff, finely crystalline, fossiliferous	62.0'
15.	Shale, gray, thin bedded, calcareous, contains numerous pelecypods	80.0'
14.	Sandstone, light tan weathering to orange-buff, hard	3.0'
13.	Shales, gray calcareous, thin bedded	29.0'
12.	Limestone, dark gray weathering to buff, crystalline; contains productids	21.0'
11.	Gray shales interbedded with limestones; grades upwards into brownish and buff colored beds	106.0'
10.	Limestone, argillaceous, gray; interbedded with shales, dark gray weathering to light gray, thin bedded, calcareous; some gypsum fragments	245.0'
9.	Limestone, medium gray, medium grained, highly fractured	29.0'
8.	Shale, dark gray weathering to light gray, calcareous, thin bedded; interbedded argillaceous limestones	67.0'
7.	Limestone, light to medium gray weathering to buff, finely crystalline, highly fractured; fractures filled with secondary calcite	14.0'

6.	Shale, dark gray weathering to light gray, calcareous, thin bedded; interbedded argillaceous limestones	43.0'
5.	Limestone, gray, thin bedded, argillaceous..	67.0'
4.	Limestone, buff colored, thin bedded, silty.	10.0'
3.	Limestone, dark gray, fine grained, petroliferous	4.0'
2.	Shale, gray weathering to lighter gray, thin bedded, calcareous, contains pelecypods	86.0'
1.	Limestone, dary gray weathering to buff, dense, compact	48.0'
	Total thickness.......	2022.0'

Quadrant quartzite. The Quadrant formation of Pennsylvanian age was first named by A. C. Peale (1893, p. 32-43), and the formation included those beds lying above the Mississippian Madison and below the Ellis Group of Jurassic age. The type locality is on the southeast side of Quadrant Mountain in the northwestern part of Yellowstone National Park. The Quadrant has been redefined by D. D. Condit (1918, p. 111). H. W. Scott (1935, p. 1013), and W. H. Weed (1896, p. 5) do include rock units of different ages and lithology. The Quadrant quartzite as it is considered here consists of all rocks above the Amsden formation and below the Phosphoria formation.

The age of the Quadrant is considered to be Middle Desmoinesian. This age is based on finds of Wedekindellina and Fusulina. The Quadrant quartzite is believed to correlate with the Tensleep sandstone of northwestern Wyoming.

The formation is made up of thick, massive, quartzitic, sandstones with thinner units of more friable sandstone. The color of the sandstones is usually white to light tan to tan, but pink banded quartzites and purple sandstones have been encountered. Gray dolomites with chert inclusions are found near the top of the formation. The quadrant forms very conspicuous talus slopes in the area. They appear very dark, as a result of black lichens that grow in great abundance on the talus blocks.

The total thickness is over 3,000 feet with the formation thinning toward the north and east (Wallace, 1948, p. 14).

The following Quadrant section was measured in the E. half Sec. 35, T. 13 S., R. 10 W. by Krusekopf, Lipp, and Becker (1947).

12.	Sandstone, dark gray, massive, calcareous cement	26.3'
11.	Covered interval; dolomite and chert layers present	280.9'
10.	Limestone, more pitted than before, otherwise similar to unit 8	8.8'
9.	Dolomite	15.5'
8.	Limestone, finely crystalline, dense, slightly pitted, gray to light tan, weathers white to tan	5.0'
7.	Dolomite, dense at base, white to light gray, chert near top, sandy	54.9'

6. Sandstone, soft, white, easily weathered, forms rolling slope .... 131.0'

5. Sandstone, (first exposure), dense white to light gray, weathers to brownish tan, becomes light tan toward top .... 1724.9'

4. Sandstone, friable, massive, dark tan, weathers to yellowish tan. Many black lichens covered talus slope near top .... 913.6'

3. Sandstone, friable, massive, light tan, weathers to light gray, interbedded with 2 inch thin layers of more quartzitic and slightly dolomitic near the center. Also another member of quartzitic, slightly dolomitic sandstone near top ....109.4'

2. Sandstone, quartzitic, very dense, gray to buff, weathers to tan, thinly bedded with thin 3 inch shaly sandstone layers .... 5.0'

1. Sandstone, white to buff, friable, mottled slightly reddish, fine well sorted sand, weathers to light gray, becomes more dense near top, massive, cross bedded .... 42.8'

Total thickness ....3319.9'

Permian system

Phosphoria formation. The Permian system is represented in the area by the Phosphoria formation which was named by R. W. Richards and G. R. Mansfield (1912, p. 683-689) for exposures in Phosphoria Gulch near Mead Park, Idaho.

The formation consists of massive gray limestones and dolomites. These are interbedded with sandstones and siltstones. The outstanding characteristic of the formation is the abundance of chert layers and inclusions, some of which form outstanding benches and cliffs. These cherts seem to correspond to the Rex chert of Idaho and Wyoming. None of the characteristic öolitic phosphorite layers were seen in the area, but according to Adam and Benner, the phosphorite occurs to the south in the Lima Peaks area (personal communication).

There are several fossil beds, one of which yielded several unidentifiable brachiopods and a Bucksonia sp. which was identified for the author by Carl Moritz of the Phillips Petroleum Company. Mr. Moritz stated that this fossil is very characteristic of the Phosphoria in the area.

On the basis of this information the author and his associated identified a gray limestone as Phosphoria which had been considered Madision by Wallace and Krusekopf, and which had been interpreted as a klippe of the Tendoy Thrust.

The thickness of the Phosphoria formation is upwards of 800 feet.

The following Phosphoria section was measured by Krusekopf, Lipp, and Becker in Sec. 35, T. 13 S., R. 10 W. (1947).

20. Limestone, Tan to medium gray, weathers medium gray, very hard, fine grain, crystalline, partly covered, mottled with white calcite spots..... 10.0'

19. Dolomite and chert, gray, massive, fractured, hard, weathers gray with slight red-brown color, slight limonitic stains, also thin limestone

	slight limonitic stains, also thin limestone beds interbedded. Forms a vertical, prominent cliff in one place but is partly covered in other places	196.6'
18.	Covered interval	88.0'
17.	Sandstone, mostly covered brownish sandstone; the sandstone weathers into small angular talus. Some chert present	66.0'
16.	Limestone, massive, hard, gray, weathers light yellowish tan	15.7'
15.	Shale, light buff, mostly covered	31.6'
14.	Siltstone, red, very slightly limy, rather hard, forms small cliffs over tan limestone; massive at top and bottom and thin bedded between	45.1'
13.	Limestone, yellowish tan, friable, fine grain, thinly bedded, also more or less massive in places	10.0'
12.	Dolomite, dense, medium dark gray, weathers light gray, chert is bluish, greenish and dary gray (concretions), some lime present, hard, also some chert lenses that resemble angular conglomerates	8.4'
11.	Sandstone, calcareous cement, fine grain, hard, light gray, weathers buff to medium dark gray, faint light gray or white color bands	6.3'
10.	Solomite, contains a few chert concretions, sandy, light gray to white, weathers same, hackly weathered surface, massive but well fractured, horizontal joints, more chert lenses near the top	92.6'
9.	Covered interval	11.7'
8.	Chert, gray green	0.8'
7.	Limestone, hard, slightly sandy, dark gray-green, weathers gray, occasional thin chert layers, massive	6.0'

6.	Limestone with chert beds; limestone is gray, weathers same, chert is white to gray to medium dark, beds of chert 2 inches to 8 inches thick. Toward the top it becomes less limy and the chert layers disappear and become concretions and are a little darker....	76.3'
5.	Chert and dolomite; chert is medium dark gray, dolomite is light gray, more chert than dolomite	12.5'
4.	Covered interval	8.4'
3.	Sandstone, more calcarious near base, fine grain, hard, massive, light gray weathers same, few calcite stringers throughout......	44.5'
2.	Limestone, light gray, contains chert that is dark gray; the chert is in large concretions in the limestone. Limestone is very fine grain, hard, and massive	71.6'
1.	Dolomite, sandy, very fine grain, weathers light gray to gray-buff	5.0'
	Total thickness	802.1'

Triassic system

<u>Dinwoody formation</u>. The Dinwoody formation was named by E. Blackwelder (1918, p. 425) for exposures in the Canyon of the Dinwoody Lakes in the Wind River Range, Wyoming. Originally the formation was defined as consisting of all of the rocks above the permian Phosphoria formation and below the bright red siltstones and shales of the overlying Chugwater formation. It was found by N. O. Newell and B. Kummel (1942, p. 941-947) that the red of the Chugwater is not a true stratigraphic marker, but transcends both time and

lithologic boundaries, and as a result only the lower silty portion of Blackwelder's original Dinwoody is included by them in the formation. The Dinwoody is considered Lower Triassic in age. In the Tendoy Mountain area it is made up primarily of limestones and shales. These are reddish brown to brown in color. A limestone member is present that weathers a very dark brown to black. In places this weathering causes the surfaces of an outcrop to appear as if it had been covered with tar.

There are two fossil zones in the formation, the lower *Lingula borealis* and the upper *Claraia claria*.

The following section was measured by Lipp and Becker (1947) in the W. half, Sec. 26, T. 13 S., R. 10 W.

33.	Limestone, gray, weathers reddish brown, argillaceous, thin bedded, sandy	4.7'
32.	Covered interval	37.4'
31.	Limestone, light gray, weathers dark gray, hard, massive	4.7'
30.	Covered interval	2.0'
29.	Limestone, light gray, weathers dark gray, argillaceous	1.0'
28.	Covered interval	14.0'
27.	Limestone, light gray, weathers dark gray, hard, dense	2.0'
26.	Covered interval; includes a thin limestone bed in the middle	9.3'
25.	Limestone	1.0'

24.	Covered interval	4.7'
23.	Limestone, gray, weathers buff; argillaceous, thin bedded	6.0'
22.	Covered interval	18.7'
21.	Limestone, gray, weathers dark gray, massive	1.0'
20.	Covered interval	14.0'
19.	Limestone, gray, weathers reddish, thin bedded	6.0'
18.	Covered interval; includes 3' bed of shaley.	14.8'
17.	Limestone, weathers chocolate brown, calcareous, fossiliferous, thin bedded; contains shale partings; forms a prominent ledge	63.9'
16.	Covered interval	25.7'
15.	Limestone, gray-brown, weathers chocolate brown, interbedded with shale partings; forms a ledge	6.3'
14.	Covered interval	23.4'
13.	Limestone, gray-brown, weathers chocolate brown; interbedded with shale partings; forms a ledge	9.3'
12.	Covered interval	39.8'
11.	Limestone, weathers chocolate brown, argillaceous	2.0'
10.	Covered interval	6.0'
9.	Limestone, weathers chocolate brown, argillaceous	3.0'
8.	Shale, mostly covered	7.0'
7.	Limestone; two thin white limestone layers separated by a shale parting; shale weathers reddish brown	2.0'
6.	Shale; largely covered	7.0'
5.	Limestone, light colored, weathers reddish brown; thin bedded	44.1'

4.	Shale, reddish brown, weathers chocolate brown; thin bedded	44.1'
3.	Covered interval	10.0'
2.	Limestone, weathers reddish brown; thin bedded, calcareous; forms a ledge	5.0'
1.	Shale, dark brown, largely covered	153.7'
	Total thickness	553.0'

Woodside formation. J. M. Boutwell (1907, p. 446) named the Woodside formation for exposures in the Park City District, Utah. The Montana usage of the term Woodside includes the entire Triassic system. However, Wallace (1948, p. 21) has provisionally divided the Triassic into the underlying Dinwoody, the middle Woodside, and the overlying Thaynes formations. This division was made on the basis of lithology, but paleontological studies are necessary to confirm the propriety of the nomenclature. The Triassic rocks present in the area are found in the Little Water Syncline that was mapped in lory by Wallace and his associates. His divisions were easily recognized by the writer.

The Woodside formation consists of interbedded sandstones, limestones and shales. The units vary in color from red to brown to gray. No fossil horizons were noted.

The following is a Woodside section measured by Lipp and Becker (1947) in W. half, Sec. 26, T. 12 S., R. 10 W.

19.	Covered interval	18.7'
18.	Shale, brown, weathers dark brown; sandy, calcareous, thin bedded	2.5'
17.	Covered interval; dark brown soil	107.4'
16.	Covered interval; red soil	65.4'
15.	Sandstone, light gray, arenaceous, thin bedded	1.5'
14.	Covered interval	7.9'
13.	Sandstone, gray to buff, weathers light gray; fine grained, calcareous, thin bedded	6.0'
12.	Covered interval	7.0'
11.	Sandstone, gray, weathers light gray; fine grained, thin bedded	2.0'
10.	Covered interval	5.5'
9.	Sandstone, light gray, weathers to gray buff; well indurated, massive at base, thin bedded near top	36.0'
8.	Covered interval	4.7'
7.	Sandstone, light gray, weathers brownish red and gray; well indurated, thin bedded to massive	9.3'
6.	Sandstone, light gray; firable, thin bedded..	23.4'
5.	Covered interval	10.6'
4.	Limestone, light gray, weathers to brownish red in places, dark gray patches in places; very sandy, very thin bedded	14.0'
3.	Covered interval	11.7'
2.	Limestone, gray, weathers grayish buff; arenaceous, thin bedded at base, massive at top; forms a prominent ledge	9.3'
1.	Covered interval	11.0'
	Total thickness	353.9'

Thaynes formation. The Thaynes formation was named by Boutwell (1907, p. 448-452) for exposures in Thaynes Canyon in the Park City District, Utah. The Thaynes consists of a thick series of a gray, massive limestones and finely crystalline, calcareous sandstones. The limestones very closely resemble the Madison limestone, and it is extremely difficult to distinguish between the two on lithologic grounds. During the summer of 1947 Wallace and Krusekopf identified a belt of Thaynes on the west side of the Little Water Syncline as Madison limestone, and thus postulated the Tendoy thrust. Upon examining this proposed thrust sheet the writer and his associates found numerous columnals of the Triassic-Jurassic crinoid Pentacinus sp. establishing the limestone as Thaynes. This portion of the area was remapped showing the sedimentary nature of the contact.

The following section was measured in W. half, Sec. 26, T. 13 S., R. 10 W. by Wallace, Krusekopf, Lipp and Becker. (1947)

17.	Covered interval; silty limestone with chert.	84.4'
16.	Limestone, light gray; finely crystalline, pitted on weathered surfaces	4.5'
15.	Limestone, buff colored, silty, thin bedded; contains some sandy layers; mostly covered ..	68.8'
14.	Limestone, gray to buff; finely crystalline; largely covered	50.5'
13.	Siltstone, tan, calcareous, cherty	22.9'

12.	Limestone, dark gray, weathers to light gray; massive, fine grained; pitted on weathered surfaces	18.3'
11.	Siltstone, light gray to buff; calcareous; largely covered	18.3'
10.	Limestone, light gray; crystalline, thin bedded	18.3'
9.	Siltstone, tan; largely covered; abundant chert in float	18.3'
8.	Covered interval; gray limestone with chert in float	22.9'
7.	Limestone, buff to gray; massive, crystalline; forms a prominent ledge	27.5'
6.	Covered interval, calcareous tan siltstone and chert in float	27.5'
5.	Limestone, light gray to buff, some pinkish mottling, coarsely crystalline; massive; forms a prominent ledge capping a ridge; contains abundant Pentacrinus sp. columnals..	15.0'
4.	Covered interval	314.2'
3.	Limestone, gray brown, weathers gray, thick to thin bedded; forms a ledge	32.7'
2.	Covered interval	26.8'
1.	Limestone, gray brown, weathers to chocolate brown; thick to thin bedded; very dense	21.0'
	Total thickness ...	791.8'

Jurassic system

Sawtooth formation. The Sawtooth formation was named by W. A. Cobban (1945, p. 1274-1276) for exposures in Rierdon Gulch in the Sawtooth Range, Montana. The Sawtooth is the lowest member of the Ellis Group (Cobban, 1945, p. 1264). The upper members are the Rierdon and the Swift formations. Both of the lower members were mapped by Wallace (1948, p. 26), but the presence of the Swift was considered doubtful. L.L. Sloss stated that the Swift, as well as the overlying Morrison, was recognized in a trench dug in the Little Water Canyon (personal communication). These two formations were not seen by the author.

The sawtooth formation consists principally of fissile gray shales in the Tendoy Mountains, but gray and brown siltstones and limestones are also present. Unidentified pelecepods were found by Adam and Benner in the Lima Peaks area. The outstanding bed is a mottled, dark tan siltstone.

The following section is incomplete. It was measured by Wallace and Krusekopf in S. half, Sec. 22, T. 13 S., R. 10 W.

3.	Shale light gray to buff, slabby and thin bedded, calcareous; not top of formation.....	105.5'
2.	Siltstone, buff, weathers with a speckled appearance, white spots	64.2'
1.	Covered interval	82.6'
	Measured thickness.	252.3'

Rierdon formation. W. A. Cobban (1945, p. 1277-1280) named the formation for exposures in Rierdon Gulch in the Sawtooth Mountains, Montana. The only outcrop seen by the writer was a gray, öolitic limestone. Wallace (1948, p. 27) describes it as consisting of interbedded calcareous shales and öolitic limestones, and being 116' thick.

4. Covered interval .... 78.0'

3. Öolitic limestone, gray to buff, massive ...... 10.0'

2. Shale, light brown, calcareous .... 20.0'

1. Öolitic limestone, gray to buff, massive ...... 8.0'

Total thickness ...116.0'

The above Rierdon section was measured by Wallace and Krusekopf in W. half, Sec. 10, T. 13 S., R. 10 W. (1947).

Cretaceous system

Kootenai formation. The Lower Cretaceous Kootenai was named by C. A. Fisher (1909, p. 28-35) for exposures near Great Falls, Montana. The formation consists of a thick series of shales that range in color from red to yellow to purple. These shales are interbedded with an easily recognized salt and pepper sandstone. One of the prominent marker beds in the formation is the gastropod limestone in the lower part.

There is some controversy as to whether or not the shales below the lowest salt and pepper sandstone belong to the Kootenai or the Morrison and Swift formations. In Wallace's (1948, p. 28) measured section they are included in the Kootenai. He states that the formation is over 2,200 feet thick and that the upper beds are covered by the Tendoy Thrust. Since this thrust is believed by the author to be a sedimentary contact between Triassic and Jurassic sediments the following section measured by Wallace and Krusekopf (1947) in E. half, Sec. 9, T. 13 S., R. 10 W. seems to be too thick.

35.	Covered interval	250.0'
34.	Sandstone; salt and pepper, massive; some beds contain subangular to rounded pebbles of black and brown chert	26.0'
33.	Covered interval	26.0'
32.	Sandstone, rusty brown, very well indurated, salt and pepper	26.0'
31.	Covered interval	52.0'
30.	Sandstone, salt and pepper, massive	21.0'
29.	Shale, reddish	52.0'
28.	Sandstone, fine grained, salt and pepper	5.0'
27.	Shale, brownish red	42.0'
26.	Sandstone, salt and pepper	5.0'
25.	Shale, brownish red	29.0'
24.	Sandstone, salt and pepper, interbedded with several beds of dark brown weathering calcareous sandstones	10.0'
23.	Shale, variegated, red, brown, and purple	31.0'
22.	Sandstone, salt and pepper	5.0'
21.	Shale, red	33.0'
20.	Limestone, gray, weathers to dark brown, arenaceous	2.0'
19.	Sandstone, salt and pepper	28.0'
18.	Shale, red	21.0'
17.	Sandstone, salt and pepper	5.0'

16.	Shale, red	23.0'
15.	Shale, purple-gray; includes a two-foot bed of reddish brown arenaceous limestone	10.0'
14.	Shale, red	57.0'
13.	Sandstone, gray to reddish gray; includes some interbedded sandy limestones............	26.0'
12.	Sandstone, salt and pepper	5.0'
11.	Shale, red	10.0'
10.	Sandstone, medium grained, salt and pepper, thin bedded, weathers into slabby blocks	36.0'
9.	Shale, alternating red and brown	73.0'
8.	Covered interval; includes a dark gray gastropod limestone and some gray shales not seen in measured section	702.0'
7.	Shale, red	21.0'
6.	Sandstone, light brown to gray, medium grained, friable; toward top coarse sandstone, salt and pepper with pebbles of black chert; thin bedded	36.0'
5.	Shale, variegated red, purple, and brown	42.0'
4.	Shale, light gray, hard, sandy	52.0'
3.	Shale, red, calcareous; contains gastroliths.	109.0'
2.	Sandstone, salt and pepper with small limonite concretions; massive	10.0'
1.	Shale, dark colored; poorly exposed- possibly Morrison or Swift formations?...............	260.0'
	Measured thickness	2,201.0'

Tertiary system

Intrusive rocks. A pluton of unknown extent occurs in the Tendoy-Medicine Lodge area, and largest outcrops are in the western part. The intrusive has a decidedly gneissic appearance that is probably due to the alignment of the ferro-magnesian minerals. Until petrographic studies are made the intrusive is being considered a grano-diorite because of its megascopic appearance.

The intrusive was first noted by the writer in the Medicine Lodge Basin where the Madison limestone has been cut by the igneous body. Considerable mineralization is persent in this locality.

The Sweeney mine workings in Sec. 7, T. 13 S., R. 11 W. were inspected and small vein deposits of lead and zinc ore were observed. The ore contains galena, cerrusite and sphalerite with varying amounts of limonite. An unknown amount of ore has been shipped, and the mine is working at the time of writing.

The vein and its contact are well exposed in the adits of the Sweeney Mine. The vein is approximately 5 feet thick with a vertical extent of about 100 feet. The lateral extent of the vein is unknown. There are a number of smaller veins that parallel the major one which strikes northwest and dips 55° to the southwest. The Madison limestone was recrystallized to form a zone of considerable thickness next to the vein.

Additional mineralization was noted up McBride Creek just north of Graphite Springs. Again the intrusive was in contact with the Madison limestone. The mineral for which this prospect was opened is graphite. It is found in large flakes in a schistose rock.

The writer was told that this rock contains as much as 28 percent graphite. Since the claim is not active and the trenches are small little was learned about the deposit.

Pegmatitic material was found in several nearby gullies. On this basis the presence of pegmatites in the area is postulated even though none were seen.

The age of the intrusive has not been definitely established. Similar intrusions were described by Kupsch (1948, p. 43), and were found to be in contact with extrusives. The intrusive-extrusive relationship is one in which extrusives lie unconformably on intrusives, and the younger nature of the extrusives was shown. Since the extrusives have been assigned to the Oligocene the upper age limit of the intrusive is established. This dating indicates that the intrusive more nearly corresponds to the pluton on the Idaho side of the Continental Divide described by Umpleby (1913, p. 42) rather than to any other previously described intrusion. Umpleby dates this intrusion as Late Cretaceous or early Tertiary.

No significant relationships with the intrusion were located by the writer. At the suggestion of Kupsch the writer tentatively is considering the age as being early Tertiary.

Red Rock conglomerate. The name, Red Rock conglomerate, has been used tentatively by Professor A. J. Eardley and students in Beaverhead County for a thick, coarse, generally red conglomerate of early Tertiary age. The formation forms large spurs along the east front of the Tendoy Mountains in the writer's area. It consists of very thick, massive conglomerates with red, calcareous cement. The conglomerate is made up of a wide variety of pebbles and cobbles of Paleozoic and Mesozoic rocks. Some pre-Cambrian, quartzite cobbles are also found. These range in size from small rounded pebbles to large angular boulders, several feet in diameter. Some bedded red and tan sandstones that appear as separate units are over 10 feet thick. The presence of large angular boulders indicates that the source area was very near the observed outcrops.

The formation has yielded no fossils to date, and as a result, the age is not well established. It lies unconformably below the upper Eocene Sage Creek formation and pre-dates the main thrusting in the Beaverhead Range. It post-dates the earliest Laramide movements however. It also post-dates the Mesaverde (?) formation, and is thus considered Paleocene in age.

The thickness is estimated by Dr. Eardley to be over 2,000 feet near the Lima anticline (Personal communication).

Volcanic rocks. There are numerous outcrops of basaltic flows and breccias interbedded with thin layers of rhyolite in the area. The largest concentration of these is found in Muddy Creek Basis where they form cliffs as high as 300 feet. In one place a volcanic tongue extends over the crest of the Tendoy Mountains to the north of Timber Butte.

The extrusives consist mainly of a dense basalt with associated rhyolite. The basalt is not uniform in color, and specimens were noted that were variegated and similar to porcelainite. Some vesicular basalts occur. The presence of basaltic breccia suggests that explosive eruptions occurred occasionally. Wallace (1948, p. 32) describes spatter cones in Little Water Syncline. He states that these have sufficiently retained their shape to form closed drainage basins and small lakes.

Basin beds. The Tertiary rocks designated as Basin beds have formerly been referred to as the Bozeman Lake beds by Peale (1893, p. 32-43). W. P. Haynes (1916, p. 27-29) states that the basin beds are in part sub-aerial, fluviatile deposits rather than lacustrine, and should not be termed lake beds.

The Basin beds have a great aerial extent and are present in appreciable thicknesses in the Muddy Creek Basin, the Medicine Lodge Basin, and all intervening basins. They consist of a series of interbedded volcanic tuffs, basalts, sandstones, massive fresh water limestone, shales and conglomerates. In places there is a large amount of organic matter present, and in one locality sub-bituminous coal is present. The white rhyolite tuffs contain numerous plant and wood fragments. Brown bentonitic clays are also present. The basalts were found to be a mappable unit and have been treated previously. Sandstones vary widely in color and in texture. Some are very friable and thin bedded whereas others are sufficiently indurated to form cliffs. The limestones present are mainly dense, massive, and light in color. In places large cliffs are formed.

To date the basin beds have not yielded any diagnostic fossils. There have been a number of gastropods collected, but none of them are restricted enough to date the beds. The writer and associates found some fairly well preserved plant fossils in the Peterson Coal Mine located in Section 33, R. 12 W., T. 12 S. At the time of writing these plants have not been identified, and their value is not known.

The age of the basin beds is still a matter of controversy. The graduate students of the U. of M. who worked in the area in 1947 have tentatively dated them as Miocene. This assignment was made in part on the similarity of lithology between the Basin beds of this area and the Miocene beds mapped in the Ruby Reservoir to the north. According to Professor Eardley at the time of this writing the basin beds are more likely the equivalent of Douglas's (1903) Sage Creek beds which have been dated upper Eocene on vertebrate fossil evidence. These beds have 3 lithologic similarities. In both places bentonites and tuffs with wood fragments are present, and associated basalts and rhyolites are found in both places. The nearness of the Sage Creek beds to the Basin beds in the Tendoy-Medicine Lodge area is another factor in this tentative correlation (Eardley, personal communication). It is probable that these sediments were deposited in interconnecting basins prior to block faulting.

Great thicknesses of basin beds are found in the area. Scholten (1948, p. 32) estimates that 5000 feet are present in Nicholia Creek Basin.

High terrace gravels. The spurs that flanked the basins showed evidences of a high erosion surface at approximately 7,500 feet. This surface was covered with a veneer of gravel which consists of fairly well rounded pebbles and boulders of various sizes. Examination of the gravels failed to show evidences of ice transportation. They consist of all types of rocks ranging from pre-Cambrian through the Mesozoic. The dominant type of rock seems to be Beltian (A. J. Eardley, personal communication).

The age is not definitely established but may be as young as pleistocene.

Quaternary system

Three Quaternary units were mapped, landslide, terrace gravels, and alluvium. Of the three, landslide seems to be the least important. It is included here to show the landslide mapped by Wallace and Krusekopf. Alluvium is generally restricted to the very immediate stream valleys. However there is, in places, a sufficient expanse of alluvium to permit the cultivation of hay. The thickness of the alluvium is unknown. Terrace gravels were mapped in Muddy Creek Basin and the Red Rock Basin. Along Highway 91 terrace gravels attain thickness of 40 feet. Road cuts and gravel pits show excellent stratification and sorting.

STRUCTURE

Regional features

The mountain ranges of southwestern Montana have a very diverse arrangement. See index map, figure 3. The Beaverhead and Lemhi Ranges trend northwest-southeast, the Gravelly, Ruby and Snowcrest Ranges trend northeast-southwest, the Tendoy Range trends north-south, and the Centennial Range has an east-west trend. This suggests a rather complex orogenic history.

Kupsch (1948, p. 56) states that three major periods of deformation have been reported. They are as follows:

1. Folding of pre-Cambrian rocks at the close of the Algonkian period. This was accompanied by low grade metamorphism.
2. Folding, thrusting, and faulting of rocks during the Laramide orogeny.
3. Gentle folding and high angle faulting in Tertiary time.

The first of these periods of deformation was not found in the writer's area. The second two were well represented.

The Laramide structures are usually considered to have a northwest trend with overturning to the east. The major thrusts in this area are parallel to this northwest fold axis, and are overthrust to the east. A period of crustal deformation is shown by the presence of the Beaverhead thrust. This structure also has a northwest trend, and is believed to be lower Eocene in age. Another period of Laramide activity is indicated by the presence of folds normal to the major northwest trending folds. These cross folds are believed to be the oldest of the Laramide structures.

Laramide structures.

Folds. In the western part of the area there are a series of broad, gentle folds that trend northwest-southeast. This folding is well represented in Graphite Mountain. The Madison in Wilson Creek dips about 15° to the southwest. A complete reversal of dip was observed on the south side of Graphite Mountain, and the Madison again crops out at the surface. A similar synclinal relationship was noted in Ellis Peak and in several of the other high peaks in the area. This broad folding is found throughout the part of the area west of the West Muddy Creek Fault.

In the eastern part of the area tighter folding is represented by the Little Water syncline named by Wallace (1948, p. 39) from the Little Water Canyon which is eroded in the northeast end of the structure.

It differs from the maj or Laramide structures in that it trends northeast and is asymmetrical to the southeast. The northern flank swings first northerly, then westerly, then southerly to form a basin-like structure. Both flanks are broken to the south by the later East Muddy Creek fault, and it is not known whether or not the syncline forms a closed basin.

The nose of the syncline is broken by two small faults which bring the Dinwoody formation in contact with the Thaynes formation. In both instances the northwest block is upthrown. These faults die out along bedding planes.

The western flank of the northwestward trending syncline was mapped as Madison in a former report (Wallace, 1948) and considered part of the Beaverhead thrust. The synclinal structure is indicated by the presence of Thaynes. This identification was based on finds of the Triassic-Jurassic crinoid, Pentacrinus sp. The front of the thrust must now be considered buried below the Muddy Creek Basin beds.

A small anticlinal flexure was mapped within the closed northwest part of the syncline. Its axis trends east-west, and plunges eastward.

Thrusts. One major thrust fault was mapped in the area. This thrust is the continuation of the Beaverhead thrust of Kupsch and Scholten (1948). The Beaverhead thrust front is found in the northeastern part of the area. See geologic map, plate . The Madison limestone has over-ridden the Quadrant quartzite of Timber Butte, and overlies the Red Rock conglomerate to the north. The east Muddy Creek fault truncates the thrust sheet at Timber Butte, and no evidence of the thrust is found in the southern limit of the area.

The age of the thrusting is lower Eocene (?). Since the Madison overrides the Red Rock conglomerate of Paleocene (?) age, and is covered by basin beds of upper Eocene (?) age, it is assumed that the thrusting occurred in lower Eocene time.

Another small reverse fault is postulated in the Little Water Canyon. Here the western block is apparently upthrown. The structure is proposed to explain the horizontal displacement of the Mesozoic sediments.

A second thrust was suggested by Wallace in Sec. 15, T. 13 S., R. 11 W. where the Thaynes is supposed to overly the Kootenai. A sedimentary contact was found here with a thin Jurassic section lying between the Kootenai and the Thaynes.

Mid-Tertiary structures

High angle faults. Wallace (1948, p. 40) states that four major high angle faults are present in the area. Extensions of three of these faults and a fourth fault were mapped by the writer. They have been designated as the Red Rock fault, named by Wallace for the Red Rock Basin, the East Muddy Creek fault and the West Muddy Creek fault which derive their names from the graben-like Muddy Creek basin that they form. The fourth fault which lies to the north between East and West Muddy Creek faults has not been assigned a definite name.

The faults trend roughly north-south parallel to the major Laramide structures. The surface has been broken into a series of horsts and grabens by the mid-Tertiary movement along these faults. Subsequent movement and differential erosion along these faults have produced the major topographic expressions in the area.

The Red Rock fault bounds the steep eastern front of the Tendoy Mountains which are on the upthrown side. The fault cuts the cross structure expressed in the Little Water syncline. Mississippian, Pennsylvanian, Permian, Triassic, and Paleocene sediments have been disturbed.

The downfaulted basin has been filled with an unknown thickness of Quaternary alluvium which makes the displacement difficult to figure. Wallace (1948, p. 41) estimates the throw to be at least 1,000 feet. There has been recent movement along the fault. This is clearly shown by the triangular facets which have been formed where the fault has cut the alluvium.

The Tendoy Range is bounded on the west by the East Muddy Creek fault which also has its upthrown block to the east. This indicates that the Tendoys are a large horst block. The displacement, although of considerable magnitude, is not believed to be as great as the displacement along the Red Rock fault. The beds are dipping to the southwest indicating that the horst block is tilted.

Muddy Creek basin is shown to be a graden bounded by the East and West Muddy Creek faults. Displacement along West Muddy Creek fault is less than that along the East Muddy Creek fault. The basin beds are dipping basinward on the West, and in the opposite direction on the east. See cross section, plate 2.

The fourth fault appears along the northern reaches of Sourdough Creek. The upthrown block is to the east. The exact relationship of this fault is not known, and further work is necessary. It is noted that this fault has about the same trend and position as Wallace's intermediate basin fault, but since the fault to the south has the upthrown block to the southwest the two cannot be tied together.

Age relationships.

Thrusts. The Beaverhead thrust pre-dates the high-angle faults which cut and displace the thrust sheet. The upper eocene (?) beds were observed to lie on the thrust sheet, and its older age is thus established. The Paleocene (?) Red Rock conglomerate was found to underlie the thrust showing that it post-dates the formation. These factors indicate that the thrust is the result of late Paleocene or early Eocene orogeny.

Intrusive rocks. The intrusive rocks present in the area are very difficult to date in that no clear relationship with other structures and formations were noted. The age of the intrusion is tentatively placed by Kupsch (1948) as being late Cretaceous or early Tertiary. This tentative age assignment was made from observations made in the Beaverhead mountains to the west.

Red Rock conglomerate. The Red Rock conglomerate has yielded no fossils and a definite age has not been established. The Red Rock is overlain unconformably by Sage Creek beds of upper Eocene age near Dell on Highway 91 (Wallace, p. 43) indicating its younger age. It also predates the Beaverhead thrust which is considered early Eocene (?). Since the Red Rock is believed to be the result of the erosion of highlands produced by early Laramide folding it is considered older than Cretaceous. It is thus dated Paleocene (?).

Basin beds. The thick sedimentary deposits designated as Basin beds are believed, at the time of writing, to be the equivalent of the upper Eocene Sage Creek beds (A. J. Eardly, personal communication). The Basin beds are broken by the high angle normal faults that are believed to be mid-Tertiary. They also lap up on the lower Eocene (?) Beaverhead thrust showing a younger age. The assignment of the Basin beds to the upper Eocene is tentative, and further paleontological study is needed for exact dating.

PHYSIOGRAPHY

The area mapped by the writer lies in the Northern Rocky Mountain Physiographic Province. In the southwestern part of this province the mountain ranges have a diverse trend. The orientation of the ranges has been mentioned previously.

In the immediate area the summit level is approximately 9,000 feet above sea level, but a few peaks rise above this level. The elevation of the basins ranges from 6,300 feet to 7,000 feet above sea level.

In general, the topographic expression is due to a horst and graben pattern in the east, and to folding in the west. The area is in a late youthful to early mature stage of erosion.

Three erosional surfaces seem to be represented in the area. They appear at levels of 7,500 to 9,000 feet, 6,500 to 7,500 feet, and the present surface at approximately 6,500 feet above sea level. These levels are believed to correspond to the erosional surfaces in Wyoming described by Blackwelder. There is not enough known concerning the age of these surfaces to make a definite correlation, but until further work is done Blackwelder's names are tentatively being assigned to them. They are designated as the present surface represented by terraces, the Circle surface at approximately 6,500 to 7,500 feet above sea level which appears as a pediment surface, and The Black Rock surface at 7,500 to 9,000 feet above sea level. There is a possibility that the generally accordant peak elevations in the Beaverhead Range represent a fourth erosional surface that may be equivalent to Blackwelder's Union Pass surface. This is doubtful however.

The cycle of erosion forming these surfaces was, at the time of writing, suggested to be as follows: (Eardley, personal communication)

1. Deposition of the Basin beds.
2. High angle faulting.
3. Erosion of the Black Rock surface.

4. Uplift and erosion of the Circle surface.

The other alternatives are:

1. Erosion of the Black Rock surface.
2. Deposition of the Basin beds.
3. High angle faulting.
4. Uplift and erosion of the Circle surface.

or:

1. Deposition of Basin beds.
2. Erosion of the Black Rock surface.
3. High angle faulting.
4. Uplift and erosion of the Circle surface.

SUMMARY OF EVENTS

Recent	Dissection to formmodern gravel terraces and river bottoms.
Late Pleistocene	Uplift and dissection of pediment. Glaciation and deposition of outwash in two stages.
Early Pleistocene	Uplift and erosion of intermediate pediment surface.
Pliocene	Erosion followed by uplift resulting high erosion surface. Deposition of high level gravels.
Miocene	Block faulting.
Oligocene	Continued Basin bed deposition and further volcanic activity.
Middle and upper Eocene	Erosion of great intermountain basins and subsequent deposition of Basin beds. Accompanied by volcanic activity.
Late Paleocene & early Eocene	Laramide thrusting from west to east. The Beaverhead thrust was formed on the west and the Tendoy thrust on the east.
Paleocene	Erosion of highlands and deposition of Red Rock conglomerate.
Late Cretaceous	Major Laramide deformation producing a western highland and northeastward trending folds.

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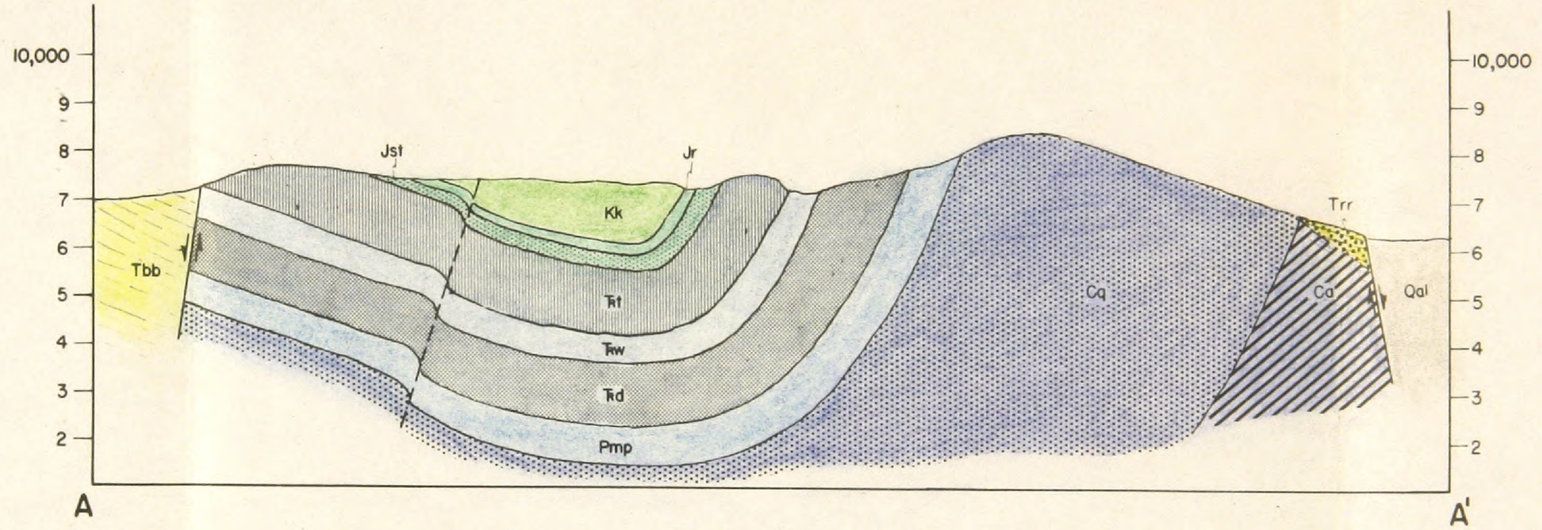
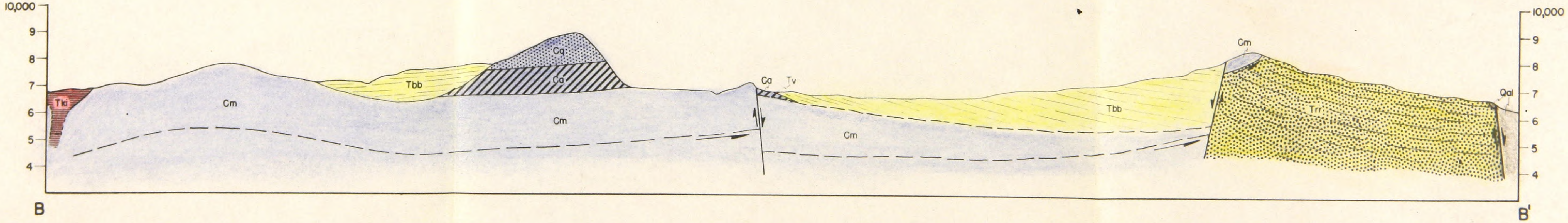
PLATE I
GEOLOGY OF PART OF THE
TENDOY-MEDICINE LODGE AREA
BEAVERHEAD COUNTY, MONTANA
BY D. L. CUMMINS & W. T. SMITH
EXPLANATION
SEDIMENTARY ROCKS
QUATERNARY
Qal Alluvium
Qls Landslide
Qt Terrace gravels
PLEISTOCENE
Tg High terrace gravels
UPPER EOCENE
Tbb Basin beds
PALEOCENE
Tr Red Rock conglomerate
CRETACEOUS
Kk Kootenai formation
JURASSIC
Jr Rierdon formation
Jst Sawtooth formation
TRIASSIC
Trt Thaynes formation
Trw Woodside formation
Trd Dinwoody formation
PERMIAN
Pmp Phosphoria formation
CARBONIFEROUS
Cq Quadrant quartzite
Amsden formation
Cm Madison limestone
IGNEOUS ROCKS
UPPER EOCENE (?)
Tv Basalt flows and breccia
LARAMIDE
Tki Intrusive granite gneiss
SCALE IN MILES
0
1
2
R 11 W
R 10 W
T 12 S
T 13 S
20
Ellis Peak
Graphite Mountain
Grassy Top
Muddy Hole Basin
Timber Butte
Dixon Mountain
Beaverhead Fault
Thrust
East Muddy Creek Fault
Red Rock Fault
West Creek Fault
Wilson Creek
Sourdough Creek
Muddy Creek
McBride Creek
Kate Creek
Erickson Creek
Graver Creek
Johnson Creek
Trail Creek
Big Sheep Creek
Low Creek
Lodge Creek
A
A'
B
B'
Map compiled by radial line assembly of AAA aerial photographs, Series CXM, August, 1942, photograph numbers as shown on map. Control, U.S. Forest Service Map of Beaverhead National Forest, 1934.

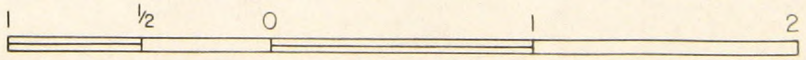
STRUCTURAL CROSS SECTIONS

Profile and elevations approximated



Legend: Cm, Madison ls.; Ca, Amsden fm.; Cq, Quadrant qtzite.; Pmp, Phosphoria fm.; Trd, Dinwoody fm.; Trw, Woodside fm.; Trt, Thaynes fm.; Jst, Sawtooth fm.; Jr, Rierdon fm.; Kk, Kootenai fm.; Tki, Intrusive rock; Trr, Red Rock congl.; Tbb, Basin beds; Tv, Volcanic rocks; Qal; Alluvium.





SCALE IN MILES

D. L. CUMMINS & W. T. SMITH

COLUMBIAN [illegible] CLASP NO. 75N
PAT. 1,290,083
THE UNITED STATES ENVELOPE [illegible]
7½ x 10[illegible]