GEOLOGY OF THE LIMA PEAKS AREA
OF THE TENDOY MOUNTAINS,
BEAVERHEAD COUNTY, MONTANA
AND CLARK COUNTY, IDAHO

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ABSTRACT

The area mapped and described in this report is a part of the Tendoy Mountains in Beaverhead County, Montana and Clark County, Idaho. The Lima Peaks are south of the town of Lima, Montana.

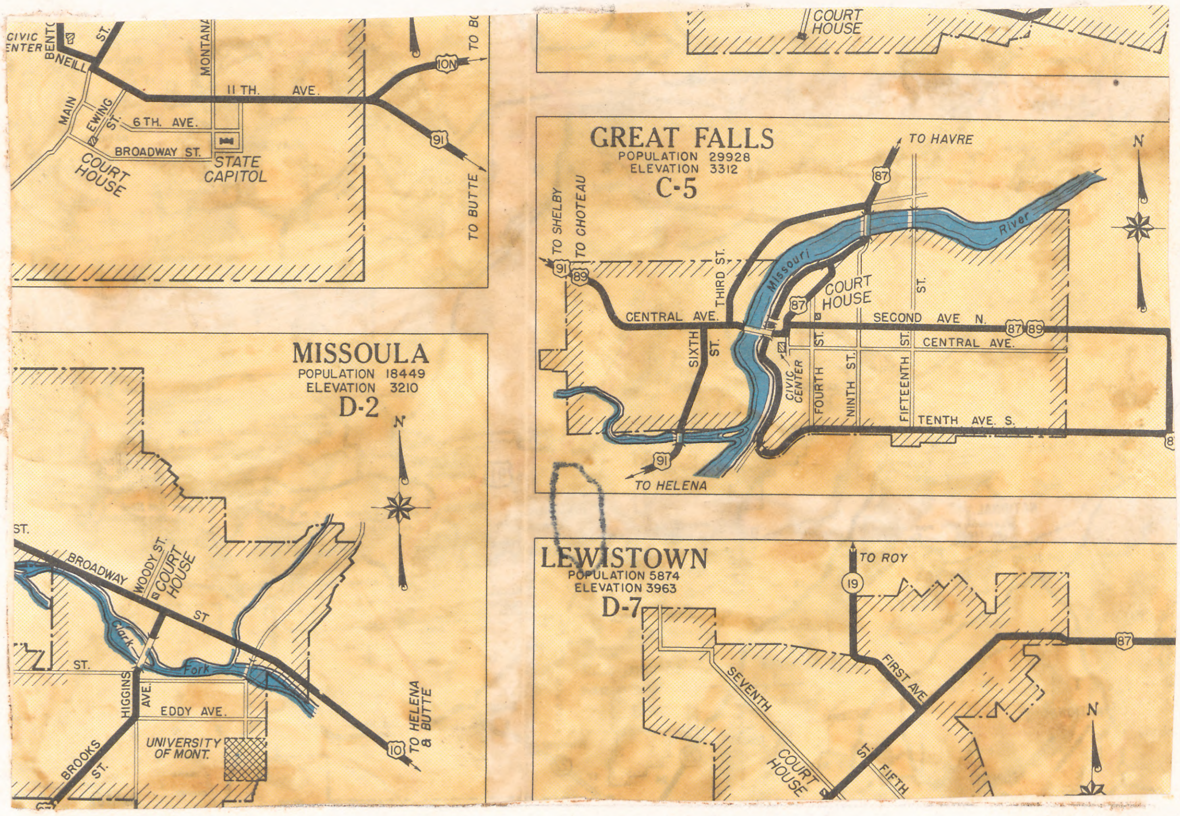
The following formations crop out in the area; Madison limestone (Mississippian), Amsden formation (Mississippian - Pennsylvanian), Quadrant (Pennsylvanian), Phosphoria (Permian), Dinwoody (Triassic), Woodside (Triassic), Thaynes (Triassic), Sawtooth (Jurassic), Rierdon (Jurassic), Kootenai (Cretaceous), Red Rock Conglomerate (Tertiary), and the Basin Beds (Tertiary).

There are two major thrusts and two major faults in the area. The thrusts are parallel and trend northwest-southeast. The high angle faults form large basins, one of which is to the north and the other to the south of the area. The thrusting and the high-angle faulting is of mid-Tertiary age.

INTRODUCTION

Location of the area

The Lima Peaks are a part of the Tendoy Mountains which are a part of the Bitterroot Range. The area lies partly in Beaverhead County, Montana and partly in Clark County, Idaho and includes the continental divide which separates the two states. A total of about 85 square miles has been mapped. Most of the area is bounded by the Red Rock Basin on the north, a wide, alluviated valley in which is located the town of Lima, Montana. On the south it is bounded by Warm Creek and Irving Creek. The western boundary is Little Sheep Creek and the extension of its west fork southward to Warm Creek. The eastern part is bounded by Alder Creek and its southern extension to Irving Creek. These boundaries, as well as township and range locations, can best be seen by referring to the map (PLATE 1) in the pocket and the index map (FIGURE 1) gives the general geographical location.


11 TH. AVE.
6TH. AVE.
BROADWAY ST.
COURT HOUSE
STATE CAPITOL
TO BUTTE
MISSOULA
POPULATION 18449
ELEVATION 3210
D-2
BROADWAY
WOODY ST.
COURT HOUSE
Clark Fork
HIGGINS AVE.
EDDY AVE.
UNIVERSITY OF MONT.
BROOKS ST.
TO HELENA & BUTTE
GREAT FALLS
POPULATION 29928
ELEVATION 3312
C-5
TO HAVRE
TO SHELBY
TO CHOTEAU
Missouri River
COURT HOUSE
CENTRAL AVE.
SECOND AVE N.
CENTRAL AVE.
SIXTH ST.
THIRD ST.
CIVIC CENTER
FOURTH ST.
NINTH ST.
FIFTEENTH ST.
TENTH AVE. S.
TO HELENA
LEWISTOWN
POPULATION 5874
ELEVATION 3963
D-7
TO ROY
FIRST AVE
SEVENTH
COURT HOUSE
FIFTH

Index Map

Accessibility

The area north of the divide in Montana is best reached by using Little Sheep Creek Road and its three branches, West Fork, Middle Fork, and East Fork Roads. Little Sheep Creek Road makes a junction with U.S. Highway 91 at Lima, Montana. At the end of Middle Fork Road is located U.S. Forest Service Trail No. 40 which leads into Sawmill Creek and the eastern side of the area.

The area south of the divide in Idaho is best reached by using the Medicine Lodge Road of Idaho, which makes a junction with U.S. Highway 91 two miles north of Dubois, Idaho. From the Medicine Lodge Road, the Warm Creek Road gives access to the western part of the Idaho area and the Irving Creek Road gives access to the eastern part. The high peaks and the continental divide must be travelled by foot as no roads are located there.

Figure 2

THE LIMA PEAKS

Covered by Quadrant talus

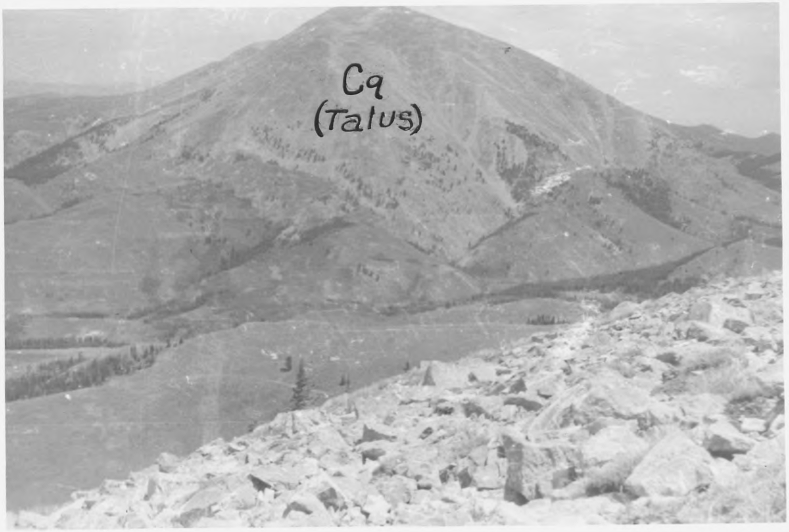
Description of the area

The area is composed primarily of high mountains in the central part flanked by a basin to the north and one to the south. These basins are formed by high angle faults which are part of a system of block faults of regional extent. The basin to the north of the area in Montana is the Red Rock Basin or Lima Basin. The basin in the southern part of the area in Idaho is the Medicine Lodge Basin. These basins range in elevations from 6200 to 6500 feet above sea level.

The central part of the area is composed of mountains. The northern part of the high area contains peaks of Quadrant quartzite and sandstone talus. The highest peak in this locality is Mount Garfield, 10,961 feet high.

South of the Quadrant formation but north of the continental divide in the eastern part of the area are the Red Conglomerate Peaks. These peaks are not as high as the peaks farther north but they are much more rugged. The Red Conglomerate Peaks, as the name indicates, are composed of the formation called the Red Rock conglomerate.

Figure 3



MOUNT GARFIELD

Elevation 10961 ft.

The climate of the area is semi-arid. The average annual temperature is 38 degrees. Winters are cold (average 18 degrees) with cool summers (average 60 degrees). The annual precipitation is 8.7 inches with most of this rain falling in the late spring and early summer.

The vegetation consists of sagebrush, conifers, and aspen trees for the most part. The sagebrush grows on the plains, the conifers mostly on the sandy soil of the Quadrant formation, and the aspen prefer the alluvium of the creek bottoms in the mountains.

Previous work

Clark County, Idaho has been covered by a geologic reconnaissance by V.R.D. Kirkham. His work has been published by the Idaho Bureau of Mines (Kirkham, 1927). H.T. Stearns also worked in this area between 1921 and 1939 on a water resource study. The results of his work was published in a U.S. Geologic Survey Water Supply Paper (Stearns, etc., 1939, p. 1-125).

Beaverhead County, Montana was covered in 1946 by a geologic reconnaissance map by two professors from the Montana School of Mines, Eugene S. Perry and Uuno M. Sahinen. Some of this region has been mapped by other graduate students from the University of Michigan in the summer of 1947.

Purpose of study

It is the purpose of this study to compile a detailed geological map, interpret the structure and physiography, and give a description of the stratigraphy. This work will also add to that done by other students in the locality and will help form a more complete picture of the geology of southwest Montana. It is hoped that the geology of southwest Montana can be correlated with the geology of adjacent areas of the Rocky Mountains.

Acknowledgements

Both field and office work for this report was done under the guidance and supervision of Dr. A.J. Eardley, Professor of Geology at the University of Michigan. The author is indebted to William L. Adam, graduate student at the University of Michigan with whom the author collaborated in doing the field work and compiling the map. Further acknowledgement is due Robert Scholten, graduate student at the University of Michigan, for his valuable suggestions.

STRATIGRAPHY

Stratigraphic column

The stratigraphic column was measured by students of the University of Michigan in adjacent areas in the summer of 1947. Since the formations are better exposed in their areas than in the area of this report, the author has used their measured sections. The stratigraphic chart (Table 1.) gives the approximate thicknesses of the formations.

Pre-Mississippian rocks

Flathead quartzite. Since no pre-Mississippian rocks occurred in the author's area, the following descriptions were taken from the writing of Robert Scholten (1948) and Walter Kupsch (1948) in an adjacent area.

The Flathead quartzite was first named by A.C. Peale (1893, p.20-21), from the type locality near Flathead Pass in the Three Forks quadrangle, Montana. Peale originally thought the formation was Lower Cambrian in age, but it is now believed to be of Middle Cambrian age.

Table 1

STRATIGRAPHIC COLUMN

Lima Peaks, Montana

Age	GROUP and FORMATION	FEET
Quaternary	alluvium	2000+
Pleistocene (?)	gravels	100
Oligocene	basalts	300
Upper Eocene (?)	rhyolites	100
Upper Eocene (?)	limestone (fresh water)	400
Palocene	Red Rock conglomerate	2000+
Lower Cretaceous	Kootenai	1300
Jurassic	Rierdon	100
Jurassic	Sawtooth	200
Triassic	Thaynes	410
Triassic	Woodside	558
Triassic	Dinwoody	763
Permian	Phosphoria	650
Pennsylvanian	Quadrant	3000±
Miss - Penn	Amsden	1500
Mississippian	Madison	2000+

The quartzite is reddish to maroon and is composed of silicious grains of uniform size cemented by a silicious matrix. It is fine-grained and in places cross bedded. Conglomerate beds are also found with flat or stretched pebbles. The formation is a cliff former.

<u>Kinnikinic quartzite</u>. The Kinnikinic quartzite was named by C.P. Ross (1934, p.947) who described it from a locality near Kinnikinic Creek in the Bayhorse quadrangle near Clayton, Idaho. It is a pure white to light gray quartzite but in places has a lavender cast. It has shaley partings and is conglomerate at the base. It is of Upper Ordovician age.

<u>Three Forks formation</u>. A.C. Peale (1893, p.29) named the Three Forks formation from exposures near Three Forks, Montana. It is of upper-Devonian age and contains soft calcareous and argillaceous fissile shales of gray color with brown inclusions. The lower part of the formation contains a purple cherty shale with calcite veins. The formation is a slope former and is mostly covered.

Mississippian system

Madison limestone. Madison limestone was described by A.C. Peale (1893, p.33-39) from a type locality in the Madison Range near the center of the Three Forks quadrangle of Montana. L.L. Sloss and R.H. Hamblin (1942, p. 313) found no satisfactory type section there and described a section near Logan, Montana which they propose as the type section for the Madison formation. The formation is of lower Mississippian age.

The Madison limestone has been divided into the Lodgepole and Mission Canyon members. This separation is largely a lithologic division with the Lodgepole being the lower thinly bedded portion and the Mission Canyon the upper massive limestone with black chert nodules which weather brown.

The Madison limestone is a thick series of bluich gray limestones and a small amount of shale. Well silicified fossils have been found. They are mostly cup corals and crinoid remains. The limestone has a fetid or petroliferous odor in parts. Calcite veins were also present in the limestone.

The following Madison section was measured by Robert Scholten (1948, p.20) at the head of Nicholia Creek in sections 7, 8, 9, and 17, of T 17 S, R 10 W, in an adjacent area.

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

11. Limestone, dark gray, medium-bedded, weathering differentially in light gray and tan colors. Scattered chert nodules. Crinoids and big curved solitary corals, the former decreasing the latter increasing in quantity in the upper part, until finally the bed is almost entirely built up of crinoid stems, bryozoa and gastropods.--------------------------------200'

10. Limestone, light to medium gray, massive, strongly jointed, non-laminated with calcite veins and irregular chert layers. Almost entirely built up of crinoids.-------------------- 60'

9. Limestone, medium gray, medium-bedded, crystalline, strongly jointed, non-laminated, with calcite veins and irregular chert lenses, weathering in tan and light gray colors, few fossils.------------------------------ 30'

8. Limestone, light gray, massive, non-laminated, without chert. Weathering white; characteristic manganese-dendrites. Built up of crinoid stems.------------------------------------ 30'

7. Limestone, light gray, massive, laminated in gray colors; manganese-dendrites. Cliff forming. Very fossiliferous; crinoids, corals, pelecypods, bryozoa, brachipods.--------- 50'

6. Limestone, gray, thin-bedded, with chert nodules and calcite veins. Forming slopes. --------- 15'

5. Limestone, dark gray to black, with typical regular chert layers and layers of limestone breccia. Calcite veins and characteristic fan-like lamination. Some fossils, pelecypods. ---------100'

4. Limestone, dark gray to black, laminated in various colors; containing chert nodules. Weathering pink and brown. Few fossils. ------------------ 30'

3. Limestone, dark gray to black, thin-bedded with calcite veins and chert nodules. Some pelecypods, small corals and gastropods. ------------------ 25'

2. Shale and sandstone of brown and violet to pink color.------------------------------ 30'

1. Limestone, dark gray to black with calcite veins and chert layers and lenses; some layers are brecciated. Few fossils except for reefs of gray to brown limestone, built up of crinoid stems and some small corals.------- 60'

Total thickness of measured section-- 980'

The Madison limestone in the area of this report is badly folded and faulted and a good section for stratigraphic study could not be found.

Pennsylvanian system

Amsden formation. The Amsden formation was named by N.H. Darton (1904, p. 398-401) from a type section along the Amsden Branch of the Tongue River west of Dayton, Wyoming. The formation is of Mississippian and Pennsylvanian age according to M.G. Wilmarth (1938, p. 2396) and Ruth Backrach (1946, p.64). C.C. Branson proposed the name Sacajawea for the Mississippian Amsden beds and restricted the use of the term Amsden to the Pennsylvanian strata according to R.C. Moore et al. (1944, p. 701). Ruth Backrach (1946, p. 64), however, states that the Sacajawea is not a mappable unit.

The formation contains limestones interbedded with shales. Calcareous sandstones and gypsum are found in the upper part. A gypsum mine is located at the end of the road up the East Fork of Little Sheep Creek. Here gypsum has been mined from two large adits.

According to R.W. Becker (1948, p. 12) pelecypods, productids, and crinoid columnals have been found in the formation. Becker's measured section appears below.

The Amsden formation was measured by H.H. Krusekopf and S.R. Wallace (1947) in Montana's NW 1/4, Section 36, T 13 S, R 10 W, about 100 feet north of the Sheep Creek Ranger Station.

29.	Limestone, dark gray weathering to light gray, fine grained	2'
28.	Sandstone, light tan, friable	6'
27.	Limestone, dark gray weathering to light gray, fine grained	8'
26.	Covered interval	58'
25.	Limestone, dark gray weathering to light gray, massive, dense	10'
24.	Covered interval	139'
23.	Limestone, gray weathering to a buff color, crystalline, well-bedded, and containing numerous bands of dark chert	43'
22.	Shales, gray, grading upwards into brown. Upper part of bed is covered	389'
21.	Sandstone, light brown, thin bedded, calcareous. Bedding planes well developed	120'
20.	Sandstone, tan weathering to rusty brown, massive, friable	24'
19.	Covered interval	269'
18.	Limestone, gray, finely crystalline, contains numerous organic fragments	12'
17.	Limestone, dark gray weathering to buff, argillaceous, thin bedded, some interbedded chert	38'

16. Limestone, gray-brown weathering to buff, finely crystalline, fossiliferous -------- 62'

15. Shale, gray, thin bedded, calcareous, contains numerous pelecypods ------------- 80'

14. Sandstone, light tan weathering to orange-buff, hard quartzitic -------------------- 3'

13. Shales, gray calcareous, thin bedded ----- 29'

12. Limestone, dark gray weathering to buff, crystalline and containing productids ---- 21'

11. Gray shales and limestones alternating and grading upward into brownish and buff colored beds ----------------------------- 106'

10. Argillaceous limestones and dark gray shales weathering light gray, thin bedded, calcareous, contains fragments of gypsum. ----------------- 245'

9. Limestone, medium gray, medium grained, highly fractured ------------------------- 29'

8. Shale, dark gray weathering to light gray, calcareous, thin bedded with some interbedded argillaceous limestones ----------------- 67'

7. Limestone, light to medium gray weathering to buff, finely crystalline, highly fractured, fractured with secondary calcite ----------------- 14'

6. Shale, dark gray weathering to light gray, calcareous, thin bedded, with some interbedded argillaceous limestones ----------------- 43'

5. Limestone, gray, thin bedded, argillaceous ----------------- 67'

4. Limestone, buff colored, thin bedded, silty ----------------- 10'

3. Limestone, dark gray, fine grained, petroliferous odor ---------------------- 4'

2. Shale, gray weathering to lighter gray, thin bedded, calcareous, contains pelecypods ----------------- 86'

1. Limestone, dark gray weathering to buff, dense, compact -------------------------- 48'

Total thickness --- 2022'

Quadrant quartzite. Quadrant quartzite was named by A.C. Peale (1893, p. 39-43) from outcrops on Quadrant Mountain in northwestern Yellowstone National Park. Peäle's section totaled 230 feet, the intermediate Snowcrest Range has a total thickness of 1000 feet according to Condit (1918, p. 111), and the Tendoy Mountain section measures 3319 feet, R.W. Becker (1947, p. 17). These figures show an increase in thickness from east to west with geosynclinal facies of the west thinning to a shelf area in the east.

Scott (1935) has shown that the Quadrant formation grades into the Tensleep formation of Wyoming. These two formations are lithologically similar and it seems reasonable that they are the same formation.

The Quadrant quartzite contains dense tan to buff sandstone which weathers dark and assumes a reddish color. The sandstone is quartzitic and has an abundance of black lichens. Dolomite and limestones are mostly found in the upper part of the formation. Scott (1935, p. 1019) states that the Tensleep formation of western Montana and northwestern Wyoming lies disconformably on the so-called Amsden formation. This relationship holds for the Tendoy Mountain area as well (Dr. A.J. Eardley, personal communication).

The Quadrant quartzite forms Mount Garfield and most of the high peaks of the area. There large blocky talus slopes are conspicuous.

The formation was measured by R.W. Becker, E.G. Lipp, and H.H. Krusekopf (1947) in the Tendoy Mountains. The section chosen was in Hidden Pasture Canyon half a mile southwest of the Sheep Creek Ranger Station in the east one half of section 35, T 13 S, R 10 W.

The measured section is as follows:

12. Sandstone, dark gray, massive, calcareous cement ---------------------------------- 26'

11. Covered interval; dolomite and chert layers present -------------------------------------- 281'

10. Limestone, more pitted than before, otherwise similar to unit 8 ----------------------- 9'

9. Dolomite ------------------------------- 15'

8. Limestone, finely crystalline, dense, slightly pitted, gray to light tan, weathers white to tan ---------------------------- 5'

7. Dolomite, dense at base, white to light gray, chert near top, sandy --------------------- 55'

6. Sandstone, soft, white, easily weathered, forms rolling slope ----------------------- 131'

5. Sandstone (first exposure), dense, white to light gray, weathers to brownish tan, becomes light tan toward top -------------1725'

4. Sandstone, friable, massive, dark tan, weathers to yellowish tan. Many black lichens covered talus slope near top ------ 914'

3. Sandstone, friable, massive, light tan, weathers to light gray, interbedded with two inch thin layers of more quartzitic and slightly dolomitic near center. Also another member of quartzitic, slightly dolomitic sandstone near top -------------- 109'

2. Sandstone, quartzitic, very dense, gray to buff, weathers to tan, thinly bedded with thin three inch layers of shaley sandstone ----------------- 5'

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 ----------- 44'

Total thickness -------- 3319'

Permian system

<u>Phosphoria formation</u>. The Phosphoria formation was named by R.W. Richards and G.R. Mansfield (1912, p. 683-689) from outcrops at Phosphoria Gulch, 2 1/2 miles northwest of Meade Park, Idaho. It contains limestones and cherty dolomite. The limestone is light gray to light tan. The dolomite

is hard, gray and sandy. Shale is also present in small amounts.

The Rex chert of Wyoming is not identified in the column of Montana, but R.W. Becker (1948 p.19) believes that unit 19 of the measured section may be its equivalent.

Beds of pisolitic phosphorite were found 100 yards southeast of the ford in the Middle Fork Road of Little Sheep Creek. These are not mentioned in the Phosphoria formation measured by E.G. Lipp and R.W. Becker (1948) along a dry stream bed about one mile southwest of the Sheep Creek Ranger Station in section 35, T 13 S, R 10 W.

20. Limestone, tan to medium gray, weathers medium gray, very hard, fine grain, crystalline, partly covered, mottled with white calcite spots ----------------- 10'

19. Dolomite and chert, gray, massive, fractured, hard, weathers gray with slight red-brown color, slight limonitic stains, also thin limestone beds interbedded. Forms a vertical cliff in one place but is partly covered in other places -------- 192'

18. Covered interval ------------------------- 88'

17. Sandstone, mostly covered, brownish sandstone; the sandstone weathers into small angular talus. Some chert present -- 66'

16. Limestone, massive, hard, gray, weathers light yellowish tan ---------------------- 16'

15. Shale, light buff, mostly covered -------- 31'

14. Siltstone, red, very slightly limey, rather hard, forms small cliffs over the tan limestone; massive at top and bottom and thin bedded between ------------------ 45'

13. Limestone, yellowish tan, friable, fine grain, thinly bedded, also more or less massive in places ------------------------ 10'

12. Dolomite, dense, medium dark gray, weathers light gray, chert is bluish, greenish and dark gray (concretions), some lime present, hard, also some chert lenses that resemble conglomerates --------------------------- 8'

11. Sandstone, calcareous cement, fine grain, hard, light gray, weathers to buff to medium dark gray, faint light gray or white color bands ------------------------ 6'

10. Dolomite, contains a few concretions, sandy, light gray to white, weathers same, hackly weathered surface, massive but well fractured, horizontal joints, more chert lenses near top -------------------------- 93'

9. Covered interval ------------------------ 12'

8. Chert, gray green ------------------------ 1'

7. Limestone, hard, slightly sandy, dark gray green, weathers gray, occasional thin chert layers, massive -------------------------- 6'

6. Limestone, with chert beds; limestone is gray weathers same, chert is white to gray to medium dark, beds of chert two inches to eight inches thick. Toward the top becomes less limey and the chert layers disappear and become concretions and are a little darker ----------------------------------- 76'

5. Chert and dolomite; chert is medium dark gray,; dolomite is light gray, more chert than dolomite --------------------------- 12'

4. Covered interval -------------------------- 8'

3. Sandstone, more calcareous near base, fine grain, hard, massive, light gray, weathers same, few calcite stringers throughout ---- 44'

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, massive ------------ 72'

1. Dolomite, sandy, very fine grain, weathers light gray to gray-buff ------------------- 5'

Total thickness ------ 802'

Triassic system

According to Wallace (1948, p.21), the Montana use of the term Woodside generally includes all the Triassic beds, and no effort is made to differentiate them. It includes silty beds here described as Dinwoody, red beds called the Woodside and calcareous strata called the Thaynes. These represent the Triassic divisions south of the Snake River lava plains.

Since the three units were so well exposed in Wallace's area, he mapped them as Dinwoody, Woodside and Thaynes and the author has followed this precedent. A section for each of the formations has been measured by W.L. Adam and the author.

<u>Dinwoody formation</u>. The Dinwoody formation was named by E. Blackwelder (1918, p.925) from

a section exposed in the Canyon of Dinwoody Lakes in the Wind River Range of Wyoming. Blackwelder defined the Dinwoody as extending from the top of the Phosphoria formation to the red shales of the Chugwater formation. The red shales of the Chugwater, however, are not a true stratigraphic plane according to N.D. Newell and B. Kummel (1942, p.941-947) and they have rédefined the formation to include only the lower silty portion of the original Dinwoody described by Blackwelder.

The Dinwoody characteristically contains tan shaley limestones and sandstones interbedded with limestones in the Tendoy Mountains, and the fossils, Lingula borealis and Claria sp. were found in it.

W.L. Adam and the author measured a Dinwoody section up the first major valley 1/2 mile south of Two Spring Gulch on the West Fork of Little Sheep Creek. The Madison thrust sheet can be seen overriding the top of the section from the road. It is located in the southeast corner of section 32, T 14 S, R ~~32 E~~ 9 W.

The section is as follows:

15. Sandstone, light tan to gray, weathers chocolate brown, calcareous -------------- 4'

14.	Sandstone, light gray to tan, no change on weathering, thinly bedded 1/2 to 4 inches, calcareous ----------------------------------	2 1/2'
13.	Limestone, gray, weathers dark chocolate brown, arenaceous, bedding 1/2 to 6 inches-	2'
12.	Sandstone, light gray to tan, no change on weathering, thinly bedded, calcareous ----	3'
11.	Limestone, gray, weathers dark chocolate brown, arenaceous, bedding 1/2 to 6 inches-	1'
10.	Sandstone, grayish white, friable, calcareous thinly bedded 1/4 inch ------------------	3'
9.	Limestone, gray, weathers dark chocolate brown, arenaceous ------------------------	5'
8.	Sandstone, light gray to tan, calcareous, no color change on weathering, thinly bedded 1/2 to 4 inches ------------------	2 1/2'
7.	Covered interval ------------------------	3'
6.	Limestone, gray, weathering dark chocolate brown, thinly bedded ---------------------	2'
5.	Covered interval ------------------------	2'
4.	Limestone, white to light gray, weathers bluish gray, arenaceous ------------------	4'
3.	Limestone, gray, weathers dark chocolate brown, arenaceous, bedding in layers 1/2 to 6 inches, fossils: <u>Lingula borealis</u> and <u>Claria sp</u>.(?), Strike NW-SE Dip 17° SW -	78'
2.	Talus covered interval, tan and chocolate brown limestone, low grassy slopes -------	200'
1.	Covered interval above Phosphoria --------	462'
	Total thickness ------	773'

<u>Woodside formation</u>. The Woodside formation was named by J.M. Boutwell (1907, p. 446) from

exposures in Woodside Gulch in the Park City District of Utah.

W.L. Adam and the author tried to map the Woodside's tan and red units. This attempt was abandoned as it seemed that the red and tan units cut across stratigraphic hroizons. Newell and Kummel postulate the same situation for the correlatable Chugwater formation in the Wind River Range of Wyoming.

The Woodside contains red and tan siltstones, limestones and shales. No fossils were found. The section measured by the author and his field partner was above the Dinwoody at the same locality in the southeast corner of section 32, T 14 S, R ~~32~~ 9 W. E.

The section is as follows:

15. Silty shale, tan slope ------------------- 110'
14. Silty shale, red slope with small pieces of brown limestone ----------------------- 50'
13. Limestone, mottled gray and brown, ledge, weathers rusty gray ---------------------- 5'
12. Silty shale, red slope with small pieces of brown limestone ----------------------- 35'
11. Limestone, mottled gray and brown, massive ledge, weathers rusty gray (may be stained from above), calcite inclusions ---------- 10'

10.	Siltstone, greenish gray, weathers tan, soft and shaley, slightly calcareous -----	20'
9.	Limestone, reddish brown, small pieces in red slopes --------------------------------	55'
8.	Siltstone, greenish gray, calcareous, massive ------------------------------------	2 1/2'
7.	Siltstone, whiteish gray, very friable, calcareous, white slopes -----------------	10'
6.	Siltstone, white-gray, weathers tan, calcareous bedding fine, shales in 3 inch beds ------	15'
5.	Red soil, no bed rock in trench, two white patches in soil --------------------------	70'
4.	Sandstone, greenish gray, fine grain, weathers brown, forms reddish brown slopes, very calcareous --------------------------------	35'
3.	Sandstone, greenish gray, weathers brown, very slightly calcareous -----------------	20'
2.	Sandstone, gray, weathers chocolate brown, calcareous, forms reddish brown slopes ---	10'
1.	Sandstone, gray, weathers chocolate brown, forms white slopes, non-calcareous --------	11'
	Total thickness ------	458 1/2'

<u>Thaynes formation</u>. The Thaynes formation was named by J. M. Boutwell (1907, p. 448-452), for exposures in Thaynes Canyon in the Park City District, Utah.

The formation in the Lima Peaks area contained gray and buff calcareous sandstones and crystalline limestone. It is a cliff former. The section measured by W. L. Adam and the author was capped by a thrust sheet and as a result the exact thickness of the measured section is in doubt.

The Thaynes formation was measured four tenths of a mile up the west branch of the two creeks that form the West Fork of Little Sheep Creek. The measuring was done up the west canyon wall. It is in the SW corner of section 19, T 15 S, R 32 E, about 3 miles above the Dinwoody and Woodside sections along the road up the West Fork of Little Sheep Creek.

The section is as follows:

13.	Covered interval ------------------------	200'
12.	Covered interval topped with 2' bed forming a ledge, Pentacrinus ------------	30'
11.	Limestone, brown, weathers chocolate brown, thinly bedded, shaley, forms ledge ------	1'
10.	Covered interval ------------------------	20'
9.	Limestone, tan, weathers yellowish tan, silty, laminated ------------------------	40'
8.	Limestone, brown, weathers chocolate brown, shaley, thinly bedded 1/8" to 1/4", ledge former ----------------------------------	15'
7.	Limestone, white to gray, weathers blue-gray to brown, calcite inclusions, fine grain- ------------	8'
6.	Limestone, tan, weathers yellowish tan,silty, fine grain, laminated, ledge former -----	7'
5.	Siltstone, gray, calcareous, shaley -----	25'

4.	Limestone, gray, weathers brown, massive, ledge former ------------------------------	8'
3.	Siltstone, tan, tan slopes very friable, small weathered ledges ------------------	30'
2.	Siltstone, tan, weathers tan to brown, calcareous, ledge former, lower 4' shaley, upper 2' massive, Strike N-S, Dip 5°W. ---	6 1/2'
1.	Limestone, gray, weathers tan, silty, tan slope ---------------------------------	20'
	Measured thickness -------	430 1/2'

Jurassic system

Sawtooth formation. The Ellis group of W. A. Cobban (1945, p. 1264), can be subdivided into the Sawtooth, Rierdon, and Swift formations. These formations are present in the Lima Peaks area according to L. L. sloss (personal communication). However, the Swift formation could not be found by the author. Further study may reveal its presence.

W. A. Cobban (1945, p. 1274-1276), named the Sawtooth formation from outcrops in Rierdon Gulch in the Sawtooth Range, Montana. The Sawtooth formation in the Lima Peaks area is composed of a conspicuous unit of dark tan, mottled white, friable siltstone.

The following section is incomplete as the section is capped by volcanics. It was measured by Wallace and Krusekopf (1948), in S 1/2 sec. 22 T 13 S, R 10 W.

The section is as follows:

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'

<u>Rierdon</u> <u>formation</u>. W. A. Cobban (1945, p. 1277-1280), also described the Rierdon formation from the Rierdon Gulch exposures in the Sawtooth Range, Montana. The Rierdon formation of the Lima Peaks area contains interbedded, calcareous shales, and oolitic limestones (Wallace, 1948, p. 27).

Wallace and Krusekopf measured the following section in the W 1/2 sec. 10, T 13 S, R 10 W.

4. Covered interval ---------------------------- 78'

3. Oolitic limestone gray to buff, massive ------------------------------------- 10'

2. Shale, light brown, calcareous -------------- 20'

1. Oolitic limestone, gray buff, massive ------- 8'

Total thickness ----------- 116'

Cretaceous system

Kootenai formation. The Kootenai formation is the only Cretaceous formation found in the Lima Peaks area by the author. It was named first by C. A. Fisher (1909, p. 28-35), for exposures near Great Falls, Montana. The formation is of lower Cretaceous age.

The Kootenai of the Lima Peaks area contains "salt and pepper" sandstones, red and yellow silty shales, and a gastropod limestone marker bed in the lower part.

Wallace and Krusekopf (1948), measured the section below in E 1/2 sec. 9, T. 13 S, R 10 W. It is unusually thick and may have Upper Cretaceous beds present. (Eardley, personal communication).

35.	Covered interval ------------------------	250'
34.	Sandstone; salt and pepper, massive; some beds contain subangular to rounded pebbles of black and brown chert ---------------	26'
33.	Covered interval -----------------------	26'
32.	Sandstone, rusty brown, very well indurated, salt and pepper ------------------------	26'
31.	Covered interval -----------------------	52'

30.	Sandstone, salt and pepper, massive --------	21'
29.	Shale, reddish ----------------------------	52'
28.	Sandstone, fine grained, salt and pepper ---	5'
27.	Shale, brownish red -----------------------	42'
26.	Sandstone, salt and pepper ----------------	5'
25.	Shale, brownish red -----------------------	29'
24.	Sandstone, salt and pepper, interbedded with several beds of dark brown weathering calcareous sandstone ---------------------	10'
23.	Shale, variegated, red, brown, and purple ---	31'
22.	Sandstone, salt and pepper ----------------	5'
21.	Shale, red --------------------------------	33'
20.	Limestone, gray, weathers to dark brown, arenaceous --------------------------------	2'
19.	Sandstone, salt and pepper ----------------	28'
18.	Shale, red --------------------------------	21'
17.	Sandstone, salt and pepper ----------------	5'
16.	Shale, red --------------------------------	23'
15.	Shale, purple-gray; included,- two foot bed of reddish brown arenaceous limestone ------	10'
14.	Shale, red --------------------------------	57'
13.	Sandstone, gray to reddish gray; includes some interbedded sandy limestones ----------	26'
12.	Sandstone, salt and pepper ----------------	5'
11.	Shale, red --------------------------------	10'
10.	Sandstone, medium grained, salt and pepper, thin bedded, weathers into slabby blocks ---	36'

9. Shale, alternating red and brown ---------- 73'

8. Covered interval; includes a dark gray gastropod limestone and some gray shales not seen in measured section -------------- 702'

7. Shale, red -------------------------------- 21'

6. Sandstone, light brown to gray, medium grained, friable; toward top coarser sandstone, salt and pepper with pebbles of black chert; thin bedded ------------------ 36'

5. Shale, variegated red, purple, and brown -- 42'

4. Shale, light gray, hard, sandy ------------ 52'

3. Shale, red, calcareous; contains gastroliths ----------- 109'

2. Sandstone, salt and pepper with small limonite concretions, massive ------------ 70' Base Kootenai

1. Shale, dark colored; poorly exposed possibly Morrison or Swift formations ----- 260' Morrison

Measured thickness ------ 2201'

Tertiary system

<u>Red Rock conglomerate</u>. The name, Red Rock conglomerate, is a tenative name given a coarse orogenic deposit in Beaverhead County by Prof. Eardley. No fossils have been found to date the formation. It is older than the upper Eocene Sage Creek formation which overlies it unconformably, and it is older than the main Laramide thrusting.

It is therefore believed to be approximately Paleocene in age.

The Red Rock conglomerate consists of large well rounded, smooth boulders and pebbles of quartzite and limestone. The quartzite is usually red or pink and the limestone is blue. The conglomerate cement is light gray and slightly calcareous in places and red - brown and limonitic in others. Sandstones from a few inches to several feet in thickness are with the conglomerate.

The Red Rock conglomerate in the Lima Peaks area is located in front of the Beaverhead and Tendoy thrusts and each thrust has overridden some of the formation. No conglomerate section has been measured.

Tertiary Basin Beds of the Warm Creek area.

The Tertiary Basin Beds of the Warm Creek area in Idaho include three units, Fresh water limestone composes the lower unit, rhyolites form the middle unit and gravels and conglomerate form the uppermost unit.

Basin limestone. These limestones are a fresh water deposit since they contain fresh water gastropods, petrified wood fragments and plant remains. Whether the limestone resulted from spring deposits (travertine), lacustrine or sub-aerial deposition, is still to be decided. The group of limestones also constitutes the highest unit of the Nicholia Creek Basin Beds of Kupsch and Scholten (1948, p. 32).

The limestone is cavernous, very white and contains vugs filled with calcite crystals. It weathers light gray with a pitted surface and in places takes a pinkish color. Limestone breccia is found in thin layers with it. The limestone is probably equivalent to the Cook Ranch or Sage Creek formations of upper Eocene or lower Oligocene age.

Basin rhyolite. The rhyolite is the unit above the limestone. The rhyolite has a felsitic groundmass with glossy phenocrysts. It is porous and pale pink to lavender in color. Scholten (1948, p. 33), calls the rhyolites the Bannack Pass rhyolitic lavas. The rhyolite is also probably equivalent to the Cook Ranch or Sage Creek formations of upper Eocene or lower Oligocene age.

Basin gravels. Gravels are found above the rhyolite. The gravels are thought to be of Pleistocene age by Eardley (personal communication). They seem to be a fanglomerate deposit and contain a large percentage of what seems to be Madison limestone pebbles which probably originated from the higher Madison thrust sheet to the north. Some of the gravels have been cemented locally forming a soild unit.

Tertiary volcanic basalt. Basalt is found covering a small area along Birch Creek. The basalts lie upon the Red Rock conglomerate just south of the Red Rock Basin.

The rock is a heavy greenish black basalt. Along the top of the flow where the molten basalt was exposed to the air, it has oxidized to a red color and is vesicular. The basalt flow is about 300 feet thick.

Quaternary alluvium. The Red Rock Basin is covered by a thick bed of alluvium. Little Sheep Creek from the Red Rock Basin to a point about a mile up each of its three forks is covered with alluvium. Medicine Lodge Creek and Irving Creek in Idaho also have narrow valleys covered with alluvium. The thickness of the alluvium is not known.

Figure 4

LIMA AND THE TERTIARY BASALT

Looking down Birch Creek

STRUCTURE

Regional features

The diverse arrangement of the mountains of southwest Montana indicates a complex history. The Beaverhead and Lemhi Ranges trend NW-SE, the Gravelly, Ruby, and Snowcrest Ranges trend NE-SW, and the Tendoy Mountains trend N-S. The Centennial Range has an E-W trend.

According to Kupsch (1948, p. 56), there are three major periods of deformation.

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 which resulted in a graben and horst structure.

The incrrease in thickness of most Mesozoic and Paleozoic formations from east to west indicates the presence of a geosyncline in southwestern Montana and northeastern Idaho during the Mesozoic and Paleozoic eras, and a shelf zone to the east in Wyoming. This was seen in comparitive thicknesses of the Quadrant quartzite on a preceeding page.

A zone of thrusting cuts across the Tendoy Mountains. The zone has a northwest - southeast trend with thrusting from the southwest to the northeast. The thrust zone eztends southward under the Snake River lava plains. These lava plains in Idaho were formed by lava which fills a downwarped basin.

Laramide structure

<u>Folds</u>. There were two major periods of folding . The first phase of folding was the phase which formed the folds with axes trending north-east - southwest. The valley to the southeast of Mt. Garfield in which Sawmill Creek is located, the valley to the northwest of the peak and the Little Water Canyon still farther to the northwest are examples of synclines formed during the first period of folding. The Little Water syncline may be an extension of the Snowcrest Range which is also believed to be part of this folding.

The second phase of folding formed folds which trend northwest - southeast.Muddy Creek Basin syncline and the monocline forming the side of the Red Rock Basin are examples of the second phase of folding.

<u>Thrusts</u>. Two thrusts are recognized in the Lima Peaks area; the northeastern one is called the Tendoy thrust and the southwestern one the Beaverhead. In the earlier mapping of Lipp, Becker, Wallace, and Krusekopf the name Tendoy was given to what is now reguarded as the Beaverhead, and the name Tendoy is given to a new thrust along the east front of the Tendoy Mountains. (See the geological map of this report.) In the work of the summer of 1948, it was discovered that the Beaverhead thrust of Kupsch and Scholten (1948 p.34), is the same as the Tendoy thrust of Lipp, Beaker, Wallace and Krusekopf, and since the major part of the thrust sheet is in the Beaverhead Mountains, the name Beaverhead seemed the more appropriate.

The Tendoy thrust trends northwest - southeast. It crosses Little Sheep Creek just north of the junction of the West and Middle Forks of Little Sheep Creek, runs southeastward, then swings to the northeast in a sweeping arc and finally passes just in front of the red peak at the north end of the Lima Peaks. The thrust sheet is composed of Madison limestone on the western side of the area, the Amsden formation makes up the thrust sheet midway, and the Quadrant formation forms the thrust sheet on the eastern side of the area in front of the Lima Peaks. All of the formations in the Tendoy thrust have been moved from the southwest to the northeast and have overridden the Red Rock conglomerate which is in front of the thrust. The thrust sheet is very badly folded.

The Beaverhead thrust in general has the same northwest - southeast trend as the Tendoy thrust and is likewise thrust to the northeast. The Beaverhead thrust is located farther to the south along the continental devide. It passes just north of Bannack Pass in Idaho, swings northward across the border into Montana and then straightens out running south-eastward into Idaho again. It crosses Irving Creek about four miles north of the junction with Medicine Lodge Creek. The thrust is composed of Madison limestone in the Lima Peaks area and is thrust over Red Rock conglomerate which lies in front of the thrust sheet. The Beaverhead thrust sheet is cut by a high angle fault in Idaho, and the southwest part is depressed and concealed by alluvium, gravels,

Figure 5

BEAVERHEAD THRUST SHEET

South of Two Spring Gulch

rhyolite and limestone.

Mid - Tertiary structures

High angle faults. Two high angle faults are present in the Lima Peaks area. The first of these faults is in the northern part of the area and extends from the Charles Ranch on Little Sheep Creek eastward to Birch Creek where it dies out. The downthrown side of the block forms the Red Rock Basin.

The second high angle fault is in Idaho to the south. It has a southeastward trend starting across the area north of Bannack Pass and running to a point about one and one half miles up Irving Creek from its junction with Medicine Lodge Creek. The downthrown side of the block forms the Medicine Lodge Basin. The fault has displaced fine grained white Tertiary limestone against Madison limestone of the Beaverhead thrust sheet at Bannack Pass.

The high angle faults are a part of a system of block faults that extend from Utah through western Wyoming and eastern Idaho to the Snake River downwarp, and from the northern side of the downwarp northward through western Montana. (Eardley, 1947, p;1176).

Age relationships

The folding of the Madison limestone under the Red Rock conglomerate of the northern part of the area pre-dated the deposition of the Red Rock conglomerate. Uplift accompanied the folding. The Little Water syncline and the Sawmill Creek syncline (?), were also formed at this time. A sharp highland was created, mostly to the west, from which the Red Rock conglomerate was formed. The deposition of the conglomerate followed. Laramide thrusting then occurred and the Tendoy and Beaverhead thrusts rode over the Red Rock conglomerate. Finally in the mid-Tertiary high angle faults cut the Red Rock conglomerate and the Laramide thrust sheet known as the Beaverhead thrust.

A knowledge of the age of the erosion surfaces as related to the high angle faults was necessary for an understanding of the physiography. East of Bannock Pass a splinter fault from the main basin fault cuts through the high level erosion surface at about an elevation of 8,000 feet. The erosion surface is continuous across the fault which according to Eardley (personal communication), indicates that the high angle faulting pre-dates the high level erosion surface.

Figure 6

SURFACE AND FAULT

Looking southwestward to Bannock Pass

The surface is continuous across the fault and indicates that the high angle faulting pre-dates the high level erosion surface.

PHYSIOGRAPHY

Physical features

The Lima Peaks area of the Tendoy Mountains is located in Fenneman's Northern Rocky Mountain Province, N. M. Fenneman (1931 p. 213). It is more characteristic of the Basin and Range Province, however, it is a horst and graben structure. The high Lima Peaks are the horst, the Medicine Lodge Basin to the south is a graben and the Red Rock Basin to the north is a down-tilted block.

Erosion surfaces

Three erosion surfaces were found in the Lima Peaks area. They are a high level surface, an intermediate bench or pediment, and the inner lower terraces and floodplain. These surfaces may be correlated with the erosion surfaces found in the Jackson Hole country of Wyoming; the high level surface would be the Black Rock surface, the intermediate bench the Circle surface and the more modern lower surfaces the Pinedale and Recent surfaces.

The approximate elevations of the erosion surfaces of the Tendoy Mountains are 6,300 feet for the modern surface which includes the hay lands along Big Sheep Creek and the new stream cuts in Nicholia Basin. The intermediate bench is about 6,700 to 7,000 feet in elevation and includes the Nicholia Basin. The high level surface is at an elevation of about 7,500 to 8,000 feet and is composed of the high level grass lands where summer sheep grazing is profitable.

A still older surface than the three mentioned may be indicated by the accordance of summit levels of the high peaks of the Beaverhead Mountains. If this is recognized as a surface it may be correlated with the Union Pass surface in northwestern Wyoming. It would have been a monadnock at the time the Black Rock or "high level" surface was cut.

Glaciation

No evidence of glaciation is present in the area of the Medicine Lodge Basin covered by this report, nor is any evidence found in the Red Rock Basin.

Kupsch and Scholten (personal communication), found evidence of Bull Lake and Pinedale glacial till in the Nicholia Basin which resulted from glaciers moving out of the high Beaverhead Mountains.

SUMMARY OF EVENTS

late Pleistocene	Uplift and desection of pediment Glaciation and deposition of outwash in two stages Desection to form modern gravel terraces and river bottoms
early Pleistocene	Uplift and erosion of intermediate pediment surface
Miocene	Block faulting
Oligocene	Continued Basin Bed deposition Further volcanic activity
middle & upper Eocene	Erosion of great intermountain basins and subsequent deposition of Basin Beds Accompanied by volcanic activity
early Eocene & late Paleocene	Laramide thrusting from southwest to northeast forming the Beaverhead and Tendoy thrusts
Paleocene	Erosion of highlands and deposition of Red Rock conglomerate
Late Cretaceous	Major Laramide deformation producing a western highland and folds with axes that trend NE - SW.

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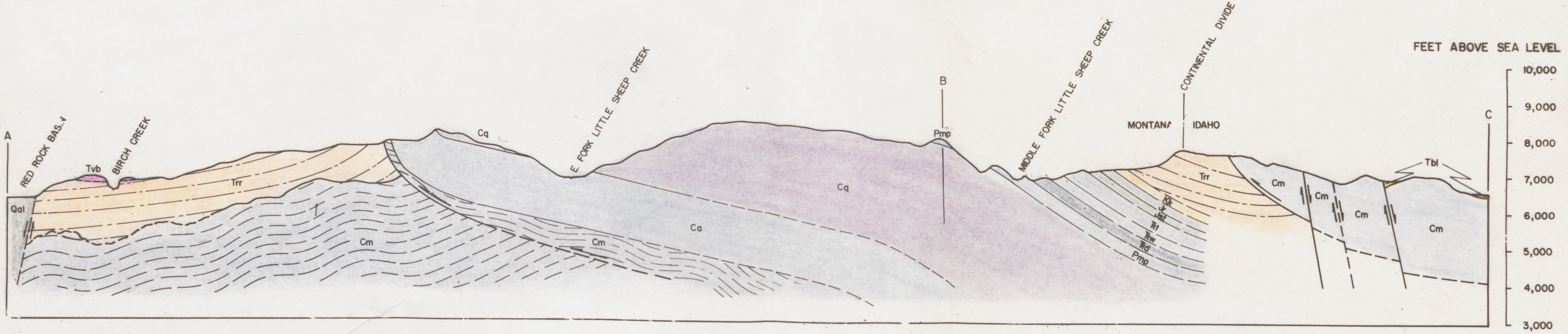
PLATE 2

STRUCTURAL CROSS SECTION ALONG LINE A-B-C



Legend: Cm, Madison ls.; Ca, Amsden fm.; Cq, Quadrant qtzite.; Pmp, Phosphoria fm.; Tid, Dinwoody fm.; Tiw, Woodside fm.; Tit, Thaynes fm.; Jst, Sawtooth fm.; Jr, Rierdon fm.; Kk, Kootenai fm.; Trr, Red Rock congl.; Tbl, Basin lss.; Tvb, volcanic basalts; Qal, alluvium.

1 ½ 0 1 2

Scale in miles

Profile and elevations approximated.

WILLIAM L. ADAM & RICHARD W. BENNER

PLATE I

GEOLOGY OF THE

LIMA PEAKS AREA

BEAVERHEAD COUNTY, MONTANA, & CLARK COUNTY, IDAHO

BY WILLIAM L. ADAM & RICHARD W. BENNER