

University of Montana

## ScholarWorks at University of Montana

---

Graduate Student Theses, Dissertations, &  
Professional Papers

Graduate School

---

1960

### Geology of the Weasel Creek area northern Whitefish Range Flathead and Lincoln Counties Montana

David Allan Bentzin  
*The University of Montana*

Follow this and additional works at: <https://scholarworks.umt.edu/etd>

**Let us know how access to this document benefits you.**

---

#### Recommended Citation

Bentzin, David Allan, "Geology of the Weasel Creek area northern Whitefish Range Flathead and Lincoln Counties Montana" (1960). *Graduate Student Theses, Dissertations, & Professional Papers*. 7085.  
<https://scholarworks.umt.edu/etd/7085>

This Thesis is brought to you for free and open access by the Graduate School at ScholarWorks at University of Montana. It has been accepted for inclusion in Graduate Student Theses, Dissertations, & Professional Papers by an authorized administrator of ScholarWorks at University of Montana. For more information, please contact [scholarworks@mso.umt.edu](mailto:scholarworks@mso.umt.edu).

GEOLOGY OF THE WEASEL CREEK AREA  
NORTHERN WHITEFISH RANGE  
FLATHEAD AND LINCOLN COUNTIES, MONTANA

BY

DAVID A. BENTZIN

B.S. University of Wisconsin, 1958

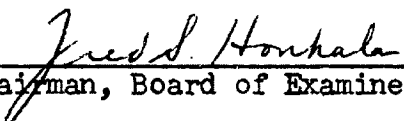
Presented in partial fulfillment  
of the requirements for the degree of


Master of Science

MONTANA STATE UNIVERSITY

1960

Approved by:

  
Chairman, Board of Examiners

  
Dean, Graduate School

MAY 27 1960

Date

UMI Number: EP37886

All rights reserved

INFORMATION TO ALL USERS

The quality of this reproduction is dependent upon the quality of the copy submitted.

In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if material had to be removed, a note will indicate the deletion.



UMI EP37886

Published by ProQuest LLC (2013). Copyright in the Dissertation held by the Author.

Microform Edition © ProQuest LLC.

All rights reserved. This work is protected against unauthorized copying under Title 17, United States Code



ProQuest LLC.  
789 East Eisenhower Parkway  
P.O. Box 1346  
Ann Arbor, MI 48106 - 1346

## TABLE OF CONTENTS

	page
ABSTRACT.....	v
INTRODUCTION.....	1
Location.....	1
Previous Work.....	3
Purpose of the Investigation.....	3
Present Study.....	4
Acknowledgements.....	5
PHYSIOGRAPHY.....	6
Geomorphology.....	6
Drainage.....	6
REGIONAL GEOLOGY.....	8
Structural Setting.....	8
STRATIGRAPHY.....	11
Ravalli Group.....	11
Piegan Group.....	14
Missoula Group.....	14
Cambrian.....	14
Devonian(?).....	19
Devonian-Mississippian(?).....	19
Mississippian.....	20
Pennsylvanian-Permian.....	20
Eocene(?).....	21
Pleistocene.....	21

STRUCTURE.....	23
Thrust Faults.....	23
Normal Faults.....	24
Folds.....	25
THE STRATIGRAPHY AND ITS STRUCTURAL SIGNIFICANCE.....	26
REFERENCES CITED.....	30
APPENDIX.....	32
Measured Sections.....	32

LIST OF ILLUSTRATIONS

	page
Figure 1. The Weasel Creek area and previous geologic work.....	2
Figure 2. Tectonic map of the Rocky Mountains at the International Boundary.....	9
Figure 3. Correlation chart of the Missoula group for northwestern Montana and southeastern British Columbia.....	12
Figure 4. Cambrian correlation chart for northwestern Montana and southeastern British Columbia.....	13
Plate I Geologic map of the Weasel Creek area	
Plate II Cross-sections for geologic map	

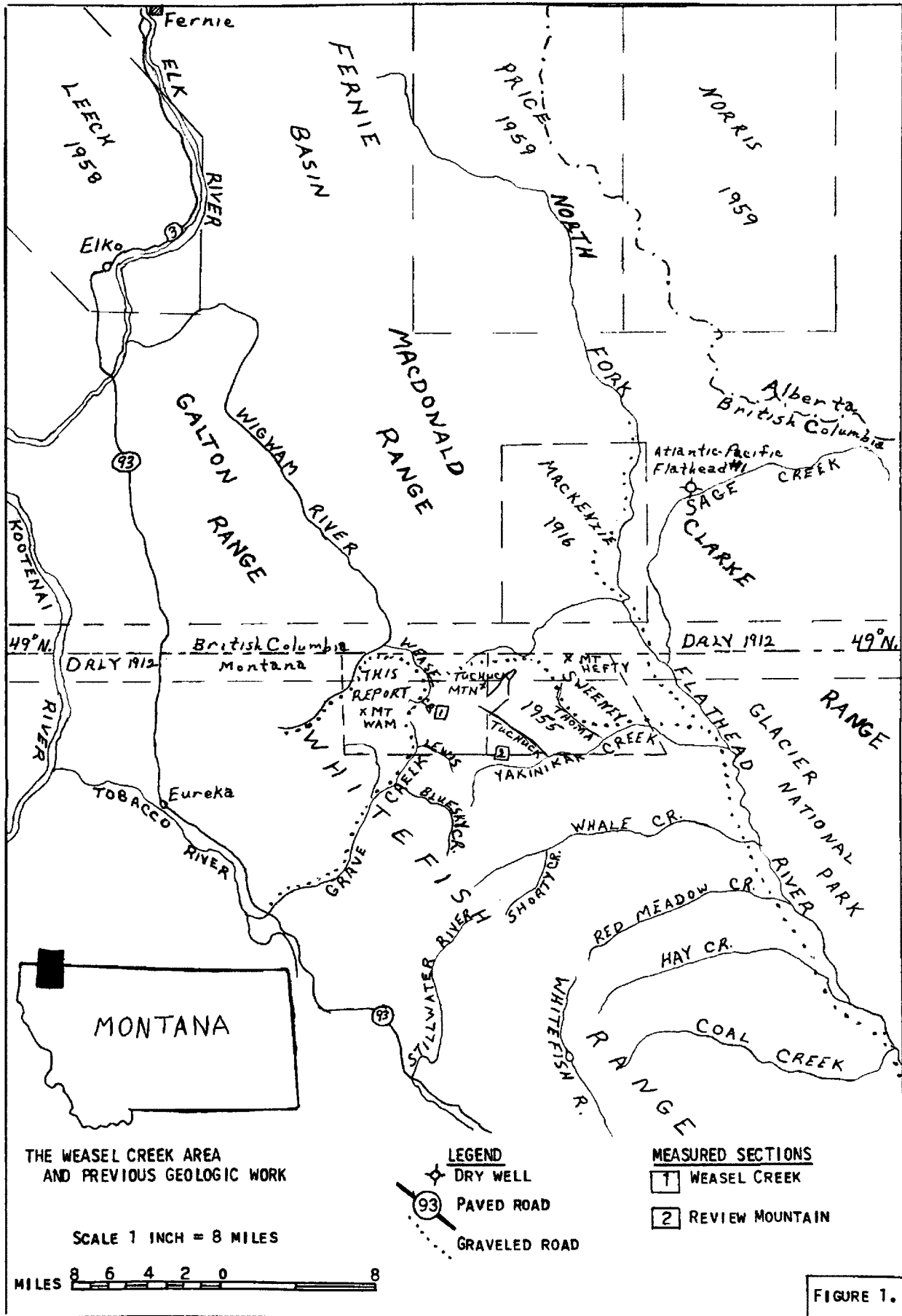
## INTRODUCTION

### LOCATION

The Weasel Creek area includes 40 square miles in T. 37 N., R. 24 and 25 W., Montana Base and Meridian, and is in the north central portion of the Whitefish Range, Flathead and Lincoln Counties, in northwestern Montana. The mapped area is bounded on the west by  $114^{\circ}40'$  West Longitude and on the east, with the exception of an additional traverse to resolve some local structure, by  $114^{\circ}50'$  West Longitude. The southern boundary of T. 37 N. is the southern boundary of the mapped area and the International Boundary at  $49^{\circ}$  North Latitude is the northern boundary (see Figure 1 and Plate 1). The area is in both the Flathead and Kootenai National Forests.

A graveled road along Grave Creek leaves U.S. Highway 93 about 8 miles south of Eureka and 11 miles southwest of the area. This road provides access except during parts of February, March, and April when the snow is too deep for logging operations or road maintenance. Temporary logging roads are present along many of the creeks in the area from the east side of the Whitefish Range by way of Yaknikak and Thoma Creeks and Frozen Lake. The roads are located in the valleys only, and the ridges must be reached by foot or on horseback. The numerous trails in the area are not currently maintained and hence cannot be depended upon for horseback traverses.

Field work is limited by heavy snowfall to the months of July, August, and September.





## PREVIOUS WORK

The only previously published work in the area is the reconnaissance survey along the Forty-Ninth Parallel by R. A. Daly (1912). An unpublished Master's thesis by G. L. Sweeney (1955) includes the area in a reconnaissance map of the Whitefish Range while detailed work by Sweeney borders the mapped area on the east. Other unpublished, but also unavailable, work includes recent reconnaissance studies by the California Company, Continental Oil Company, and Shell Oil Company.

Several shallow wells have been drilled in and immediately east of the valley of the North Fork of the Flathead River, particularly near Sage Creek. One deep well, the Atlantic-Pacific Flathead #1, was drilled to a total depth of 10,500 feet on the Sage Creek structure and was plugged and abandoned in 1954.

Of help in understanding the regional geology are the contributions of R. A. Daly (1912), G. S. Hume (1933), North and Henderson (1954), G. B. Leech (1958, 1959), R. A. Price (1959), D. K. Norris (1959), and Henderson and Dahlstrom (1959). New data from the Weasel Creek area now makes it possible to revise certain structural and stratigraphic interpretations previously presented by R. A. Daly (1912), J. D. MacKenzie (1916), and G. L. Sweeney (1955).

## PURPOSE OF THE INVESTIGATION

The main objective in studying the Weasel Creek area was to determine its structure for consideration of the petroleum producing possibilities. An allied objective was a study of the stratigraphy in the area.

## PRESENT STUDY

Two months were spent from July to September of 1959 in the northern Whitefish Range doing reconnaissance and detailed mapping. About half of that time was spent in the mapped area and the balance in adjoining areas. Field data were plotted on U.S.D.A. air photos of 1:20,000 scale. The data were then transferred to a U.S.C.G.S. topographic map of the of the Stryker Quadrangle enlarged to a scale of 1 inch equals 4,000 feet. This map was later enlarged to a scale of 1 inch equals 2,000 feet and the contour interval changed from 100 to 200 feet to provide the base for the geologic map of this thesis.

Most of the geological information was gained from the ridge crests and their west or south-facing slopes. The north- and east-facing slopes are generally heavily forested and the valley bottoms are covered with alluvium. Formation contacts, important intraformational units, and structural features were correlated between ridges where deemed possible.

Stratigraphic thicknesses were obtained from aerial photos and from measured sections in and near the area. Lithologic descriptions represent a composite of the measured sections and descriptions from individual field stations. The formations described by G. B. Leech (1958) in the Elko, British Columbia area are used in the Weasel Creek area because the lithologies and stratigraphic succession are similar.

## ACKNOWLEDGEMENTS

The author is grateful to Pan American Petroleum Corporation for permission to use data collected while in their employ. Special thanks are due two employees; Mr. J. J. Pedry for his helpful criticism during the course of the work, and Mr. W. F. Jirikowic for his assistance in the field. The assistance of Dr. F. S. Honkala, Dr. John Hower and other faculty members in this study is gratefully acknowledged.

## PHYSIOGRAPHY

### GEOMORPHOLOGY

The glacial geomorphic cycle in the Weasel Creek area developed to an early mature stage of glaciation as evidenced by steep-sided ridges and U-shaped, alluvium-filled valleys. Tuchuck Mountain, a horn rising 600 feet above the adjoining ridges, is the most prominent topographic feature in the area. Cirques are common on the north sides of the ridges but are not spectacular as their headwalls average only 400 to 500 feet in height and are commonly vegetated.

The ridges east of the Whitefish Fault generally trend N30W while those west of that fault trend more nearly north to south. The highest peak in the area and second highest in the Whitefish Range is Tuchuck Mountain, which is 7,713 feet above mean sea level. The lowest point is on Grave Creek and is at an elevation of 4,332 feet. The maximum relief is approximately 3,400 feet while the average relief is 1,700 feet.

### DRAINAGE

Drainage in the Weasel Creek area is in three general directions. Streams on the east side of the Whitefish Divide, which is the dividing line between Lincoln and Flathead Counties, flow east to the southeastward flowing North Fork of the Flathead River. The creeks in the southwest part of the area form the southwesterly flowing Grave Creek while those in the northwest part form Weasel Creek which flows into the northwesterly flowing Wigwam River just north of the International Boundary, which in turn flows into the Elk River, and then into the Kootenai River.

Tuchuck Creek and Ottertail Creek flow in valleys coincident with the Tuchuck Fault. The other creeks follow glacial valleys that may or may not be parallel to the strike of the beds.

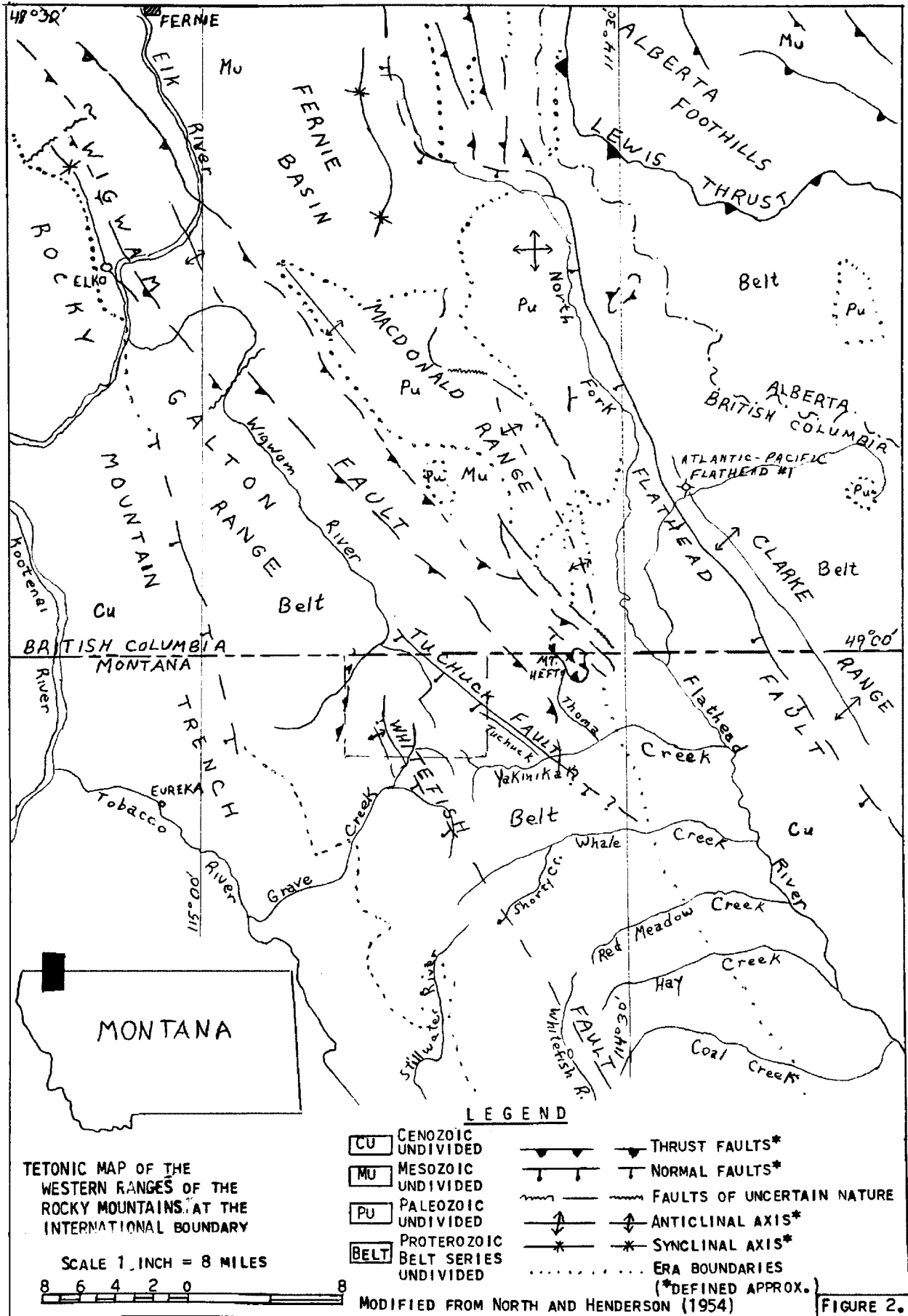
## REGIONAL GEOLOGY

### STRUCTURAL SETTING

The Weasel Creek area is located in the western ranges of the Rocky Mountains at the International Boundary. The regional tectonic map (see Figure 2) is modified from North and Henderson (1954) by the more recent work of Price (1959) and the author. The western ranges at the International Boundary are comprised of the MacDonald and Galton Ranges in Canada and the Whitefish Range in the United States.

These ranges are bounded on the west by the westward dipping normal fault separating them from the Rocky Mountain Trench and on the east by the valley of the North Fork of the Flathead River, a downwarped block along the west-dipping Flathead Fault. This fault separates the western ranges from the eastern ranges which are underlain by the gently west-dipping Lewis Thrust. This thrust plane probably dips steeply to the west in the vicinity of the North Fork valley, and the Flathead Fault later developed along the line of weakness of the steeply dipping fault plane and beds. Whether the Lewis Thrust underlies the western ranges at very great depth, is not known.

The western ranges are divided into two parts by the Wigwam Fault of Henderson and Dahlstrom (1959) which is tentatively extended into Montana to join the thrust present in the vicinity of Mt. Hefty. The Wigwam Fault is a thrust which places the Gateway formation of the Belt Series and younger formations, at least through the Cambrian, over Mississippian limestones. Belt and lower Paleozoic sediments contain folds and normal faults with minor thrust faulting to the west of the Wigwam Fault and including the Weasel Creek area. East of the



Wigwam Fault Paleozoic and Mesozoic rocks have been extensively folded and thrust faulted.



## STRATIGRAPHY

As stated previously, lithologic units of the Weasel Creek area are most similar to those described by Leach (1958) and thus are correlated with them. Group names are in accordance with Ross (1959). The rocks exposed in the Whitefish Range are mostly of the Belt series (Purcell series of Canadian literature) of Proterozoic age. In this range the Belt series is divisible into three groups named the Ravalli group, Piegan group, and Missoula group in ascending order. The oldest rocks in the Weasel Creek area occur in the middle of the Seyeh formation of the Piegan group in a fault block west of Rich Creek (see Plate 1). The first continuous section starts in the upper part of the Gateway formation in the Missoula group. The pre-Missoula group formations will be briefly considered although emphasis is placed on the Missoula group and its relationship to surrounding areas (see Figure 3). Some Paleozoic rocks are present in the eastern sector, as previously described, but, since they are highly folded and faulted and have been little studied, their age and relationship to the Fernie Basin section is uncertain. Correlation of the Cambrian is attempted on the basis of lithology and a sparse fauna (see Figure 4).

### RAVALLI GROUP

The oldest rocks in the Whitefish Range belong to the Ravalli group. Forty-two miles southeast of the Weasel Creek area on Teakettle Mountain near Columbia Falls, Montana the group consists of 2,500 feet of grayish-red and green argillite with abundant white, medium-grained, crinkly-

YAAK RIVER QUAD LINCOLN COUNTY, MONTANA JOHNS, 1960	ELKO BRITISH COLUMBIA LEECH, 1958	WEASEL CREEK LINCOLN Co., MONTANA THIS REPORT	CLARKE RANGE BRITISH COLUMBIA HUME, 1937	← AREA
NONE PRESENT	CAMBRIAN	CAMBRIAN	CAMBRIAN	AGE OF OVER- LYING FM.
LIBBY FM. 6,000 FT.		ROOSVILLE FM. 6,000 FT.		MISSOULA GROUP
	ROOSVILLE FM. 1,000 FT.		UNIT 4 2,000-2,500 FT.	
STRIPED PEAK 2,000 FT.	PHILLIPS FM. 500 FT.	PHILLIPS FM. 750-950 (?) FT.	UNIT 3 400 FT.	
	GATEWAY FM. 2,000 FT.	GATEWAY FM. 2,000 FT. (EST.)	UNIT 2 150 FT. UNIT 1 1200 FT.	
	THRUST PLANE AT BASE	PURCELL LAVA 100'	SHEPPARD FM. 400'-600' PURCELL LAVA 200'-300'	
WALLACE FM.		SIYEH FM.	SIYEH FM.	PIEGAN GP.

CORRELATION CHART OF THE MISSOULA GROUP FOR NORTHWESTERN MONTANA AND SOUTHEASTERN BRITISH COLUMBIA.

FIGURE 3.

CRANBROOK BRITISH COLUMBIA RICE (1937)	ELKO BRITISH COLUMBIA LEECH (1958)	WEASEL CREEK LINCOLN Co., MONT. THIS PAPER	FLATHEAD BRITISH COLUMBIA PRICE (1959)	PENTAGON MTN. FLATHEAD Co., MONT. DEISS (1939)	← AREA ↓ FAUNAL ZONE		
	DEVONIAN	DEVONIAN (?)	DEVONIAN	DEVONIAN	AGE OF OVERLYING FORMATION.		
EAGER FM. 6,000+	Elko 200'				APHELASPIS	UPPER CAMBRIAN DRESBACH	
	?			DEVIL'S GLEN DOL. 350'	CREPICEPHALUS		
				SWITCHBACK SH. 116'	CEDARIA - ARAPAHOIA		
	BURTON FM. 120'		UNNAMED IS. AND DOL. 220'		STEAMBOAT IS. 255'	DEISSELLA	MIDDLE CAMBRIAN
			ZACANTHOIDES ROMINGERI REESER		PENTAGON SH. 290'	OLENOIDES THOMSONASPIS	
			BURTON FM. 50' (?)		PAGODA IS. 365'	BATHYURISCUS ELRATHIA	
				UNNAMED DOL. 285'-350'	DEARBORN IS. 290'	EHMANIA	
				UNNAMED SH. 210'	DAMNATION IS. 190'	RECURRENT GLOSSOPLEURA	
				UNNAMED SS. 150'	GORDON SH. 275'	GLOSSOPLEURA - KOOTENAI ANORIA CLAVASPIDELLA	
					FLATHEAD SS. 120'	ALBERTELLA	
CRANBROOK CGL. 600'					OLENELLUS - BONNIA	LOWER CAMBRIAN	
					OBOLELLA		
PROTEROZOIC	PROTEROZOIC	PROTEROZOIC	PROTEROZOIC		AGE OF UNDERLYING FORMATION		

CAMBRIAN CORRELATION CHART FOR NORTHWESTERN MONTANA AND SOUTHEASTERN BRITISH COLUMBIA.  
MODIFIED FROM NORTH AND HENDERSON (1954).

FIGURE 4.

bedded quartzite bands ranging in thickness from two to sixty inches. The base was not exposed. The group does not crop out in the Weasel Creek area. Ripple marks and mud cracks are present but not abundant in the Ravalli group.

#### PIEGAN GROUP

Conformably overlying the Ravalli group on Teakettle Mountain is the Piegan group which consists of the Siyeh formation. The Siyeh formation is 4,500 feet thick and is distinguished from its neighboring formations by its more calcareous nature, although it seldom approaches limestone. The lower 500 feet are generally green, massive argillite which may be laminated with gray argillite with calcareous zones common. The middle 3,000 feet are calcareous blue-gray argillite which exhibit varying degrees of effervescence with dilute hydrochloric acid. The upper 1,000 feet are similar to the first unit and contain green argillite with intercalated gray argillite in some zones. Rezak (1957) identified three stromatolite zones within the Siyeh formation in Glacier National Park, but they were not recognized in the Teakettle Mountain section.

#### MISSOULA GROUP

The Missoula group, according to Ross (1959), is comprised of the first non-calcareous beds, and their successors, that overlie the Piegan group. In the Whitefish Range it consists of the Purcell lava at the

base and an overlying sedimentary column divided into the Gateway, Phillips, and Roosville formations.

The Gateway and Roosville formations are predominantly green and gray argillite whereas the Phillips formation is predominantly dark red in color with a basal portion consisting of green and red sandstones and quartzites. Similar units are found in both the Gateway and Roosville formations so they can only be identified with certainty by stratigraphic reference with the Purcell lava, the Phillips formation, or the Cambrian Burton formation, with the Burton formation being found only on the Roosville formation in this region.

The Purcell Lava: The Purcell lava, a single flow, conformably overlies the Siyeh formation. It crops out near the Weasel Creek area at the head of the Wigwam River, on the east wall of Blue Sky Creek and crossing Shorty Creek as it follows the general N30W strike. North of Shorty Creek it is approximately 100 feet thick and consists of altered diabase with quartz amygdules. Primary features are an agglomerate at the base and flow structure within the unit.

Another flow was seen to occur above in the red argillite zone of the overlying Gateway formation where it is crossed by Red Meadow and Hay Creeks. It is probably related to the lower lava but was not studied nor located accurately as it occurs at a horizon below those mapped in the Weasel Creek area.

The Gateway Formation: The formation is estimated to have a thickness of 2,000 feet in a section from Blue Sky to Lewis Creek. It consists predominantly of discontinuously laminated gray and green argillite of varying calcareous content and it commonly weathers to either a light gray or brown color. A 300 foot red argillite zone occurs approximately 200 feet above the base of the formation and a black argillite zone of undetermined thickness is found approximately 400 feet from the top of the formation near the Review Mountain section. Near Mt. Wam the middle portion of the Gateway formation contains some distinctive greenish-gray argillites with pink clay cross-laminations, but these do not seem to persist laterally.

A stromatolite bioherm consisting of Collenia symmetrica Walcott was encountered near the top of the formation in the Review Mountain section, but it does not correspond to any of the zones outlined by Rezak (1959) for the Glacier Park area. Mud cracks and ripple marks are abundant on some red argillite beds, but they are not generally present throughout the formation.

The Phillips Formation: A thickness of 770 feet for the Phillips formation was measured in the Review Mountain section 0.6 miles southeast of the Weasel Creek area while 7.0 miles to the west near Mt. Wam it was scaled from reliable contacts on the map to be 950 feet thick. The section near Mt. Wam may be thicker because of deposition or possibly because of unrecognized minor faults at the terminus of the Whitefish Fault.

The base of the Phillips formation is a white to light green quartzite varying in thickness from five feet in the western part of the Weasel Creek area to 58 feet in the eastern part. The basal quartzite is overlain by red sandstones and cross-bedded red and white quartzites which grade upward into red argillite. The upper 125 feet are interbedded red and green argillite with bedding ranging in thickness from one to six inches.

The Roosville Formation: The formation is 6,000 feet thick in the area but is terminated by a disconformity and thus was probably thicker when Beltian deposition ended. The predominant lithology is continuously laminated green and light gray argillite of varying calcareous content with some green fine-grained quartzites throughout the section. In the upper half of the formation the light gray argillite becomes more abundant than the green. The uppermost 100 to 200 feet consists of olive-colored sandstone and black argillite. A 140 foot zone of red argillite with subordinate gray bands is found 800 feet from the base.

A six inch thick bioherm of the stromatolite Collenia undosa Walcott was found on the ridge east of Weasel Lake and a well preserved colony of Collenia symmetrica Walcott was found in the float on the ridge north of Ottertail Creek. None of the stromatolite zones outlined by Rezak (1957) are found in the portion of the section present, however. Ripple marks and mudcracks are present on some beds but are not abundant throughout the formation.

The formation names proposed by Daly (1912) for the Weasel Creek area are abandoned because they denote a pre-Siyeh age. The fact that the beds are underlain by the Purcell lava and overlain by beds of Cambrian age indicate them to be of post-Siyeh age. Daly's assignment of the calcareous beds west of Rich Creek to the Siyeh formation is probably correct, however.

#### CAMBRIAN

Burton Formation: The formation is divided into a basal unit of predominantly quartz pebble grit overlain by a fossiliferous shale unit and is described from the Cambrian exposures near Camp Creek (see Plate 1).

The basal unit is 2 to 10 feet thick and consists of a red hematitic quartzite that varies in thickness to a maximum of one foot overlain by a pink to white quartz pebble grit up to 8 feet thick. The grit is entirely composed of poorly sorted quartz grains ranging from 1/16 mm to 1/2 cm in diameter. The larger grains are sub-rounded while the small grains are sub-angular. The grit has good porosity and very little siliceous cement. The unit is unfossiliferous.

The overlying shale unit is approximately forty feet thick and consists of fossiliferous green shale, red shale, and interbedded dolomite lenses approximately six inches thick. Several dorsal valves of the Middle Cambrian brachiopod, Prototreta trapeza Bell, were found in the green shale. The presence of the trilobite, Zacanthoides romingeri Reesor, further dates the shale as belonging to the Bathyriscus-Elrathia biozone.



Unnamed: An unfossiliferous carbonate unit overlies the shale unit with apparent conformity. It does not appear to be represented in the Elko section of Leech (1958) and thus is unnamed. Tentative correlation may be made with the Steamboat limestone of the Pentagon Mountain section, however (see Figure 4). A complete section of the unit is not found anywhere in the Whitefish Range but is thought to be approximately 200 feet thick. The base consists of 10 to 20 feet of black, finely crystalline limestone with limonite mottlings and is overlain by an estimated 180 feet of white crystalline limestone that is terminated by the Tuchuck Fault. The fresh surface of the white limestone often appears nodular while its weathered surface resembles that of an algal limestone.

#### DEVONIAN(?)

The rocks ascribed to the Upper Devonian occur in a small fault block at the eastern edge of the mapped area. They consist of a dark brown crystalline dolomite that resembles the lower part of the Fairholme formation of Upper Devonian age in the Elko, British Columbia region. This unit was not measured.

#### DEVONIAN-MISSISSIPPIAN(?)

A small downdropped block immediately southwest of the Fairholme(?) formation outcrop near the head of Tuchuck Creek is composed of blue-gray to black crystalline limestone that weathers gray. Some horizons are very fossiliferous and contain horn corals, bryozoans, crinoid

columnals, and a few brachiopods in a generally poor state of preservation. Because large portions of the Upper Devonian and the Mississippian sections in the Rocky Mountains consist of this lithology, correlations were not attempted.

#### MISSISSIPPIAN

The beds exposed along Yakinikak and Thoma Creeks are composed of light gray to black limestones, occasionally arenaceous, with dolomite mottlings. Some horizons are fossiliferous and contain horn corals, crinoid columnals, and bryozoans. Willis (1902) studied the limestones along Yakinikak Creek and named them the Yakinikak limestone. In discussing their age he stated,

"The Yakinikak limestone contains numerous fossils of the Saint Louis horizon of the Mississippian series, and was fully identified by Weller as identical in lithologic character and faunal content with that formation in the Mississippi valley."

The St. Louis formation is Meramec in age, and thus the Yakinikak limestone can be correlated with the lower part of the upper Rundle formation in the front range of the Rocky Mountains in southwestern Alberta (Clark, 1954b).

#### PENNSYLVANIAN-PERMIAN

Northeast of the junction of Thoma and Yakinikak Creeks and south of the klippe of Beltian rocks are gray quartzite beds that may exhibit cross-bedding. Their relationship to the underlying Mississippian rocks

is uncertain and they cap the hill where they outcrop. Price (1959) placed the quartzites overlying the Mississippian limestones in the Rocky Mountain formation of Pennsylvanian-Permian age and these are similarly assigned, although no paleontologic evidence is available. The thickness here is unknown but Price (1959) assigned 660 feet of strata to the Rocky Mountain formation.

#### EOCENE(?)

The downwarped fault block of the valley of the North Fork of the Flathead River contains fresh water sediments of clay with interbedded sandstones and lignites named the Kishenehn formation by Daly (1912). The formation consistently dips east at an average of 20° along the length of the valley from the International Boundary north to the westward bend of the North Fork of the Flathead River. No total thickness is known for the formation but Erdmann (1947) has suggested an apparent thickness of 8,400 feet.

The fauna reported by Daly were modern species, but their nearest known relatives among the western fossil species are in the Eocene. This led Daly, and later MacKenzie (1922), to conclude that the Kishenehn formation is Eocene (?) in age. The formation is not present in the area.

#### PLEISTOCENE

Sorted, unconsolidated sediments are present in the valley of Weasel Creek and at the head of Grave Creek. The sediments in the

Weasel Creek valley consist of a light-gray clay overlain by well-sorted, fine-grained sand, and that in turn overlain by cobbles, mostly limestone, averaging approximately 75 mm in diameter. The beds are poorly exposed, but it is estimated that their individual thicknesses do not exceed 20 feet. The occurrence at the head of Grave Creek consists of a small exposure of clay resting on the Roosville formation.

Since these sediments are undisturbed they were probably laid down during the last stage of glaciation. Erdmann (1947) states that the youngest glacial stage in the Whitefish Range was the Wisconsin stage; therefore these beds are assigned to it.

## STRUCTURE

### THRUST FAULTS

Wigwam Fault: The Wigwam fault is a high angle thrust fault whose northwest-southeast trending trace is located in a covered area approximately 2.4 miles northeast of Tuchuck Creek. The Weasel Creek area is on the upthrust block as the thrust plane dips west.

The relationship of the thrust to the overlying and underlying beds can be determined best near the junction of Thoma and Yakinikak Creeks. There the thrust plane is nearly flat and is underlain by Mississippian(?) limestone beds. The thrust sheet includes approximately 500 feet of the Phillips formation and 200 feet of the Roosville formation. After a half mile of a nearly horizontal attitude the plane plunges toward the west with a dip increased to 30° and presumed to be increasing. A traverse to locate the thrust in the area of cross-section D-D' (Plate 2) showed the Gateway formation to overlie the thrust plane and Mississippian(?) rocks to underlie it although the trace could not be exactly located.

Rich Creek Fault: This North-south trending high-angle thrust fault is located in the northwest corner of the map area and is named after Rich Creek which parallels the fault trace. Although the fault trace cannot be specifically located, the fault is inferred because of the anomalous occurrence of the blue-gray argillites of the middle zone of the Siyeh formation which seems to be in fault contact with the lower part of the Gateway formation. The stratigraphic displacement on this fault is from 1,000 to 4,000 feet.

## NORMAL FAULTS

Two major normal faults accompanied by subsidiary faults are found in the Weasel Creek area, namely the Tuchuck and the Whitefish faults. Two minor normal faults are found northeast of the Tuchuck fault but are interpreted to be sympathetic to the Wigwam fault below (see cross-section D-D', Plate 2) and formed contemporaneously. These minor faults cannot be found on the next ridge to the northwest but the southeastern extent of their traces is unknown.

Tuchuck Fault: The Tuchuck fault is a northwest-southeast trending fault named from Tuchuck Creek which follows its trace for a distance of seven miles to the southeast. Neither the fault plane or trace are seen in the area but the fault is defined by stratigraphic displacement across it and geomorphologic relationships along Tuchuck Creek. It is thought to dip steeply to the west because of the westward sloping scarp on the northeast side of Tuchuck Creek. The plane appears to be warped near the head of Tuchuck Creek where the Devonian Fairholme(?) formation is found against the Roosville formation. In this area the fault appears to be a zone of gouge.

A pair of related faults west of the Tuchuck fault have allowed a small block of Devonian-Mississippian(?) limestone to be preserved. Stratigraphic displacement by the Tuchuck fault is approximately 6,250 feet along section D-D' (see Plate 2).

Whitefish Fault: The second major normal fault is the Whitefish fault which, in this area, is the northern termination of a fault which

has a N30W trend and is probably present along much of the length of the Whitefish Range (see Figure 2). In the Weasel Creek area the fault trace attains a more north-south trend. The fault forms a saddle on most of the ridges it crosses and is marked by a zone of gouge at the head of Shorty Creek eleven miles to the southeast. The fault trace is nearly straight indicating a high angle of dip, and determinations at the head of Shorty Creek indicate a west dip of  $70^{\circ}$ . Stratigraphic displacement varies from zero at the northern terminus to approximately 600 feet at the southern boundary of the Weasel Creek area. The stratigraphic displacement at the head of Shorty Creek appears to be on the order of 3,000 feet.

#### FOLDS

Folds are found in different parts of the area but none can be traced with certainty for any great distance. The fold northeast of Weasel Creek is the southern end of a broad, symmetrical anticline that becomes more prominent to the north across the border into British Columbia.

The two tentatively joined anticlinal folds west of the Whitefish fault are small, slightly asymmetrical features that are 1,000 feet wide. Their axial planes, like that of the nearby synclinal fold, are interpreted to dip west.

The overturned anticlinal fold to the west of the synclinal fold is a local feature that is well exposed in the cirque at its northwest end. The normal limb on the west dips  $30^{\circ}$  west and the inverted limb on the east dips  $73^{\circ}$  west. Another small anticlinal fold occurs in the southwest corner of the map area but is poorly exposed and ill-defined.

THE STRATIGRAPHY AND ITS  
STRUCTURAL SIGNIFICANCE

The Ravalli, Piegan, and Missoula groups of the Belt series were deposited during the Proterozoic era. At that time the Weasel Creek area was part of a semi-stable shelf covered by very shallow water as shown by the mud cracks and current ripple marks in the argillites and quartzites. The sea level did fluctuate, however, so that oscillation ripple marks are found in some places, and beds with abundant clay chips, sometimes approaching an edgewise conglomerate, are found in other places. Greater thicknesses of Beltian sediments are found to the west and southwest (Johns, 1959) indicating a more rapidly subsiding area although similar sedimentary features show that the sea was not necessarily deeper. An indefinite period of erosion followed the deposition of the Belt series in this area while the Beltian(?) geosyncline was partially destroyed to the west (North and Henerson, 1954).

Ross (1956, 1959) has stated that this period of erosion was not of long duration. At Elko, British Columbia, Schofield (1914) noticed a slight angular discordance between the Belt series and the Cambrian with the conclusion that a slight uplift occurred during that interval. The Roosville formation at Elko is only 1,740 feet thick compared to the 6,000 feet in the Weasel Creek area, which supports Schofield's postulated uplift. An alternative suggestion is that if the Roosville formation was flat, the erosion surface would only be a three per cent slope to the north and the initial transgressing Cambrian sediments would then overlie it with apparent angular unconformity. Exposures of the Precambrian-Cambrian boundary are poor in the Weasel Creek area but general



accordance of beds at several locations indicate that no great deformation occurred prior to Cambrian deposition.

The initial Cambrian sea in the Weasel Creek and Elko areas was of Middle Cambrian age. Its transgressive nature is suggested by the ascending sandstone, shale, and carbonate lithologies. A similar, but thicker, lithologic sequence was noted 32 miles northwest of Elko at Cranbrook, British Columbia by Rice (1937) and was identified as late Lower Cambrian age.

Because of the paucity of reliable information on the Paleozoic sediments in the Whitefish Range and the complete lack of Mesozoic sediments, the discussion of the geologic history from the Upper Cambrian to the Laramide Orogeny will be based on other authors.

In Upper Cambrian time a positive area, named Montania by Deiss (1941), existed in the vicinity of the Weasel Creek area and extended to southwestern Montana. This emergent area persisted until the Upper Devonian when the part including the Weasel Creek area subsided with the prototype of the Fernie Basin to the north (North and Henderson, 1954). A great thickness of marine sediments was deposited in this basin during the Upper Devonian to Jurassic interval with over 7,000 feet of sediments for this interval in the Flathead map-area. A similar, but thinner, sequence was probably deposited in the northern Whitefish Range region. Record of this deposition is sparse because of faulting, but outcrops of the Fairholme(?), Rundle, and Rocky Mountain formations are present proving deposition during Upper Devonian, Mississippian, and Pennsylvanian time.

The transition of sedimentation in the Fernie Basin from the shallow marine Jurassic Fernie shales to the Upper Jurassic and Lower Cretaceous continental beds of the Kootenay and Blairmore formations is an indication of the destruction of the geosyncline to the west forming the Cordilleran geanticline of Eardley (1951). Thus the source area was now nearby and to the west instead of the distant Canadian shield to the east. Throughout the Cretaceous period the alternating marine and continental sediments to the north in the Fernie Basin and Alberta foothills indicate considerable instability of that region and the adjacent Cordilleran geanticline. It is probable that the Weasel Creek area became a positive feature during this time allowing erosion to the Mississippian and Pennsylvanian age beds before the first period of thrusting in Eocene time. The area in the vicinity of the Pacific-Atlantic Flathead #1, a dry well 14 miles to the northeast and closer to the Alberta trough, was not as high, however, as indicated by the presence of Triassic Spray River formation beds immediately below the Lewis thrust plane in that well.

There is no way of determining when, in the Laramide Orogeny, the major movements occurred in the Weasel Creek area. The Wigwam fault, a compressional feature, is the first major structure to occur in the area and is thought to have been contemporaneous with the other northwest trending compressional features. Since the Lewis thrust to the northeast is the most prominent feature of this type and the most easily dated, it will be briefly considered for this reason.

Paleocene beds east of the Lewis thrust were deformed by its north-eastward movement; thus the thrust is younger than those beds. The Flathead fault cuts the west side of the Lewis thrust salient and Eocene(?)

beds of the Kishenehn formation lie unfolded in the valley created by that fault. With the age of the Lewis thrust and related northwest trending compressional features established as Eocene(?), it can be noted that the Flathead fault, a northwest trending tensional feature, also occurred during the Eocene(?) but later than the Lewis thrust.

A similar sequence is indicated for the Whitefish Range. The Wigwam fault occurred first accompanied by two minor normal faults and was followed by the Tuchuck fault, a northwest-trending tensional feature, which may terminate the trace of the Wigwam fault where it crosses Yakinikak Creek. The Whitefish fault, another northwest-trending tensional feature probably occurred at this same time but was affected by eastward compression in the western part of the Weasel Creek area as indicated by the northward shift in strike of the fault and neighboring beds; the northward termination of the fault; and the nearby north-trending Rich Creek fault, which is a compressional feature.

In summary, a study of the Weasel Creek area suggests the following sequence of Laramide tectonic events in the region. (1) Northwest-trending compressional features formed first in response to forces from the southwest. (2) Northwest-trending tensional features followed the compressional features and were affected by eastward compression in the western part of the area.

## REFERENCES CITED

- Clapp, C. H., 1932, Geology of a portion of the Rocky Mountains of north-western Montana: Mont. Bur. of Mines and Geol. Mem. 4, 30p.
- Clark, L. M., 1954a, Cross-section through the Clarke Range of the Rocky Mountains of southern Alberta and southern British Columbia: Alberta Soc. Pet. Geol. Fourth Ann. Field Conf. Guidebook, p. 105-109
- \_\_\_\_\_, 1954b, Geology of Rocky Mountain front ranges near Bow River, Alberta: Western Canada Sedimentary Basin, Am. Assoc. Pet. Geol. symposium, p. 27-46
- Daly, R. A., 1912, Geology of the North American Cordillera at the Forty-Ninth Parallel: Can. Geol. Survey Mem. No. 38, 857p.
- Deiss, C. F., 1939, Cambrian of northwestern Montana: Geol. Soc. America Special Paper 18, 135p.
- \_\_\_\_\_, 1941, Cambrian geography and sedimentation in the central Cordilleran region: Geol. Soc. America Bull., v. 52, p. 1085-1116
- Eardley, A. J., 1951, Structural geology of North America: Harper & Brothers, New York, 624p.
- Erdmann, C. E., 1947, Geology of dam sites on the upper tributaries of the Columbia River in Idaho and Montana: U.S. Geol. Survey Water-Supply Paper 866-C, 219p.
- Henderson, G. G. L., 1959, A summary of the regional structure and stratigraphy of the Rocky Mountain Trench: Can. Min. and Met. Bull., v. 52, p. 322-327
- \_\_\_\_\_, and Dahlstrom, C. D. A., 1959, First-order nappe in Canadian Rockies: Am. Assoc. Pet. Geol. Bull., v. 43, p. 641-653
- Hume, G. S., 1933, Waterton Lakes-Flahead area, Alberta and British Columbia: Can. Geol. Survey Summary Rept., 1932, Pt. B, p. 1-20
- Johns, W. M., 1959, Geologic investigations in the Kootenai-Flathead area, northwest Montana: Mont. Bur. Mines and Geol. Bull. 12, 56p.
- \_\_\_\_\_, 1960, Personal communication
- Leech, G. B., 1958, Fernie map-area, west half, British Columbia: Can. Geol. Survey Paper 58-10, 40p.
- \_\_\_\_\_, 1959, The southern part of the Rocky Mountain Trench: Can. Min. and Met. Bull., v. 52, p. 327-332

- Mackenzie, J. D., 1916, Geology of a portion of the Flathead coal area, British Columbia: Can. Geol. Survey Mem. 87, 53p.
- \_\_\_\_\_, 1922, The historical and structural geology of the southernmost Rocky Mountains of Canada: Roy. Soc. of Canada Trans., v. 16, sec. 4, p. 97-132
- Norris, D. K., 1959, Geology, Carbondale River, Alberta and British Columbia: Can. Geol. Survey Prelim. Series Map 5-1959
- North, F. K., and Henderson, G. G. L., 1954, Summary of the geology of the southern Rocky Mountains of Canada: Alberta Soc. Pet. Geol. Fourth Ann. Field Conf. Guidebook, p. 15-81
- Price, R. A., 1959, Cranbrook map-area, British Columbia: and Alberta: Can. Geol. Survey Prelim. Series Map 1-1959
- Rezak, R., 1957, Stromatolites of the Belt series in Glacier National Park: U.S. Geol. Survey Prof. Paper 294-D, 153p.
- Rice, H. M. A., 1937, Cranbrook map-area, British Columbia: Can. Geol. Survey Mem. 207, 67p.
- Ross, C. P., 1956, The Belt series in relation to the problems of the base of the Cambrian system: El sistema Cambrico, su paleogeografia y el problema de su base, XX International Geological Congress Symposium Pt. II, p. 683-700
- \_\_\_\_\_, 1959, The Classification and character of the Belt series in north-western Montana; U.S. Geol. Survey Open File Report
- Schofield, S. J., 1914, The Pre-Cambrian (Beltian) rocks of southeastern British Columbia and their correlation: Can. Geol. Survey Bull. 2, 13p.
- Sweeney, G. L., 1955, A geologic reconnaissance of the Whitefish Range, Flathead and Lincoln counties, Montana: Montana State Univ. thesis, unpublished, 43p.
- Willis, B., 1902, Stratigraphy and structure, Lewis and Livingstone Ranges, Montana: Geol. Soc. America Bull., v. 13, p. 325

APPENDIX

MEASURED SECTIONS

Weasel Lake Section

Location: Sec. 28, T. 37 N., R. 24 W., Lincoln County, Montana  
Section in Roosville formation, Missoula group measured up ridge  
east of Weasel Lake. Approximately 4,400 feet to unconformable  
contact with the Middle Cambrian. (Particle sizes correspond  
to the Wentworth classification.)

Unit Number		Unit Thickness (in Feet)
8	Quartzite, gray-green, massive, fine grained; weathers orange; also contains some interbedded argillites with a few well preserved mud cracks and ripple marks, mica on bedding planes.	95.0
7	Argillite, laminated light gray and green, massive; weathers gray and orange; sparse mud cracks and ripple marks, mica on bedding planes.	121.0
6	Stromatolite zone, weathers brownish-gray; irregu- larly encrusting type with concave downward laminae. <u>Collenia undosa</u> , Walcott	0.5
5	Argillite, laminated light gray and green with gray more prominent toward top; weathers gray with some buff to orange zones; mud cracks and ripple marks present. Interval partly covered.	499.0
4	Covered interval.	120.0
3	Argillite, interbedded gray and grayish-red; mud cracks and ripple marks abundant.	39.0
2	Argillite, interbedded red and grayish-green.	5.5
1	Quartzite, laminated gray and green; weathers buff to reddish-brown; mud cracks sparse. Splits into plates along clay laminae.	55.0
	Base covered	<u>Cumulative thickness</u> 935.0

## REVIEW MOUNTAIN SECTION

Location: Sec. 2, T. 37 N., R. 24 W., Flathead County, Montana  
 Section in Gateway, Phillips, and Roosville formations, Missoula  
 group measured up ridge north of Yakinikak Creek 1.2 miles south-  
 east of Review Mountain. Top of section approximately 50 feet  
 below the Weasel Lake Section.

Unit Number		Unit Thickness (in Feet)
3	Argillite, continuously laminated green and light gray; buff weathering. A few small zones have discontinuous laminae.	246.5
2	Quartzite, green, massive; very fine grained.	210.0
1	Argillite, laminated green and light gray; a few thin interbedded white quartzite beds.	170.0
	Lower portion of the Roosville formation	<u>626.0</u>
5	Argillite, interbedded red, grayish-red, and gray.	125.0
4	Sandstone and argillite, red. One inch white quartzite bands are found in the red sandstones, commonly cross bedded with them. Quartz pebbles, white, coarse, well-rounded, frosted are abundant in the red sandstone.	576.0
3	Argillite, interbedded red and gray. Quartzite predominant at base.	10.0
2	Quartzite, light green and argillite, greenish-gray interbedded. Individual beds vary from 2-24 inches thick. Quartzite has well sorted, well rounded, possibly frosted, medium size grains. A given quartzite bed may have different layers of well sorted grains, one with fine grains and another with medium size grains. Ripple marks are common on the quartzite. Argillite is greenish-gray laminated with light grayish yellow on fresh surface. Bedding surfaces are wavy and weather reddish-brown.	30.5
1	Quartzite, green, medium grained. Thin, discontinuous, light green argillite laminae are common. Some vertical 1 inch thick quartz veins cut this unit.	28.0
	Total thickness, Phillips formation	<u>769.5</u>

Unit Number		Unit Thickness (in Feet)
5	Argillite, green, weathers dark green and buff. Splits along bedding planes into 1 inch thick plates.	24.0
4	Stromatolite zone—concave downward encrusting coarse laminae with smooth surfaces. <u>Collenia symmetrica</u> , Walcott.	2.0
3	Argillite, light and dark green interbedded. Sericite on fresh bedding planes but weathered surface is stained brown with light and dark green bands. A 4 inch green argillite bed has abundant pyrite cubes 65.1 feet from the base.	109.6
2	Argillite, greenish-gray, dolomitic with indistinct tan to buff laminae. Weathers brown to orange. Massive appearance.	4.0
1	Argillite, dark green with light gray discontinuous partings. Slightly calcareous.	25.4
	Base covered    Upper portion of the Gateway formation	<u>165.0</u>