

GEOLOGY OF A PART OF THE BLACKTAIL
RANGE, BEAVERHEAD COUNTY,
MONTANA

By

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thesis submitted by Lawrence E. Mannion in fulfillment
of the requirements for the M. A. in Geology.

May 26th, 1949

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Lawrence E. Mannion

Submitted in partial fulfillment
of the requirements for the degree
of Master of Science in Geology at
the University of Michigan, 1948.

ABSTRACT

The area described is a portion of the Blacktail Range located south of Dillon in Beaverhead County, southwest Montana. The geologic section includes pre-Cambrian crystalline rocks, Cambrian, Devonian, Mississippian, Pennsylvanian, Permian, Triassic, Jurassic, Cretaceous and Tertiary sediments and Tertiary basalts and tuffs. Pre-Cambrian rocks are exposed in the eastern part of the area where the Paleozoics lap upon them from the west. The central portion of the area is occupied by Paleozoic sediments whereas Mesozoic rocks crop out in the western part of the area. Tertiary volcanics overlap the pre-Cambrian, Paleozoic, and Mesozoic rocks on the south and west.

The major structural feature of the Blacktail Range is a late Tertiary block fault that has brought up rocks from pre-Cambrian to Miocene in a northeast facing escarpment. Other structural features of less topographic influence are of Laramide age. In the east part of the area Paleozoic rocks dip westward off the pre-Cambrian and represent the eroded west limb of a major anticline. The east limb of this anticline is found in the Snowcrest Range four miles southeast of the Blacktail Range. The same episode of orogeny is represented in the west part of the area by a minor thrust. Late Laramide structures are found in the northwest part of the area where upturned beds trend northwest crossing the earlier structures.

Three erosion surfaces may be recognized in the area which are related primarily to the late Tertiary block faulting and regional uplift.

INTRODUCTION

Location and accessibility of the area

The Blacktail Range is located 20 miles southwest of Dillon in Beaverhead County, southwestern Montana. (See index map.) The area described is in the central part of the range and includes all or parts of the following townships: T8S-R8W, T8S-R9W, T9S-R8W, T9S-R9W, T10S-R8W, T10S-R9W, T11S-R8W, T11S-R9W. The area is roughly bounded by Beaverhead River on the northwest and by Blacktail Creek on the northeast. It covers about 170 square miles.

The area may most easily be reached by a graded road which leaves U. S. Highway 91 one mile southwest of Dillon and runs southward along Blacktail Creek. Twenty miles south of the road junction the Blacktail Range rises in a steep escarpment some two miles west of the road. Several rut roads lead up to the face. One such road is passable to automobile in good weather for about five or six miles into Small Horn Canyon. The interior and southern portions of the area are best reached on foot although a road from Dell, Montana, called the Sage Creek road goes to the Wheat Ranch from which a track is just passable north to as far as Divide Creek near the southern boundary of the area.

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Plate 1 Index map

GENERAL STRATIGRAPHIC COLUMN FOR THE BLACKTAIL RANGE				
	Time Units	Formation	Character	Thickness
CENOZOIC	Recent	Alluvium	Unconsolidated and unsorted material deposited chiefly as alluvial fans.	?
	Miocene?	Basalt flows	Hard, black extrusive rock with olivine phenocrysts weathers brown.	100-200
	Oligocene?	Cook Ranch	Volcanics; white breccia, tuffs, scoria, rhyolite.	?
	Eocene?	Basalt flows	Similar to above with quartz in vesicles.	?
	Paleocene?	Beaverhead (Red Rock)	Conglomerate, coarse with quartzite, limestone, sandstone pebbles and cobbles, calcareous cement.	2,500
MESOZOIC	Cretaceous	Kootenai	Sandstones, salt and pepper, weather white, shales, red and brown, some limestones.	700 exposed
	Jurassic	Morrison	Shales, siltstones and sandstones, reddish, brown and greenish slabby; much ripple marking, mud cracks.	200
	Triassic	Thaynes	Sandstones, siltstones, some limestones.	800-1000
		Dinwoody	Sandstones, tan cherty; limestones gray to purplish brown. Few fossils.	400-450
PALEOZOIC	Permian	Phosphoria	Sandstones, quartzitic, cherty, black and brown chert, some phosphatic rock.	350
	Pennsylvanian	Quadrant	Sandstone, massive, white, porous, some limestone near top. Weathers buff to almost black in talus.	700
	Pennsylvanian-Mississippian	Amsden	Shales and limestones, reddish, purplish and greenish. Fossiliferous.	75-100
	Mississippian	Mission Canyon	Limestone, massive to medium bedded, gray weathers light gray to white often with a bluish stain. Fossiliferous in some beds.	1100
		Lodgepole	Limestone, thin bedded 2" to 8", gray. Fossiliferous	600
	Devonian	Three Forks	Limestone, thin bedded, shaly, very fossiliferous in middle portion.	40
		Jefferson	Limestone, black crystalline, massive with some thin bedding.	82
	Cambrian	Pilgrim	Limestone, white massive, cliff forming.	91
		Park shale	Shale, crumbly, greenish gray, interbedded limestone at top.	300
		Meagher	Limestone, light gray, dolomitic, weathering to light orange gray cliffs.	700
		Wolsey	Shale, micaceous, greenish gray, glauconitic.	100
Flathead		quartzite and sandstone, tan to reddish, with shaly layers.	125	
PRE-CAMBRIAN	Proterozoic	Cherry Creek	Gneisses and schists, orange, red, and brown, with some pegmatitic granites.	?

The thesis area was mapped by Thomas Beard, John O'Connor and the author during the period July 25, 1948, to August 16, 1948.

Topography and drainage

The Blacktail Range is a member of the group of northwesterly trending mountains such as the Tendoy, Red Rock and Beaverhead Mountains. It is a fault block range with the escarpment slope facing northeast. It has a roughly rectangular shape with the longest dimension parallel to the escarpment. The maximum relief of about 3,200 feet is near the midpoint of the fault face where Blue Mountain reaches an elevation of 9,200 feet.

To the northeast across Blacktail Valley lies the Ruby Range, to the south the Red Rock Mountains, and to the southwest the Tendoy Mountains.

The area is drained by Divide Creek which flows south and by a large number of north flowing intermittent streams that drop down the partly dissected fault face and drain into Blacktail Creek. This in turn flows north to Beaverhead River a stream which apparently antedates the faulting of the Blacktail Range.

Previous and contemporary work

Little geologic work other than some on economic geology has been done in the Blacktail Range. A topo-

graphic survey was made in 1887-1888 by H. Gannet of the U. S. Geographical and Geologic Survey. A similar survey is in progress at the present time. A. N. Winchell in 1914 described the economic geology of the Dillon Quadrangle which includes the northern quarter of the thesis area. H. Sinkler in 1942 described deposits of nickel ore a short distance to the east of the area. The U. S. Geological Survey is at the present time making a study of the phosphate rock in the region. W. R. Lowell is making a study of the region to the west. Dr. Heinrich of the University of Michigan has done work on the Ruby Range to the north. Work on this and adjacent regions will be included in the Bibliography.

Acknowledgments

The field work, the preparation of the geologic map and cross sections and the writing of the report were under the supervision of Dr. A. J. Eardley, Professor of Geology at the University of Michigan. The author is indebted to Dr. Eardley for his continued assistance in the work. Kendall Keenmon in whose Ph. D. thesis area the area of this report is located contributed much through his field assistance and through his larger knowledge of the area. The field work was largely done in collaboration with Thomas Beard and John O'Connor.

STRATIGRAPHY

Introduction

The rocks outcropping in the area include formations ranging in age from pre-Cambrian to recent. The pre-Cambrian rocks are mostly granite gneiss, schists and pegmatitic granites. The Paleozoic section includes the Cambrian Flathead quartzite, Wolsey shale, Meagher limestone, Park shale, and Pilgrim limestone; the Devonian Jefferson limestone and Three Forks limestone; Mississippian Lodge Pole and Mission Canyon limestones which are Madison in age; Pennsylvanian Amsden and Quadrant formations; and the Permian Phosphoria formation. The Mesozoic section contains the Triassic Dinwoody formation and Thaynes limestone; the Jurassic Morrison? formation; and the Cretaceous Kootenai formation. The Cenozoic is represented by the Paleocene Beaverhead conglomerate; Eocene? basalts; Oligocene? Cook Ranch volcanics; Miocene? basalts; and alluvium.

Good outcrops of Paleozoic rocks are found in Ashbough and Sheep Canyons. In the regional geology all the Paleozoic thicken to the south and west. The thesis area was evidently one of shelf sea deposition for the most part except in the Mississippian

when the major trough of the Madison was receiving deposition of limestones. The Paleozoics lap up on the pre-Cambrian in the east part of the area.

The Mesozoic rocks are chiefly exposed in Small Horn Canyon and Cenozoic deposits cover all older rocks in the southern part of the area.

Fossils were found in the Devonian, Mississippian and Pennsylvanian rocks. A few of them were identified as to species but many more could only be distinguished generally. Little work has been done on the fauna of this region so that the species are largely undescribed.

Pre-Cambrian rocks

Pre-Cambrian rocks crop out in the southeast part of the area forming a more rounded hill topography contrasting with the cliffs and slopes characteristic of the sedimentary formations.

Granite gneiss is the most abundant type but biotite schists, garnet gneisses and pegmatitic granites are also found.

Immediately below the contact with the Cambrian Flathead quartzite as exposed in Ashbough Canyon there are about two feet of crumbly red and purple material overlying the orange brown of the gneiss. The schistosity of this material is parallel to the bedding of the Flathead in contrast to the almost

vertical orientation of the gneiss, and may represent the weathered portion of the old pre-Cambrian surface.

Cambrian system

Flathead quartzite. The Flathead quartzite was named by Peale (1893, pp. 20-21) for exposures in Flathead Pass in the northeast corner of the Three Forks quadrangle, Montana. The formation is remarkably persistent and is found in Montana and northwestern Wyoming where it lies in most places at the bottom of the Paleozoic section. It is Middle Cambrian in age.

In this area the Flathead is best exposed in Ashbough Canyon where it rests with angular unconformity upon the pre-Cambrian. The section is as follows:

- (5) Sandstone with considerable shale forming a covered slope-----100' app.
- (4) Quartzite, hard tan, weathers reddish----- 14'
- (3) Quartzite conglomeratic, with pebbles up to one and a quarter inches in diameter in reddish sand and shale matrix----- 5'
- (2) Sandstone, crossbedded, fine grained, light tan----- 8'

(1) Basal conglomerate with pebbles

up to 1/4 inches in diameter----- 4'

The total thickness is about 125 feet. Little of this thickness is resistant and the Flathead does not form significant outcrops. No fossils are found. The Flathead is conformably overlain by the Wolsey shale.

Wolsey shale. The Wolsey shale was first described by W. H. Weed (1900, p. 285). The formation is Middle Cambrian in age and occurs in central western, central northern and central southern Montana and to the southwest of these areas. Locally it is exposed in Ashbough Canyon where it grades from the shaly upper beds of the Flathead into a gray to greenish gray micaceous shale very similar to that given for the type section. There were, however, no nodules of limestone observed such as those at the type section that contain fossils. It forms debris covered slopes below the Meagher limestone and has a general thickness of 150 feet. The Wolsey is conformably overlain by the Meagher limestone.

Meagher limestone. W. H. Weed described the Meagher limestone in 1899. Its age is Middle Cambrian and it occurs chiefly in central Montana generally succeeding the Wolsey shales. In the thesis area the Meagher limestone is exposed in Ashbough Canyon

and north west of the canyon along the fault scarp. It consists of massive dolomitic rock forming high cliffs that weather to a light orange gray as seen from a distance. The fresh rock is gray and weathers irregularly to a reddish or yellowish tan. It has a medium texture with calcite stringers and small vugs. The total thickness of the Meagher is about 550 feet. The Meagher is conformably overlain by Park shale.

Park shale. The Park shale was first named by W. H. Weed (1899) from exposures in the Little Belt Mountains. It conformably overlies the Meagher limestone. It occurs throughout central northern, central southern Montana and westward of these areas. It is Middle Cambrian in age.

The formation is exposed in Ashbough Canyon and along the fault scarp to the northwest of the canyon. It is a thin-bedded, crumbly rock of medium gray to greenish gray color with some layers of reddish rock. It contains flakes of mica similar to the Wolsey. The formation forms covered slopes between the Meagher and Pilgrim limestones and has a total thickness of about 155 feet. It is conformably overlain by Pilgrim limestone.

Pilgrim limestone. The Pilgrim limestone was first described by W. H. Weed (1899) and named from exposures in the valley of Pilgrim Creek in the

southwest corner of the Fort Benton quadrangle. It is found in central western, central southern and central northern Montana. It is Upper Cambrian in age.

The Pilgrim limestone is well exposed in Ashbough Canyon and along the fault scarp to the northwest. It is a dense gray dolomitic limestone forming cliffs that weather white. It is overlain unconformably by the Jefferson limestone and has a thickness of about 90 feet. No fossils were found.

Devonian system

Jefferson limestone. The Jefferson limestone was first described by A. C. Peale (1893, pp. 25-32) and named for its exposures along the Jefferson River a few miles above its mouth at the Three Forks of the Missouri. It is found in Montana, western Wyoming, southeastern and southcentral Idaho, northern Idaho and northern Utah. It is Middle Devonian in age.

The Jefferson limestone is exposed high on the south end of Ashbough Canyon. It is a brown to black crystalline limestone with massive and thin-bedded layers. Although massive in appearance it splits into thin slabs. The thickness of the formation is about 82 feet. Some rather poorly preserved brachiopods were found and identified as *Athyris* sp. and *Delthyris* sp.

Three Forks limestone. A. C. Peale (1893, p. 29) named this formation from exposures at the Three Forks of the Missouri River near Three Forks, Montana. It is fairly widespread in Montana and is found in western Wyoming, southeastern Idaho and northern Utah. It is Upper Devonian in age. In the thesis area the Three Forks crops out high on the south wall of Ashbough Canyon. Where it comes down along the fault scarp it is also exposed although in most places covered with vegetation. It is a shaly limestone for most of its extent, thin-bedded and highly fossiliferous in some beds. The fossiliferous beds particularly may be coarsely crystalline or dense and dark gray. They weather to a dull brown. The total thickness is about 140 feet.

Numerous fossils were collected from the highly fossiliferous middle portion of the Three Forks. These included:

Cleiothyridina devonica (Raymond)

Cyrtospirifer whitneyi (Hall) var. gallatinensis

These are both diagnostic of the Three Forks limestone.

Leptaena "rhomboidialis" (Wilckens)

Chonetes sp.

Aulopera sp. Corallites widely separated 3/8" to 1/2"

Platyceras sp.

Fenistella sp.

Pinnatopora sp.

also crinoid stems and solitary horn corals.

Robert Scholten (1948) and W. O. Kupsch found a thickness of about 600 feet of Devonian Three Forks in an area some thirty miles to the south and west. In an area to the east of the foregoing W. J. Vaughn found a thickness of 197 feet.

Mississippian system

Madison Group. A. C. Peale (1893, pp. 33) described the Madison as a thick series of limestones, laminated and compact in the bottom portion, bluish gray in the middle and massive and cherty toward the top. The type section is in the Madison Range in the central portion of the Three Forks quadrangle. The Madison limestones are widespread in Montana and Wyoming and are also found in Idaho and northern Utah. They are Lower Mississippian in age.

The Madison in this area is divided into two formations; a lower, thin-bedded member called the Lodge Pole and an upper, more massive member called the Mission Canyon. The Madison group, and in particular the Mission Canyon, is well exposed along the high portions of the fault scarp and the high surface of the range and also in the mouths of

Irishman's Gulch and Sheep Canyon. The total thickness of the Madison is about 1,700 feet.

Lodge Pole limestone. A. J. Collier and S. H. Cathcart (1922) described the Lodge Pole from exposures along Lodge Pole Canyon in the Little Rocky Mountains. It is found in central northern Montana. Exposures of this formation form cliffs and precipitous slopes along the face of the fault and are seen at the entrances to Irishman's Gulch and Sheep Canyon. It is a compact fine grained thin-bedded limestone with beds from 2" to a foot thick. It weathers to a lighter gray or brownish from a medium gray. The Lodge Pole is quite fossiliferous containing brachiopods, fenistella bryozoa and crinoid stems in abundance. The thickness of this formation is about 600 feet. It is conformably overlain by the Mission Canyon limestone.

Mission Canyon limestone. A. J. Collier and S. H. Cathcart (1922) named the Mission Canyon formation for exposures in Mission Canyon in the Little Rocky Mountain region. It is exposed particularly in central and northwestern Montana, and is Lower Mississippian in age.

In this area the Madison forms the greater part of the high back slope of the Blacktail Range in the vicinity of the western escarpment, and also stands up in spectacular vertical outcrops in Sheep

Canyon and Irishman's Gulch. The lower part of the formation is a very massive, gray limestone that weathers to a distinct bluish gray. Higher in the unit the limestone becomes more cherty with black and brown nodules and it weathers blotchy buff and yellowish. Although not so fossiliferous as the Lodge Pole the wide exposures of weathered rock on the high surface yields a large number of brachiopods, particularly productids. Several very coralline units were noted near the top of the formation, and a conglomeratic zone near the contact with the overlying Amsden.

The Mission Canyon forms cliffs or very precipitous slopes. The upper portion is apparently incompetent and is crumpled in many places into a "wavy" limestone. The thickness is about 1,100 feet. Fossils collected include:

Spirifer centronatus (Winchell)

Spirifer striatus var. madisonensis (Girty)

Platyceras sp.

Dictyoclostus sp.

Also cup corals, bryozoa, and crinoid stems.

Pennsylvanian system

Systemic boundary. The boundary between the Mississippian and the Pennsylvanian has been the subject of much controversy generally focussing on

the Amsden formation. Both Mississippian and Pennsylvanian fossils have been taken from the Amsden in various localities. Those found in the thesis area are generally non-diagnostic with a range from the Mississippian to the Permian although immediately below the selected contact with Quadrant sandstone was found the genus Juresania which is a Pennsylvanian form. The consensus appears now to assign the greater part of the Amsden to the Pennsylvanian with a transition to the Mississippian in the lower part.

Amsden formation. N. H. Darton (1904, p. 379) gave the name Amsden to a group of red shales, white limestones and sandy, cherty limestones exposed on the Amsden branch of the Tongue River. The formation is widespread in Wyoming and is also found in Montana. It was originally considered to be Mississippian in age from fossils found in the lower member only. It is now considered to be largely Pennsylvanian.

In the Blacktail Mountains the formation is thin and does not show the characteristic three-fold division. The only good exposure is in the upturned west wall beds of Sheep Canyon. It is apparently conformable on the Mission Canyon and, also conformable under the Pennsylvanian Quadrant. The section is less than a hundred feet thick and consists of:

- (7) Interbedded sandstones, sandy limestones and limestones transitional with the Quadrant sandstone.
- (6) Yellowish shaly limestone bed containing a considerable fauna.----- 1'
- (5) Yellowish brown limestone weathered from a light gray one and overlying a reddish purple limestone bed.----- 42'
- (4) Greenish gray limestone conglomerate.----- 5'
- (3) Reddish purple shaly limestone.----- 25'
- (2) Coarsely crystalline limestone that weathers sandy and white.----- 10'
- (1) Limestone conglomerate perhaps a portion of the top of the Madison.----- 10'

Fossils collected include:

Spirifer sp.

Dictyoclostus sp.

Rhipidomella sp. Particularly abundant below contact with Quadrant.

Juresania sp. Characteristic Pennsylvanian genus. The Amsden is conformably overlain by the Quadrant formation.

Quadrant formation. The name Quadrant was first applied by A. C. Peale (1893, pp. 39-43) to beds of cherty and red arenaceous limestone overlying the

Madison in the area of the Three Forks of the Missouri. W. H. Weed (1896) defined the Quadrant from exposures in Quadrant Mountain in Yellowstone Park, and in succeeding years the name was applied to strata of Pennsylvanian and Mississippian age overlying the Madison over large areas of Montana. H. W. Scott in 1935 pointed out that the lower portion of Weed's Quadrant section called talus was in reality the Amsden. The formation has more recently been restricted to the rocks lying between the Amsden and the Phosphoria. It is correlated on stratigraphic and paleontological evidence with the Tensleep and is found in Montana and northwestern Wyoming.

The Quadrant is best exposed in the thesis area in Sheep Canyon where near the mouth it forms the west wall and further south forms both walls. The sandstone is very massive, even grained and resistant although it appears rather porous and somewhat friable on a fresh surface. The dominant color is white or buff weathering to tan, red or brown or even purple or black in the talus. The lower sandstone portions are particularly massive and often cross-bedded whereas the upper portion becomes calcareous and contains some rather massive cherty limestone beds. The thickness is about 700 feet. A composite section in the Lima Peaks area south of this one shows some 2,970 feet of Quadrant of very similar lithology.

(Dillon, 1949, p. 25). In another area in the Tendoy Mountains a section of Quadrant was measured that totalled more than 3,300 feet (S. R. Wallace, 1948, p. 14).

The Quadrant is unconformably overlain by the Phosphoria.

Phosphoria formation. The Phosphoria formation was named by Richards and Mansfield from exposures in Phosphoria Gulch, Idaho (1912, p. 686). The formation is found in northeastern Utah, eastern Idaho, central western, central southern, and southwestern Montana and western Wyoming and is Permian in age.

In the thesis area the Phosphoria forms grassed slopes above the Quadrant in Sheep Canyon and has been trenched by the U. S. Geological Survey in Small Horn Canyon.

A personal communication from Mr. Klepper showed that the Phosphoria at Wadham Springs east of Lima has a thickness of 600 feet. It is divisible into five units. The thickness in the thesis area is only 350 feet but may be divided similarly.

- (5) Quartzitic tan sandstone.----- 100'
- (4) Mudstone and phosphatic rock.----- 65'
- (3) Black cherty sandstones and silt-
stones with massive black chert
near base.----- 140'

(2) Cherty siltstone and thin 1" bands
of phosphate (possibly equivalent
to the 4' to 5' bed at Wadham's
Springs) .----- 25'

(1) Tan slabby sandstones and silt-
stones gradational with the Quadrant.- 20'

No fossils were found in the Phosphoria in the thesis area. Dillon (1949, p. 18) found the Phosphoria to have a thickness of 417 feet in the Centennial Range some fifty miles south of the present area. There the upper parts of the Phosphoria were fossiliferous.

The Phosphoria in this area is unconformably overlain by the Dinwoody formation of Triassic age.

Triassic system

Dinwoody formation. D. D. Condit (1916, p. 263) first described the Embar formation, the lower part of which has become known as the Phosphoria, and the upper part of which described by E. Blackwelder (1918), has become known as the Dinwoody. The formation is named for the exposures along the Canyon of Dinwoody Lakes in the Wind River Range. It is found in western Wyoming and is Lower Triassic in age.

The Dinwoody formation in the thesis area is best exposed in Small Horn Canyon. It consists of brown sandstones and sandy shales and some thin-bedded

light gray limestones that weather to a purplish brown or brown color. In several beds of this limestone a characteristic blue chitinous lingula was found. It is unconformably overlain by the Thaynes limestone.

Fossils found were the species Lingula borealis?

Thaynes formation. The Thaynes formation was named by J. M. Boutwell (1907, p. 448) for exposures in Thaynes Canyon in the Park City District, Utah. It occurs in northeastern Utah, western Wyoming, and southeastern Idaho and is Lower Triassic in age.

In the thesis area the Thaynes is exposed on the east side of Small Horn Canyon and consists chiefly of siltstones, silty limestones and gray shales. The Meekoceras limestone found by Drexler (1949, p. 21) in the extensive exposures of Thaynes in the Red Peaks area was not observed in this area.

The Thaynes is unconformably overlain by the Morrison?

Jurassic system

Morrison formation. The Morrison formation was named by Eldridge (1896) from a town called Morrison near Denver where it is typically developed. The formation is largely one of fresh water or continental deposits.

The Morrison is exposed in the thesis area on the east side of Small Horn Canyon. Here it crops

out as red-brown to orange to greenish shales with red-brown siltstones and sandstones characterized by a large number of ripple marks and mud cracks. Its thickness is approximately 200 feet. It is unconformably overlain by the Cretaceous Kootenai formation.

To the south and west of the Blacktail Range beds of the Ellis group of Jurassic age occur in the Red Peaks area (Drexler, 1949), the Lima Peaks area, (Adam, 1948), the Tendoy Medicine Lodge area (Cummins, 1948) and in other places. This group which consists of three members, the Sawtooth, the Reardon and the Swift formations was not recognized in the area. Therefore the Morrison which in the areas to the southwest overlies the Ellis, in the Blacktails rests directly upon the Triassic Thaynes.

Cretaceous system

Kootenai formation. - The Kootenai was first described by J. W. Dawson in 1885 (pp. 531-532) from exposures in southern Alberta. Fisher (1909, pp.28-35) used the name Kootenai to refer to a coal bearing series which was found at Great Falls, Montana. The series is overlain by the Colorado shale and underlain by the Morrison formation. It is found in Alberta, British Columbia and Montana except the southern and southeastern parts. The age of the Kootenai formation is Lower Cretaceous.

In Small Horn Canyon the Kootenai rests unconformably on the Morrison formation. The basal beds are white, arkosic sandstones which weather to the same color and rounded forms. They are somewhat friable and porous. This is followed by tan, cross-bedded, weakly cemented sandstones and then more arkosic sands similar to the basal bed. A wide band of red shale separates this unit from the last distinguishable unit which is a thin-bedded, light gray sandstone. About 700 feet of Kootenai are exposed in the area and it is overlain by the Beaverhead or Red Rock conglomerate. Some limestones containing gastropods occur near the upper limit of the Kootenai in Small Horn Canyon. These limestones may correlate with the limestones found by Drexler (1949, p. 28) in the middle of the formation in the Red Peaks area.

The Cretaceous of Montana and Wyoming is noted for its salt and pepper sandstones and the basal beds of the Kootenai which is lowest Cretaceous in age contains this distinctive lithology. It is unconformably overlain by the Beaverhead or Red Rock conglomerate.

Tertiary system

Beaverhead (Red Rock) conglomerate. The name Red Rock conglomerate was first tentatively given to a thick, coarse conglomerate by Dr. A. J. Eardley. The formation is known to cover an extensive area

south of Lima and in the Red Conglomerate Peaks area. No fossils have been found that might serve to date the formation. It is known, however, to be pre-thrusting. Benner (1948, p. 35) points out that it is overlain by the Sage Creek formation of Upper Eocene age which would make the Beaverhead either Paleocene or early Eocene. Dr. A. J. Eardley has estimated the thickness to be about 2,000' feet near Lima.

The Beaverhead is composed almost entirely of conglomerates of varying sizes generally coarse. The source of the material is supposed to be rapidly uplifted highlands to the southwest because the conglomerates are in general finer towards the northeast.

In the Blacktail Range the Beaverhead is exposed on the western flank of Small Horn Canyon and also in a smaller area on the east side of the canyon where it rests upon the upturned Quadrant member of the Small Horn thrust. The conglomerate is chiefly composed of quartzites with some limestones and sandstones cemented with calcareous cement. The particles range up to 6" in diameter for the most part and are well rounded.

An isolated outcrop of a very coarse conglomerate containing boulders up to three feet in diameter is seen at the entrance to Sheep Canyon where it caps a truncated exposure of nearly vertical Lodge Pole limestone. The conglomerate which is composed of

quartzites, sandstones, and some limestones is not strongly cemented and probably is a portion of fan-glomerate derived from block faulting of the Blacktail Range.

Lower basalt. A black basalt which weathers to a brown color overlies the Quadrant formation on the west rim of Sheep Canyon near its southern extremity. It also underlies the Cook Ranch tuffs and therefore seems to correlate with the upper Eocene Sage Creek formation.

Cook Ranch formation. The Cook Ranch formation consists of volcanic clastics, breccia, tuffs, scoria, and interbedded rhyolite flows. The breccia and tuffs weather to a very characteristic white slope. A large portion of the area in the south and west is overlain by Cook Ranch deposits. The rhyolite is particularly prevalent in the south east part of the area. It has been tentatively called Oligocene.

Upper basalt. The Cook Ranch volcanics are unconformably overlain in many places by hard black basalt that weathers brown. It is amygdaloidal in many places with olivine phenocrysts. In other places it is vesicular with chalcedony and fillings of quartz. These are found capping the highest points in the southern part of the area with their summit levels dipping to the southwest about ten degrees. The age of the upper Basalts is probably Miocene.

Quaternary system

Recent deposits. The most recent deposits in the area are alluvial fans or aprons spread out at the foot of the escarpment. These cover any beds that may lie beyond the fault and are due to the last and most rapid movement along the fault.

Depositional environment

During Paleozoic time the region of the thesis area was largely one of shelf seas that were marginal to the Cordilleran geosyncline. The thickest of the Paleozoic strata are the Cambrian and Mississippian limestones which were laid down in troughs in the general shelf area. (Eardley, 1947-1 and Deiss, 1938.) In Mesozoic time the area was again one of shelf sea deposition with some terrestrial beds also laid down. (Eardley, 1947-2.) The formations of the Mesozoic were generally thin until the Cretaceous when deposits over 5,000 feet thick accumulated over a wide area of the shelf. In general the Cordilleran geosyncline deepened and the accumulation of sediments was greater to the south and west of the thesis area.

The greater amount of deposition to the west and south of the area and corresponding lesser amount of deposition to the east and north is illustrated by the thicknesses observed in the surrounding region.

North of the area near Dillon Shenon (1931) measured a thickness of Madison limestone of 1,200 feet compared to a thickness of 1,700 feet in the Blacktail Range. Forty miles east of the area near the west fork of the Madison River, Vaughn (1948) observed 2,600 feet of Paleozoic and 2,000 feet of Mesozoic sediments. This contrasts with the greater thickness in the Blacktail Range where there are 4,200 feet of Paleozoic and 2,100 feet of Mesozoic rocks. Fifteen miles to the southeast in the Tendoy Mountains Brandt (1949) found a thickness of 5,100 feet of Paleozoic rocks which is an increase of 900 feet over the section found in the thesis area. In the Tendoy Mountains thirty miles to the southwest Wallace recorded a thickness of 14,000 feet of Carboniferous beds alone, and also found 4,200 feet of Mesozoic beds.

The Tertiary was a period of terrestrial deposition with uplift supplying coarse and fine clastics to intermontane valleys. Vulcanism produced large quantities of tuffs and lavas.

STRUCTURAL GEOLOGY

Regional features of southwestern Montana

Arrangement of mountain ranges. The mountains of southwestern Montana take three major directions: the northeast-southwest is represented by the Snowcrest, Ruby and Gravelly Ranges, the northwest-southeast by the Tendoy, Red Rock, Beaverhead and Blacktail Mountains, and the east-west by the Centennial Range. These three directions produce a complex structural pattern suggesting an equally complex orogenic history for the area.

Periods of orogeny in southwestern Montana

Laramide folding and faulting. Laramide structures in southwestern Montana have been referred to three episodes of deformation. The first two produced northeast trending folds and minor faults. The third episode of the Laramide orogeny gave rise to thrust sheets athwart the earlier folds and trending in a northwest direction.

The earliest Laramide orogeny is probably pre-Paleocene. A prominent element in the structure of this episode is the Snowcrest Range which contains part of the east limb of a northeast striking anticline.

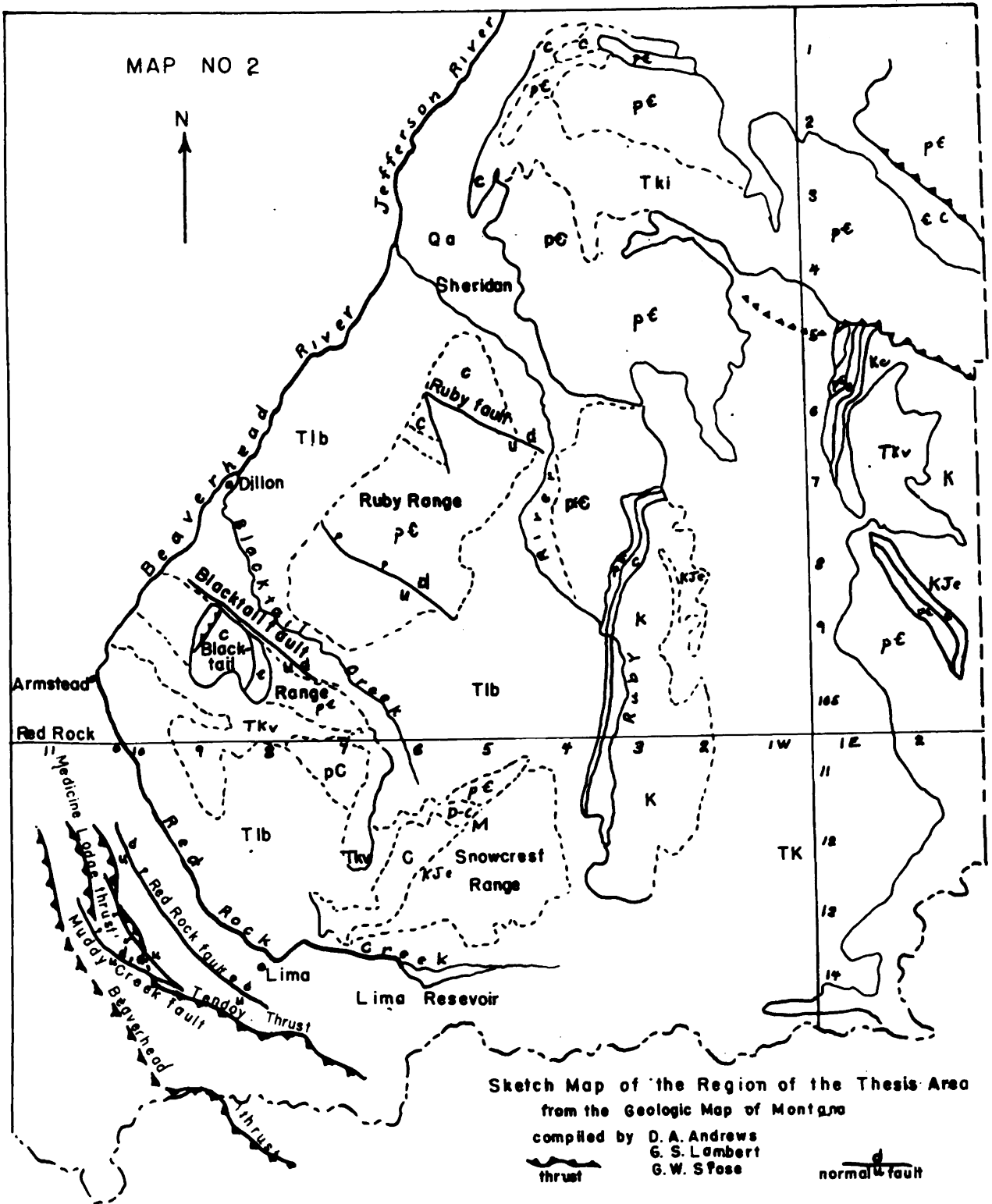


Plate 3

The second period of Laramide orogeny is probably post-Paleocene. It is represented by northeast folding of the Paleocene or early Eocene Beaverhead conglomerate along the Snowcrest Range and other places.

Late Laramide orogeny produced three thrust sheets crossing the earlier structures and containing elements of them. (See sketch map.) From east to west the thrusts are the Tendoy, the Medicine Lodge, and the Beaverhead. These thrusts strike northerly to northwesterly and have moved eastward. To the north Bevan (1929, p. 448) recognized another zone of faults which have a similar strike and direction of thrust.

Post-Oligocene normal faulting. (See sketch map.) A number of high angle normal faults have been recognized in southwestern Montana. They all trend northwesterly and produce horsts, grabens, and simple fault block mountains.

Cummins (1948, p. 37) mentions four normal faults which form the graben of the Muddy Creek Basin, the horst of the Tendoy Mountains, and a tilted fault block the Red Rock Basin. The Ruby Range is cut in the center and on the north by normal faults with northwest trend.

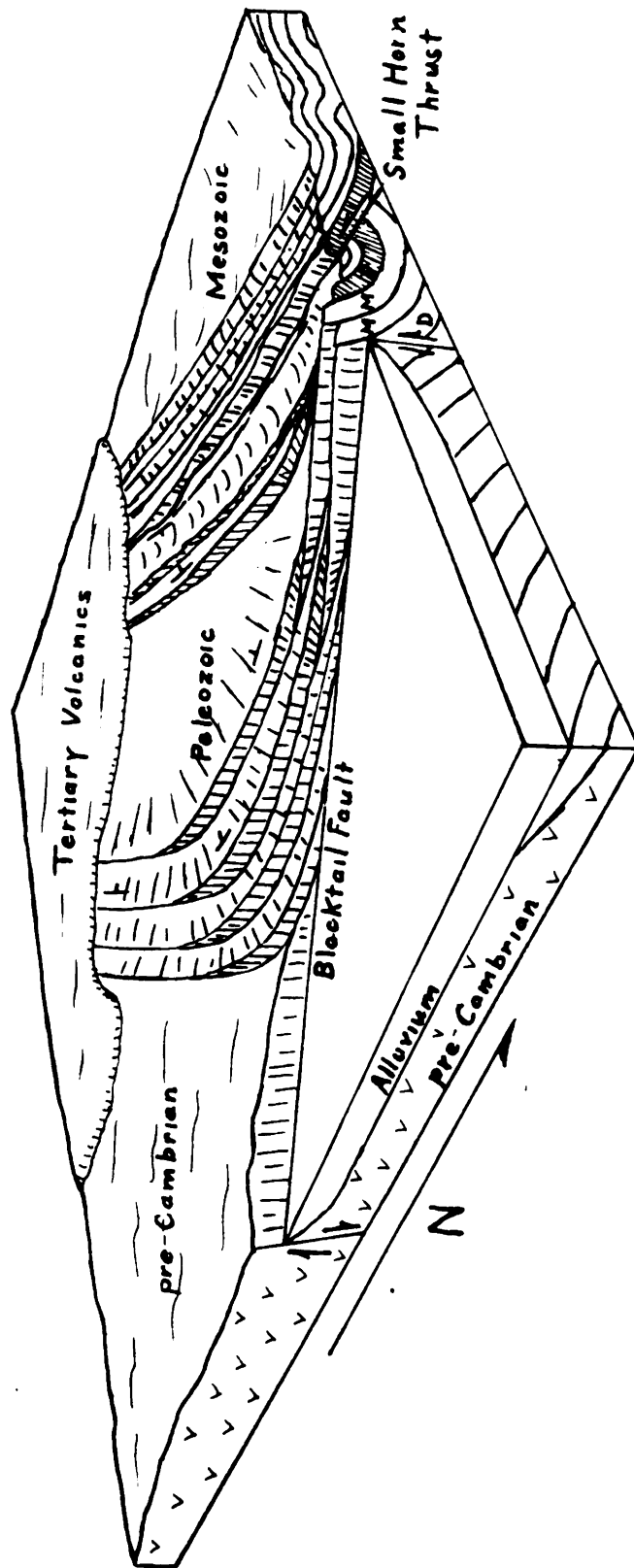


Fig. I Diagrammatic view of the structure of the Blacktail Range.
 There is no attempt to show topography.

Laramide structures in the area

In the eastern part of the area Paleozoic beds strike northeasterly and dip to the westward off the pre-Cambrian. In the western part of the map area a northeasterly trending syncline and a northerly trending anticline occur. Along the escarpment of the Blacktail Range in the northwest part of the area are abruptly upturned beds that strike northwest. (See Fig. 1.)

The eastern uplift consists of Cambrian, Devonian and Mississippian beds that strike N 30 degrees E and lap upon the pre-Cambrian with dips from 15 to 20 degrees to the west. (See Figs. 1 and 2.) The strike of these beds is almost parallel with the direction of the Ruby and Snowcrest Ranges. In the Snowcrest Range Mississippian beds strike N 30 degrees E and dip to the east. If the beds of the eastern part of the Blacktail Range and the beds of the western part of the Snowcrest Range are projected upward they form a major northeasterly trending anticline. This correlation with the structure of the Snowcrest Range puts the folding of the beds in the eastern part of the area in the early episode of Laramide orogeny.

In the west part of the area the beds dipping westerly pass through a syncline which involves the Quadrant, Phosphoria, Dinwoody and Thaynes formations. The west limb of the syncline is broken by a north

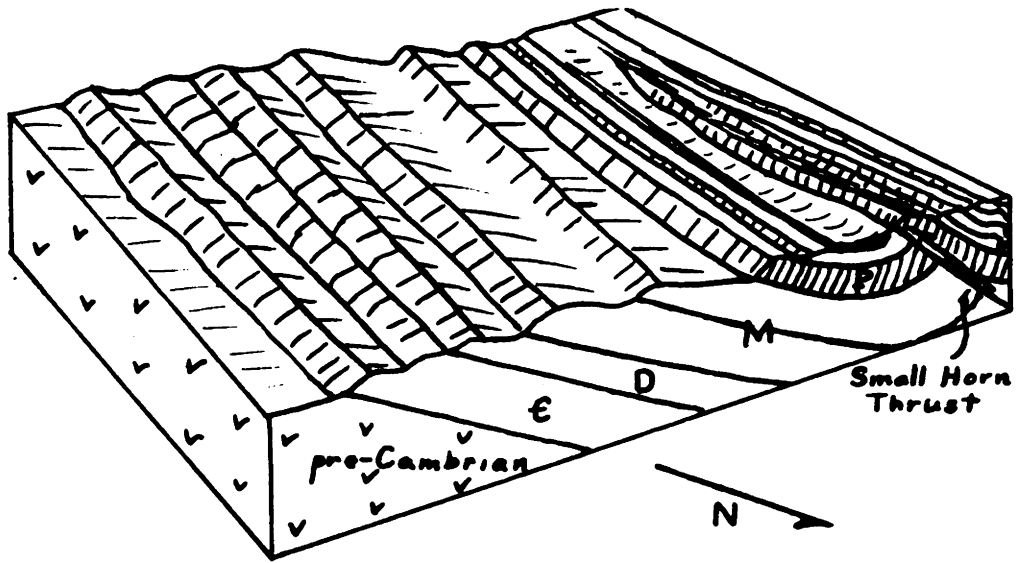


Fig. II. Diagram to show the effect of early Laramide folding on the structure of the Blacktail Range.

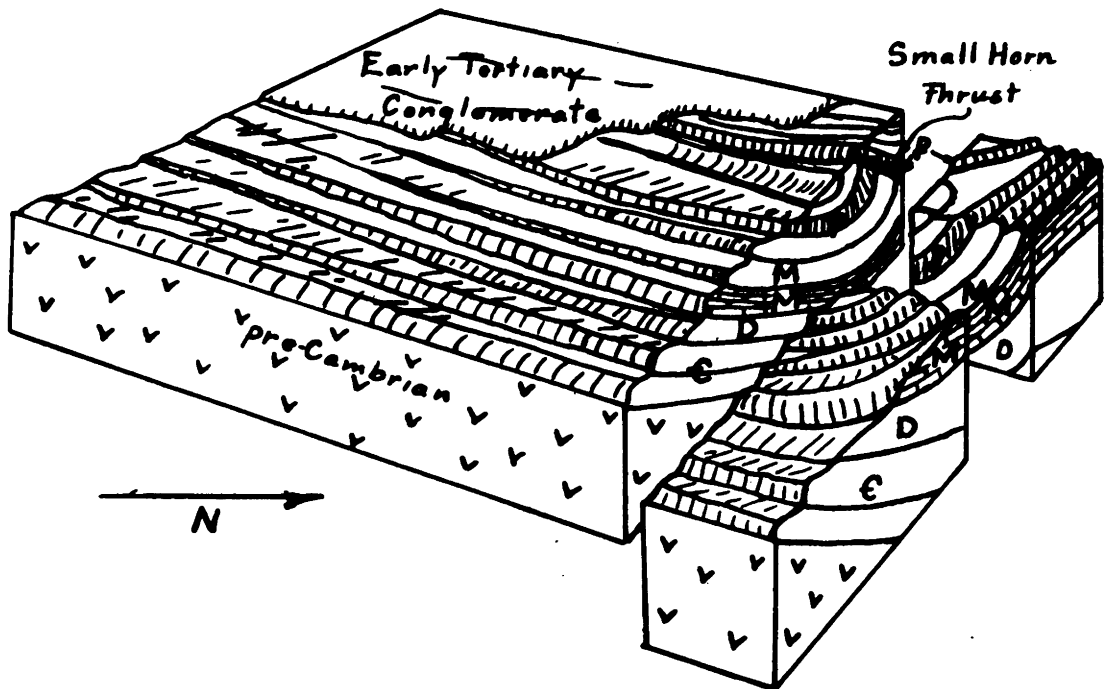


Fig. III Diagram to show the effect of late Laramide cross-folding on the earlier structure of the Black-tail Range.

trending fault termed here the Small Horn thrust. The Quadrant has been thrust over the Phosphoria with a maximum stratigraphic displacement of something over a thousand feet. The south end of the thrust is covered by Oligocene Cook Ranch volcanics. The angle of thrust is high, probably 40 degrees or more, judging from the high dips of the beds in the thrust sheet.

The upturned and in places folded rocks of the thrust sheet are overlain unconformably by the Paleocene Beaverhead conglomerate. The age of the thrust is therefore pre-Paleocene and belongs to the early Laramide episode of folding.

The only northwest trending structures in the area are upturned beds along the escarpment of the range in the northwest part of the area. The upturning involves the Madison limestone, and the Amsden and Quadrant formations. The strike of the beds is roughly N 40 degrees W making a small angle with the northeast front of the range. The dip on the beds ranges up to 80 degrees but diminishes rapidly to the southeast dying out into the general dip off the pre-Cambrian. The structure crosses the earlier folding mentioned above and closes the north end of the syncline. (See figure III)

The strike of these beds is very similar to that of late Laramide features such as the thrusts to the northeast and southwest of the area. The beds may

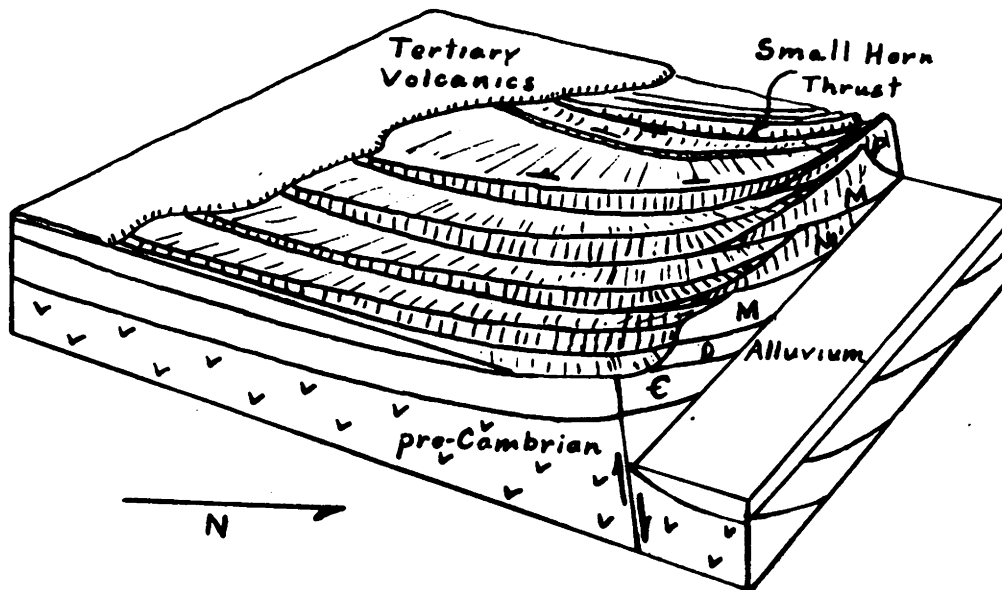


Fig. IV Diagram to show the effect of mid-Tertiary normal faulting on the structure of the Blacktail Range.

be part of the south limb of an anticline which trends similarly. The structure crosses and disturbs earlier structures as do the late Laramide thrusts to the southwest and so may be referred to the same orogenic episode.

Post-Laramide high angle faulting

The Blacktail fault. The northeast facing escarpment of the Blacktail Range is considered to be the site of a major late Tertiary normal fault here termed the Blacktail fault. (See map and Fig. IV.)

The evidence for such a fault lies first in the abrupt rise of the Blacktail Range to a height of several thousand feet above the alluvial valley. The escarpment is further remarkable for its straightness and consistent strike to the northwest. The face of the range consists of rocks from pre-Cambrian to Oligocene and several structures which are cut off indicating that no particular beds or previous structure forms the escarpment.

The age of the fault is at least post Middle Oligocene since the Cook Ranch volcanics have been tilted. However from the presence of alluvial aprons or fans at the foot of the escarpment which are very slightly dissected may be inferred that the faulting has continued up until very recent time.

There have been several effects of the movement along the fault. One has been the warping of the westerly dip of beds off the pre-Cambrian to a south-westerly dip in the vicinity of the escarpment. (See map and Fig. IV.) Another has been the production of three erosion levels or stages (see Fig. V) which are more fully discussed under Resume of post-Jurassic history.

Relation to other normal faults. (See sketch map.) The strike of the Blacktail fault is parallel or similar to almost all of the normal faults in the region. Other normal faults mapped in the region include those of the Medicine Lodge Basin area described by Adam (1948, p. 47), the Muddy Creek and Red Rock faults mentioned by Wallace (1948, pp. 45-46) and by Cummins (1948, p. 37) and also those of the central and northern Ruby Range. All of them are parallel, high angle, normal faults apparently belonging to the same system. The erosion surfaces found on the fault blocks also indicate that a similar series of movements occurred. (See Resume of post-Jurassic history #12, 13, 15 and Fig. 5.)

ECONOMIC GEOLOGY

The economic significance of the area is slight although parts of it have been rather extensively prospected. Test pits were noted along the pre-Cambrian-Cambrian contact in Ashbough Canyon and in the vicinity of the fault scarp. There was some slight evidence of mineralization. A small mine has been worked at the foot of the fault scarp near the middle of its extent in the area. (See geologic map.) In the mine dump were found malachite and azurite with calcite and quartz gangue. A dike like mass of milky quartz which strikes parallel to the fault crops out near the mine. The mineralization may be related to the block faulting and rhyolite flows in the area which may in turn be correlated to similar late epithermal mineralization associated with block faulting and rhyolite flows in the Butte district described by Billingsley (1918, pp. 321-324).

A number of outcrops of limonite gossan were found higher on the fault scarp which were apparently related to the bedding of the limestone. Test pits have also been put into these patches.

The United States Geological Survey has trenched the Phosphoria formation in Small Horn Canyon as part

of their investigation of the formation in southwest Montana. However little phosphatic rock appears to have been uncovered.

RESUME OF POST-JURASSIC HISTORY OF THE REGION

The following outline of events for the region of southwestern Montana was worked out by Dr. A. J. Eardley and students of the University of Michigan who did field work during the summer of 1948. Evidence for all of them is not found in the Blacktail Range but those indicated by an asterisk represent phases of the history which are shown in the area. These particular events have been elaborated upon.

*(1) Uplift (probably orogenic) of the Cordilleran geanticline and deposition of the Kootenai clastics; conglomerate generally at the base.

(2) Uplift (probably orogenic and lasting through most of upper Cretaceous) of the Cordilleran geanticline and deposition of the Colorado group of clastics.

*(3) Early Laramide orogeny to form northeast trending folds. Snowcrest Range is a prominent element.

To this period belongs the uplift of the Paleozoic and pre-Cambrian in the east part of the area and also the folds and thrust fault in the west part.

*(4) Deposition of the Beaverhead (Red Rock) conglomerate. The position of the highland was possibly to the southwest in Idaho, but the relation to the northeast trending folds is not yet clear. The

distribution and lithologic varieties of the conglomerate must be better understood before the location and character of the highland can be discerned.

In the thesis area a very coarse conglomerate consisting mainly of quartzitic boulders caps a small outcrop of upturned Lodge Pole limestone in the mouth of Sheep Canyon. It is rather poorly cemented with calcium carbonate and may represent recemented material derived during the block faulting from the Beaverhead. It rests upon structures which are considered to have been formed during late Laramide time. Therefore the conglomerate is probably not Beaverhead in age since in all other places noted the Beaverhead is affected by the late Laramide orogeny.

(5) Mid-Laramide orogeny; a second episode of northeast folding resulting in upturning of the Beaverhead Conglomerate along the Snowcrest Range and folding of the conglomerate in other places.

*(6) Late Laramide orogeny; formation of three thrust sheets athwart the northeast trending folds. The thrusts strike northerly and northwesterly and contain elements of the northeasterly folds. All over-ride the Beaverhead conglomerate. The thrusts from east to west are the Tendoy fault, (north of Sheep Creek Canyon), Medicine Lodge (from Medicine Lodge Pass, Idaho-Montana line to Armstead and beyond, and Beaverhead (pre-Cambrian, pink granite gneiss sheet

and klippen in Medicine Lodge Valley west of Armstead).
(See sketch map.)

To this period of orogeny is assigned the folded structure at the northwest end of the area which cuts across the earlier Laramide structures. (See Fig. 3.)

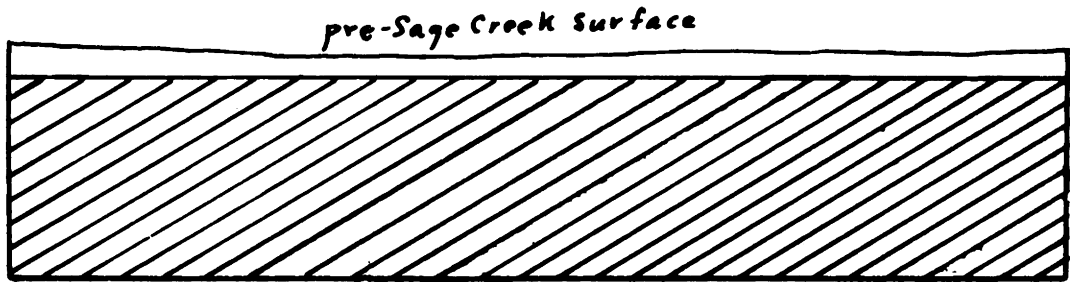
*(7) Long erosion and possibly some additional crustal movements during lower middle and early upper Eocene time which resulted in the formation of great, broad intermontane valleys.

The surface now found as high remnants on the Madison and Quadrant near the fault face may have been produced in this period.

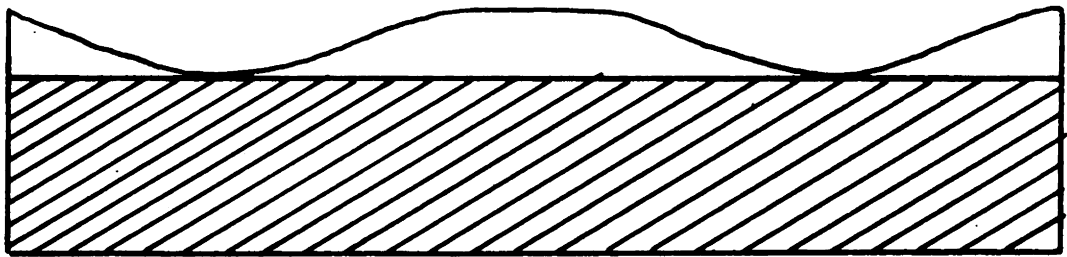
*(8) Vulcanism broke out in nearby regions, focussing in Yellowstone Park and Absaroka Range. This started in late Eocene. Vulcanism of superior magnitude also occurred in the Coast Range region of Washington and Oregon at this time. It resulted in damming of drainage ways and abundant ash and dust falls. The alluviation of the great intermontane valleys of southwestern Montana was heavy. Deposition of Sage Creek formation (late Eocene) in Southwestern Montana, and other formations of equivalent age elsewhere took place over a wide region.

To this era of vulcanism may the basalts that underlie the Cook Ranch beds be assigned.

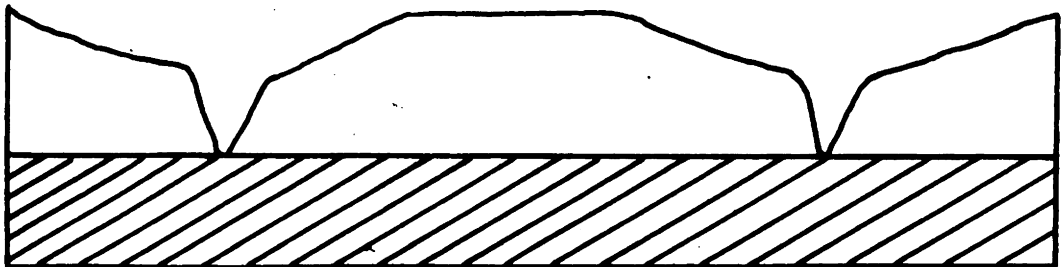
(9) Gentle deformation and erosion in early Oligocene.



Early block faulting; pre-Sage Creek surface
exhumed.



Second episode of block faulting; wide valleys
in uplifted block.



Third episode of block faulting; deep canyons
formed in fault block.

Fig. V The sequence of development of the three
erosional surfaces of the Blacktail Range that are
related to mid-Tertiary normal faulting.

*(10) Continued vulcanism nearby and deposition of Cook Ranch beds in middle Oligocene time on the Sage Creek Beds. Contact is obscure and the extent of erosion is not known.

In the Blacktail Range the Cook Ranch beds are volcanic clastics interbedded with flows of rhyolite. These cover the south portion of the area. Isolated beds of rhyolite beyond the fault scarp at the north end of the area may also belong to this period of vulcanism.

*(11) Early episode of block faulting. Vulcanism broke out at the north end of the Blacktail Range and extensively in the Snake River Valley and Yellowstone Park and the Columbia Plateau. Deposition of Lower Miocene Blacktail Deer beds and associated basalts, tuffs and agglomerates in Upper Sage Creek, along the northwest flank of the Snowcrest Range and in the Ruby Basin. These have been called Passamari by Dorr and Wheeler.

This was the time of deposition of the olivine basalt on top of the Cook Ranch volcanics.

*(12) Erosion to extensive surfaces of moderate relief. In places the pre-Sage Creek surface may have been exhumed and become coextensive with this post-Blacktail surface. This is present now in the summit areas of the Blacktail Range where the lower Miocene basalts and tuffaceous beds are gently beveled.

(See Fig. 5.)

This surface is best seen in the basalt capped hills of the southern part of the area where erosion has proceeded slowly. The gentle dip of less than 10 degrees seen on the summit of Blue Mountain near the fault face is shown also in the rear of the fault block on the basalts. The elevation of this surface varies from over 9,200 feet on Blue Mountain to over 8,500 feet in the south. The tilt is due to later block faulting. The highest surface mentioned by Adam (1948) as being related to the block faulting in the Tendoy Mountains is at 7,500 to 8,500 feet. He also states that some of the ridges of the Tendoy rise to 9,000 feet. Thus the surfaces recognized by Adam are rather similar to that noted in the Blacktail Range and the differences may be related to the extent of the normal faulting in the Ranges. (See Fig. 4.)

*(13) A second episode of block faulting.

This was followed by a rather extensive erosion of shallow valleys by streams draining the faulted block. The valleys now appear as gently sloping surfaces intermediate between the highest surface and the present valleys. The formation of the rather broad valleys was controlled to a certain extent by stripping on the dip slope of the Mission Canyon formation. The elevation of the surface varies from 6,700 feet to over 7,000 feet. Adam (1948, p. 56)

has recognized an intermediate erosion surface in the Tendoy Mountains at 6,700 to 7,000 which apparently correlates with this one. (See Fig. 5.)

(14) Deposition of upper Miocene and lower Pliocene Madison Valley beds in Ruby Basin.

*(15) Regional uplift, in places possibly more block faulting, and erosion of extensive pediments. Those on the northwest side of the Snowcrest Range were the most extensively and perfectly developed. Pediments on the basin beds of the back valleys in Beaverhead Range (graben valleys) are of this age. In valleys like Beaverhead River, Blacktail Creek, and Sweetwater, downfaulting was so extensive that alluvial aprons were deposited along the base of the fault scarps.

These alluvial aprons are well exposed on the north side of the Blacktail Range. In addition the downfaulting or uplift was so rapid along the Blacktail fault that the streams such as those that drain Ashbough Canyon and Sheep Canyon cut downward vigorously to form V-shaped valleys. (See Fig. 5.) The valley bottoms have a general elevation of over 6,000 feet. Adam (1948, p. 56) recognizes a similar system of valleys in the Lima Peaks Area with similar elevations.

*(16) Third episode of block faulting and alluviation in places. Gentle uplift in places and

dissection of pediments. Two episodes of glaciation in the Beaverheads, probably one before dissection and one after.

Since there is no evidence for further block faulting in the Blacktail Range, the gentle uplift of the region may have been responsible for the slight dissection of the alluvial aprons at the foot of the fault scarp. Blacktail Creek and its tributaries have cut down some twenty feet into the fans.

(17) Continuation of block faulting at the front of the Tendoy Range in modern times.

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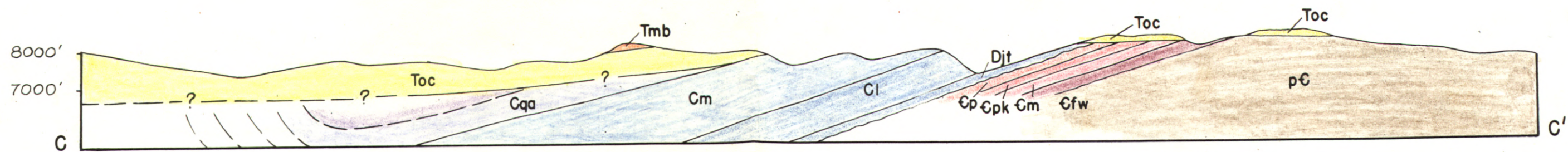
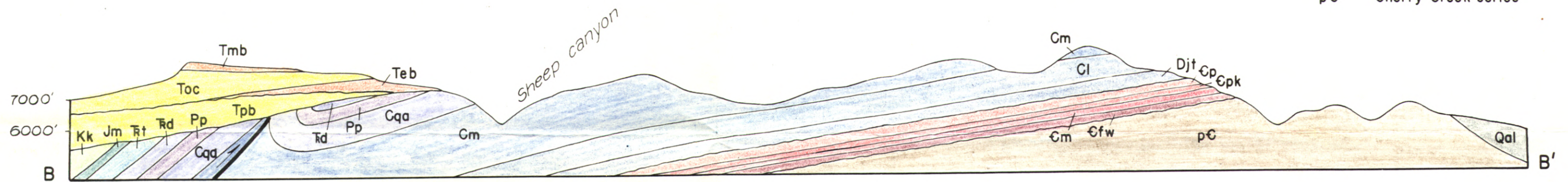
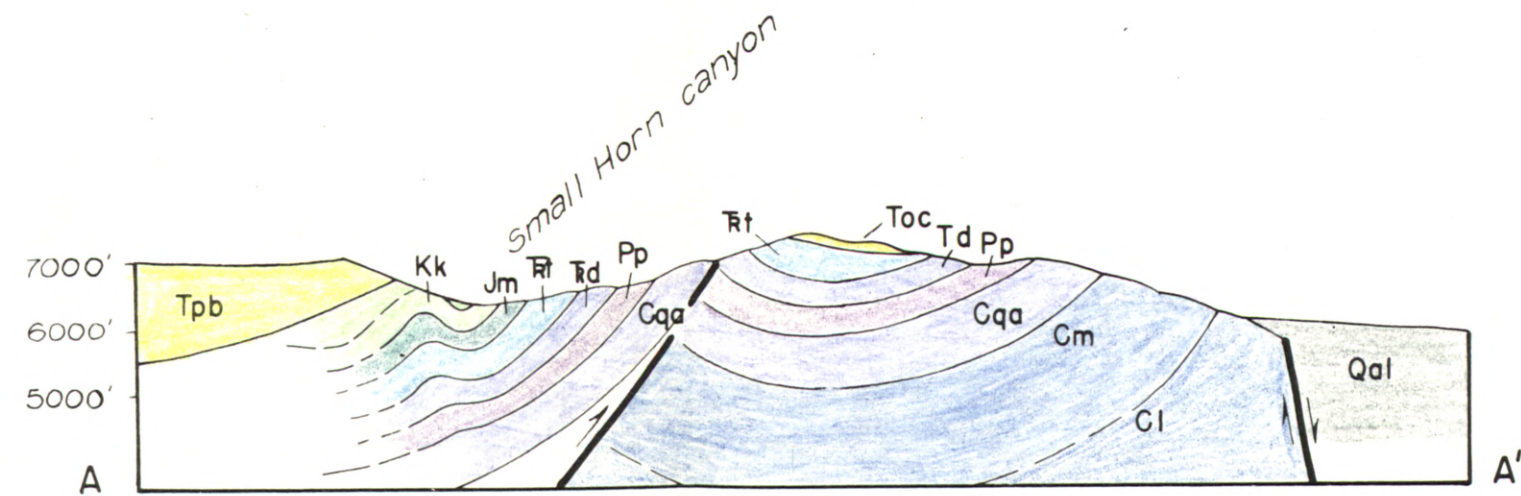
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DATE DUE

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- Qal Alluvium
- Tmb Miocene basalt
- Toc Cook Ranch fm.
- Teb Eocene basalt
- Tpb Beaverhead congl.
- Kk Kootenai fm.
- Jm Morrison fm.
- Rt Thaynes ls.
- Rd Dinwoody fm.

- Pp Phosphoria fm.
- Cqa Quadrant-Amsden fms.
- Cm Mission Canyon ls.
- Cl Lodgepole ls.
- Djt Jefferson ls., Three Forks sh.
- Ep Pilgrim ls.
- Epk Park sh.
- Em Meagher ls.
- Efw Flathead qtzite, Wolsey sh.
- pC Cherry Creek series



1 mile

CROSS SECTIONS FOR GEOLOGIC MAP

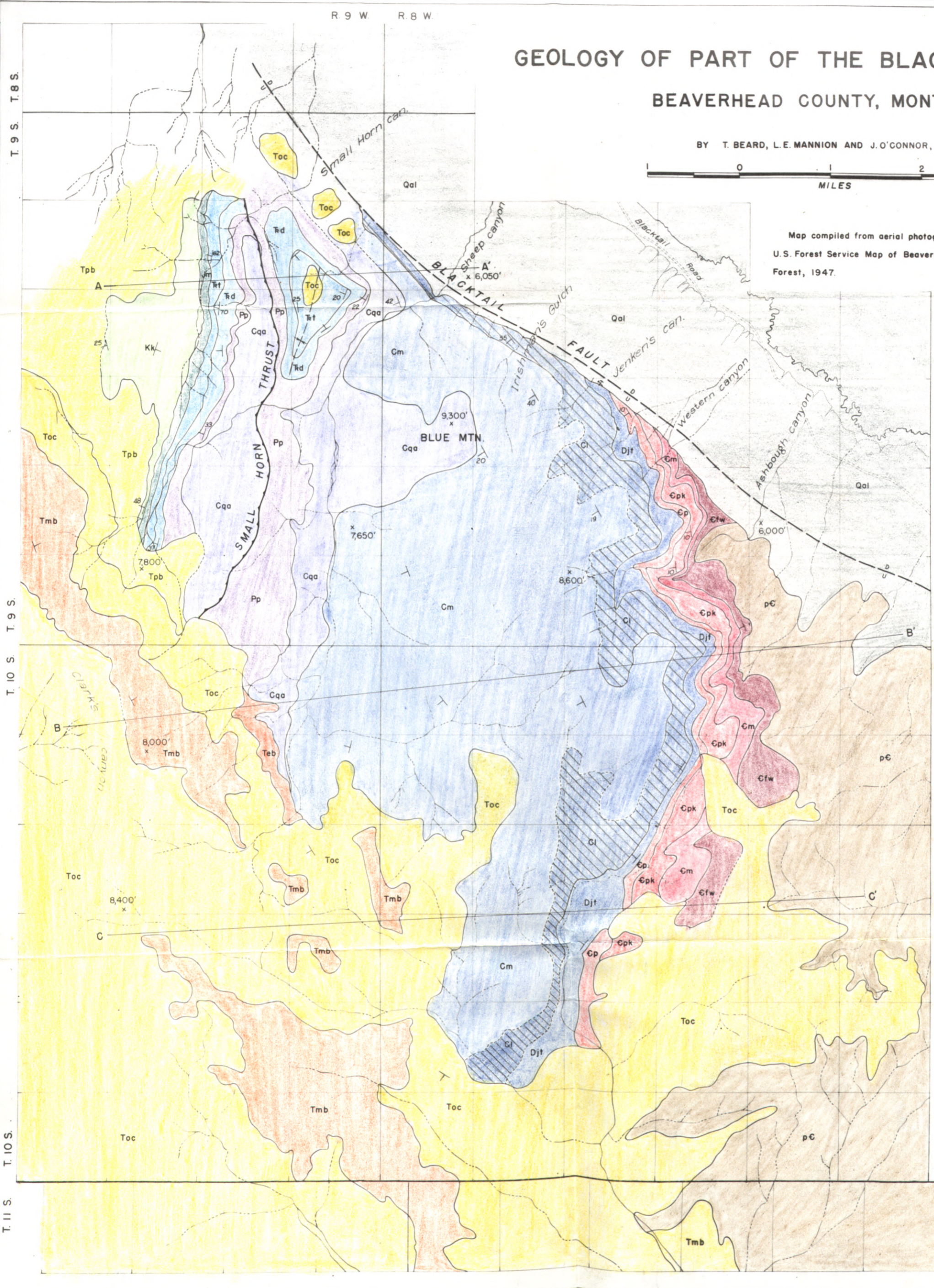
T. BEARD
L.E. MANNION
J.O. CONNOR

GEOLOGY OF PART OF THE BLACKTAIL RANGE BEAVERHEAD COUNTY, MONTANA

BY T. BEARD, L. E. MANNION AND J. O'CONNOR, 1948



Map compiled from aerial photographs. Control,
U.S. Forest Service Map of Beaverhead National
Forest, 1947.



EXPLANATION

QUATERNARY	Qal	Alluvium
	Tmb	Miocene Basalt
TERTIARY	Toc	Cook Ranch formation
	Teb	Eocene basalt
	Tpb	Beaverhead conglomerate
CRETACEOUS	Kk	Kootenai formation
JURASSIC	Jm	Morrison formation
TRIASSIC	Tt	Thaynes limestone
	Td	Dinwoody formation
PERMIAN	Pp	Phosphoria formation
PENNSYLVANIAN	Cqa	Quadrant-Amsden fms.
MISSISSIPPIAN	Cm	Mission Canyon limestone
	Cl	Lodgepole limestone
DEVONIAN	Djt	Jefferson ls., Three Forks sh.
	Cp	Pilgrim limestone
	Cpk	Park shale
CAMBRIAN	Cm	Meagher limestone
	Cfw	Flathead qtzite, Wolsey sh.
PRE-CAMBRIAN	pC	Cherry Creek series

