Type Sections of the Madison Group (Mississippian) and its Subdivisions in Montana

GEOLOGICAL SURVEY PROFESSIONAL PAPER 842

Type Sections of the Madison Group (Mississippian) and its Subdivisions in Montana

By WILLIAM J. SANDO *and* J. T. DUTRO, JR.

GEOLOGICAL SURVEY PROFESSIONAL PAPER 842

Descriptions of the type sections of the Madison Group, Mission Canyon Limestone, Lodgepole Limestone, and Paine and Woodhurst Members of the Lodgepole Limestone

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1974

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress catalog-card No. 74-600112

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 – Price $1.70 (paper cover)
Stock Number 2401-02528

CONTENTS

ILLUSTRATIONS

TYPE SECTIONS OF THE MADISON GROUP (MISSISSIPPIAN) AND ITS SUBDIVISIONS IN MONTANA

By WILLIAM J. SANDO and J. T. DUTRO, JR.

ABSTRACT

This report presents descriptions of precisely located type sections for the Madison Group and its principal subdivisions in Montana. The type section of the Madison Group, originally proposed as a formation by A. C. Peale in 1893, is on the Gallatin River at Logan, southwest Montana. Type sections for the Lodgepole Limestone and Mission Canyon Limestone, originally proposed by A. J. Collier and S. H. Cathcart in 1922, are located on the flank of the Little Rocky Mountains in north-central Montana. Inasmuch as the Mission Canyon Limestone is truncated by pre-Jurassic erosion in its type section, a complete reference section just north of Monarch in the Little Belt Mountains is described for the Mission Canyon. A section on the Dry Fork of Belt Creek in the Little Belt Mountains is described as type section for the Paine and Woodhurst Members of the Lodgepole Limestone, units that were named by W. H. Weed in 1899. Collections of fossils from the type sections are used for dating and correlation of the Madison strata and form an important reference set for future biostratigraphic analyses.

INTRODUCTION

The Madison Group is one of the more widespread stratigraphic units in the western United States. This great mass of Mississippian carbonate rocks extends over most of Montana and parts of the Dakotas, Idaho, Wyoming, and Utah. Limestone units of equivalent age in California, Nevada, Arizona, Utah, Wyoming, and Colorado, although given different names, are part of a continuous sheet of Madison-like carbonate sedimentary rocks.

The Madison has been studied and mapped since the days of the earliest geological investigations of the Western United States. From the standpoint of stratigraphic nomenclature, the more important studies were made in Montana, where most of the subdivisions of the Madison were established. Although many stratigraphic studies have been made since this stratigraphic unit was proposed in 1893, type sections for most of the fundamental Montana subdivisions have never been described in detail.

The purpose of the report is to designate and describe type sections for the Madison Group and its principal subdivisions in Montana. Collections of fossils from these sections, permanently housed at the U.S. National Museum in Washington, D.C., form an important reference set for any future biostratigraphic analyses of the type sections. These collections have already been used in several biostratigraphic studies of the Madison Group (Sando, 1960; Sando and Dutro, 1960; Sando and others, 1969).

This report deals with the type sections of the following stratigraphic units:

Madison Group (Peale, 1893).
- Mission Canyon Limestone (Collier and Cathcart, 1922).
- Lodgepole Limestone (Collier and Cathcart, 1922).
  - Woodhurst Member (Weed, 1899a).
  - Paine Member (Weed, 1899a).

A third subdivision of the Lodgepole Limestone, the Cottonwood Canyon Member (Sandberg and Klapper, 1967), is recognized in two of the type sections described herein. Inasmuch as its type section is in Wyoming and has been described in detail by Sandberg and Klapper (1967, p. B16–B19), it is not described in this report.

The name Charles Formation has been applied to interbedded carbonate, terrigenous, and evaporitic sedimentary rocks equivalent to the upper part of the Mission Canyon Limestone in the subsurface Williston basin of central and eastern Montana and the western parts of the Dakotas. The Charles was originally proposed by Seager (1942, p. 863, 864) for beds between the Kibbey Formation of the Big Snowy Group and the top of the Madison Group in the Arro Oil and Refining Company and California Company No. 4 well in sec. 21, T. 15 N., R. 30 E., Petroleum County, Mont. Although Seager originally included the formation in the Big Snowy Group,

Sloss (1952, p. 66–67) regarded the Charles as the uppermost unit of the Madison Group, and this usage has been followed in most subsequent stratigraphic work.

Perry and Sloss (1943, fig. 3) presented a graphic log of the Charles in the well section originally described by Seager, and Nordquist (1953, p. 79) referred to this section as the "type well" and redefined the limits of the formation. Although some geologists have extended the term "Charles Formation" to surface exposures of Madison rocks in parts of central and western Montana, it is defined on criteria that are difficult to use with precision in outcrop areas. Moreover, it includes beds referred by most geologists to the Mission Canyon Limestone. Pending further clarification of its exact relationships with the Mission Canyon Limestone of central and southwestern Montana, we recommend that the Charles be restricted to the subsurface in the Williston basin.

The Madison Limestone in the mountain ranges of northwest Montana was divided by Deiss (1933, p. 45–48) into five members (in ascending order): Silvertip Conglomerate, Saypo Limestone, Dean Lake Chert, Rooney Chert, and Monitor Mountain Limestone. Later work by Deiss (1943, p. 228) in the Sawtooth Range led him to conclude that these strata "are not precisely equivalent in age to the Madison or to the Brazer Limestone, but are part correlative with both." Consequently, he proposed the name Hannan Limestone (Deiss, 1941, p. 1896; 1943, p. 228) to replace Madison Limestone in the Sawtooth Range.

Deiss' nomenclature was not used in recent studies of the Mississippian rocks in the Sawtooth Range by Mudge, Sando, and Dutro (1962) and Mudge (1972, p. A35–A40). The name Hannan was abandoned, and the Mississippian strata were referred to the Madison Group, which was divided into two formations, the Allan Mountain Limestone and the overlying Castle Reef Dolomite. Three unnamed members were recognized in the Allan Mountain Limestone, and the Castle Reef Dolomite was divided into an unnamed lower member and the Sun River Member, originally published by Chamberlain (1955, p. 78, 79) and Andrichuk (1955, p. 88). Descriptions of the type sections of these currently recognized units in northwest Montana are in Mudge, Sando, and Dutro (1962), which also contains paleontological documentation based on fossils in the collections of the U.S. Geological Survey at the U.S. National Museum in Washington, D.C.

HISTORY OF NOMENCLATURE

Peale (1893, p. 32–39) proposed the name Madison formation for carbonate rocks of early Carboniferous age underlain by the Three Forks shales (Devonian) and overlain by the Quadrant formation (upper Carboniferous) in the Three Forks area of southwest Montana. Peale recognized three divisions of the Madison, in ascending order: Laminated limestones, Massive limestones, and Jaspery limestones. Iddings and Weed (1894, p. 2) used the name Madison limestone for rocks of similar age, lithology, and stratigraphic position near Livingston, Mont. Although Weed (in Hague and others, 1896, p. 4) stated that Peale's term was derived from the Madison Range, Sloss and Hamblin (1942, p. 313) suggested that the name referred to the Madison River, which joins with the Gallatin and Jefferson Rivers to form the Missouri at Three Forks.

Weed (1899a, p. 2; 1899b, p. 2) divided the Madison limestone of the Little Belt Mountains into Paine shale, Woodhurst limestone, and Castle limestone, which evidently corresponded roughly to Peale's Laminated limestones, Massive limestones, and Jaspery limestones, respectively. In a later report, Weed (1900, p. 290–294) used the term "Madison group" but does not seem to have intended formational rank for the new subdivisions of the Madison (Sloss and Hamblin, 1942, p. 313–314). The names evidently were derived from Paine Gulch, the mining camp of Woodhurst or Woodhurst Mountain in the Little Belt Mountains, and the town of Castle in the Castle Mountains.

Collier and Cathcart (1922, p. 173) were the first to use the name Madison as a group, in the modern sense, in a brief paper on the Little Rocky Mountains. They divided the Madison Group into two formations, using the names Lodgepole limestone for the lower part and Mission Canyon limestone for the upper part. Both names were derived from canyons in the northern part of the Little Rocky Mountains.

Sloss and Hamblin (1942, p. 313–315) synthesized previous work on the Madison and proposed the nomenclatural framework presently recognized throughout much of Montana by most geologists. The Madison was recognized as a group divided into Lodgepole Limestone and Mission Canyon Limestone, and Weed's Paine and Woodhurst units were retained as members of the Lodgepole. The name Castle limestone, a synonym for Mission Canyon Limestone, had already been abandoned (Wilmarth, 1938, p. 365).

Sloss and Hamblin's statements concerning type sections for the various units of the Madison were

rather generalized. They indicated that the type section of the Madison is in exposures along the Gallatin River at Logan, Mont. (pl. 1) and presented a condensed description of this section. They stated that the type locality of the Lodgepole Limestone is in the Little Rocky Mountains and also referred to a type section for the formation, but they did not indicate whether their condensed description of the section on Lodgepole Creek was to serve as a description of the type section. They presented a condensed composite section of the Madison measured at three localities in the Little Belt Mountains but did not identify this as a type section for the Paine and Woodhurst Members of the Lodgepole. No mention was made of a type section for the Mission Canyon Limestone. None of their stratigraphic sections were precisely located, and no reference was made to collections of fossils from these sections.

Holland (1952, p. 1702, 1703) was more explicit in locating the type section of the Madison. He stated that the type section is "along the north bank of the Gallatin River, directly across from Logan, Gallatin County, Montana, S¼ [sic] sec. 25, T. 2 N., R. 2 E." Holland also presented an annotated graphic log of the lower part of this section and listed fossils collected from nine precisely located levels in the Lodgepole Limestone. Limited data on the occurrence of fossils in the lower part of the Logan section were also presented by Gutschick (1964) and Rodriguez and Gutschick (1970).

Knechtel, Smedley, and Ross (1954) proposed the name Little Chief Canyon Member for the black shale that occurs at the base of the Lodgepole Limestone at many localities in Montana. They stated (p. 2397, 2399) that the type locality for the new member, as well as for the Lodgepole Limestone, is in "Little Chief Canyon of Lodgepole Creek, N½ of sec. 27, T. 26 N., R. 25 E., in Blaine County, Montana, about 3½ miles south-southeast of Lodgepole Subagency of the Fort Belknap Indian Reservation" (pl. 1) (Little Chief Canyon actually extends from N½ sec. 30 into SE¼ sec. 19). They also identified the Little Chief Canyon Member in the section at Logan, S½ sec. 25, T. 2 N., R. 2 E., Gallatin County, Mont., which they considered to be the type section of the Madison Group. A recent analysis of Devonian and Mississippian shale units in the northern Cordillera by Sandberg and Mapel (1967, figs. 2 and 10) has shown that the shale in Little Chief Canyon is the upper black shale of the Bakken Formation and that the shale at Logan belongs in the Cottonwood Canyon Member of the Lodgepole Limestone. Such usage obviates the necessity for the term Little Chief Canyon Member, which is hereby abandoned.

Knechtel (1959, p. 733, 734) again stated that the type locality of the Lodgepole Limestone is in Little Chief Canyon in the Little Rocky Mountains. He also stated that the type locality of the Mission Canyon Limestone is "in Mission Canyon, in sec. 32, T. 26 N., R. 24 E., a mile southeast of St. Paul's Mission" (pl. 1). Neither of these sections was described in Knechtel's paper.

In summary, the status of type sections of the Madison Group in central and southwestern Montana is as follows:

1. A specific type section location has been designated for the Madison Group and an annotated section log has been presented for part of it, but no detailed description has been published, and the section has not been adequately documented paleontologically.
2. Specific type localities have been designated for the Mission Canyon Limestone and Lodgepole Limestone, but no descriptions or paleontological documentation of their type sections have been published.
3. No type sections for the Paine and Woodhurst Members of the Lodgepole Limestone have been designated, described, or paleontologically documented.

DESCRIPTIONS OF TYPE SECTIONS

FIELD METHODS

The following descriptions of rock units in measured sections were made entirely from observations in the field. Principal carbonate rock designations (limestone, dolomitic limestone, and dolomite) are based on the amount of effervescence of the rock when a fresh surface is treated with 2 *N* hydrochloric acid. Rock colors on fresh and weathered surfaces were determined by comparison with the rock-color chart (Goddard and others, 1948).

Fresh rock surfaces, wetted with acid and observed with hand lens, were compared with a Wentworth grain-size chart in order to describe rock textures. Grain-size terms for terrigenous components refer to the Wentworth scale. The following terminology is used to describe grain size in granular carbonate rocks:

Fine grained: clasts less than ⅛ mm in diameter (clay, silt, and very fine sand of Wentworth scale).

Medium grained: clasts from ⅛ to 1 mm in

diameter (fine, medium, and coarse sand of Wentworth scale).

Coarse grained: clasts from 1 to 64 mm in diameter (very coarse sand to pebbles of Wentworth scale).

Grain size in crystalline carbonate rocks is described as follows:

Medium crystalline: crystals 1/8 to 1 mm in diameter.

Coarse crystalline: crystals greater than 1 mm in diameter.

Rock-term modifiers, such as crinoidal, refer to predominant biogenic constituents of granular carbonate textures.

Thicknesses of section units and beds were measured in feet and tenths of feet. Most measurements were made with an 8-foot steel tape held perpendicular to bedding directly against the outcrop. Many large units, particularly those poorly exposed, were measured with a Jacob staff where terrain and bedding attitudes were favorable. In rare instances of steep bedding attitudes, intervals were calculated from measurements made perpendicular to the strike with a 100-foot steel tape held horizontally.

Positions of fossil collections are recorded for each section unit in the descriptions of the units. The numbers refer to the U.S. Geological Survey upper Paleozoic locality file at the U.S. National Museum in Washington, D.C.

BOUNDARY CRITERIA AND NOMENCLATURE

None of the stratigraphic units described in this paper, with the exception of the Cottonwood Canyon Member of the Lodgepole Limestone (Sandberg and Klapper, 1967), was previously described in enough detail to establish precise boundaries. In the course of studying many stratigraphic sections of the Madison Group in the northern Rocky Mountain region, we have used boundary criteria that have proved applicable on a regional basis and that are consistent with the vague limits recognized by the founders of the units and subsequent geologists. Proposed boundary criteria are as follows:

1. Base of Paine Member of Lodgepole Limestone: The basal beds of the Paine Member consist of crinoidal limestone that is readily distinguished from shale, sandstone, or siltstone of the underlying Cottonwod Canyon Member of the Lodgepole.
2. Top of Paine Member of Lodgepole Limestone: All but the lowest beds of the Paine consist of fine-grained shaly and silty limestone containing varying amounts of scattered bioclastic debris but no discrete beds of crinoidal limestone. The top of the Paine Member is placed at the base of the lowest crinoidal limestone bed, which marks the beginning of cyclical alternation of crinoidal limestone (commonly oolitic) and shaly, predominantly fine grained limestone characteristic of the Woodhurst Member.
3. Top of the Woodhurst Member of Lodgepole Limestone: The lower part of the Mission Canyon Limestone is characterized by clean, thick beds of crinoidal limestone that stand in marked contrast to the shaly, thin-bedded, cyclical limestone sequence of the Woodhurst. The top of the Woodhurst is placed at the top of the highest shaly, thin-bedded, predominantly fine grained limestone beneath the thicker crinoidal beds of the Mission Canyon.

The nomenclature proposed by Sloss and Hamblin (1942) for the sequence above the Cottonwood Canyon Member is followed in this report. Weed's (1899a, b) terms "Paine shale" and "Woodhurst limestone" are changed to Paine Member and Woodhurst Member; "Paine shale" is a misnomer, and "Woodhurst limestone" is unnecessary inasmuch as both units are subdivisions of the Lodgepole Limestone.

LOGAN SECTION

The Logan section is the type section of the Madison Group. The section traverse begins at the base of the Lodgepole Limestone exposed in the northwest slope of a gully located on the north side of the Gallatin River immediately north of the town of Logan in SE1/4SW1/4 sec. 25, T. 2 N., R. 2 E., Gallatin County, Mont. (figs. 1, 2). The traverse proceeds across exposures of the Lodgepole in the gully slope (fig. 2*C*) to the base of the Mission Canyon Limestone exposed near the top of the slope (fig. 2*D*). The Mission Canyon Limestone is exposed in smooth-surfaced outcrops on a hilltop. The traverse proceeds across the hill to the top of the Mission Canyon at the edge of a swale occupied by the Big Snowy Formation in NW1/4SW1/4 sec. 25.

Thin units in the section were measured directly with an 8-foot tape, whereas thicker ones were calculated from measurements made with a 100-foot tape held horizontally. The beds dip 40°–45° NW. The section was measured in 1957. A columnar section is shown on plate 1.

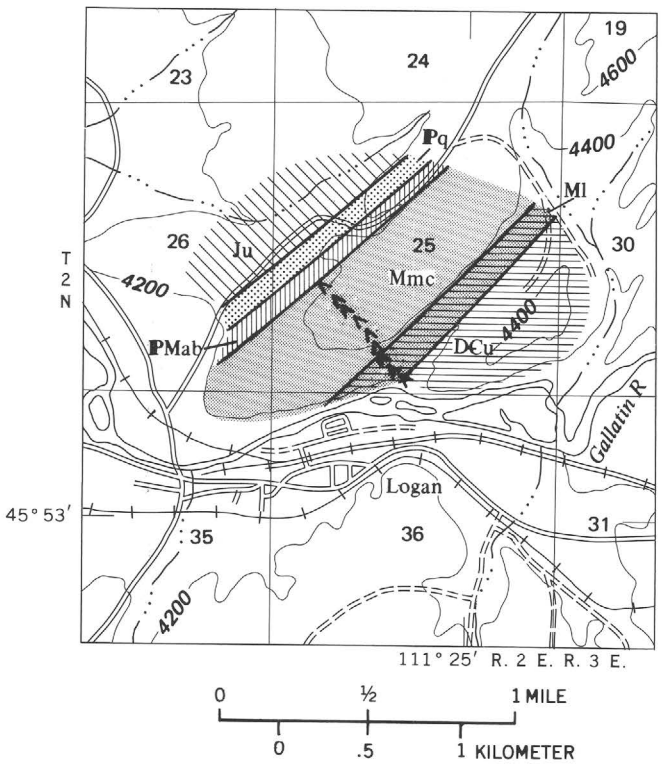
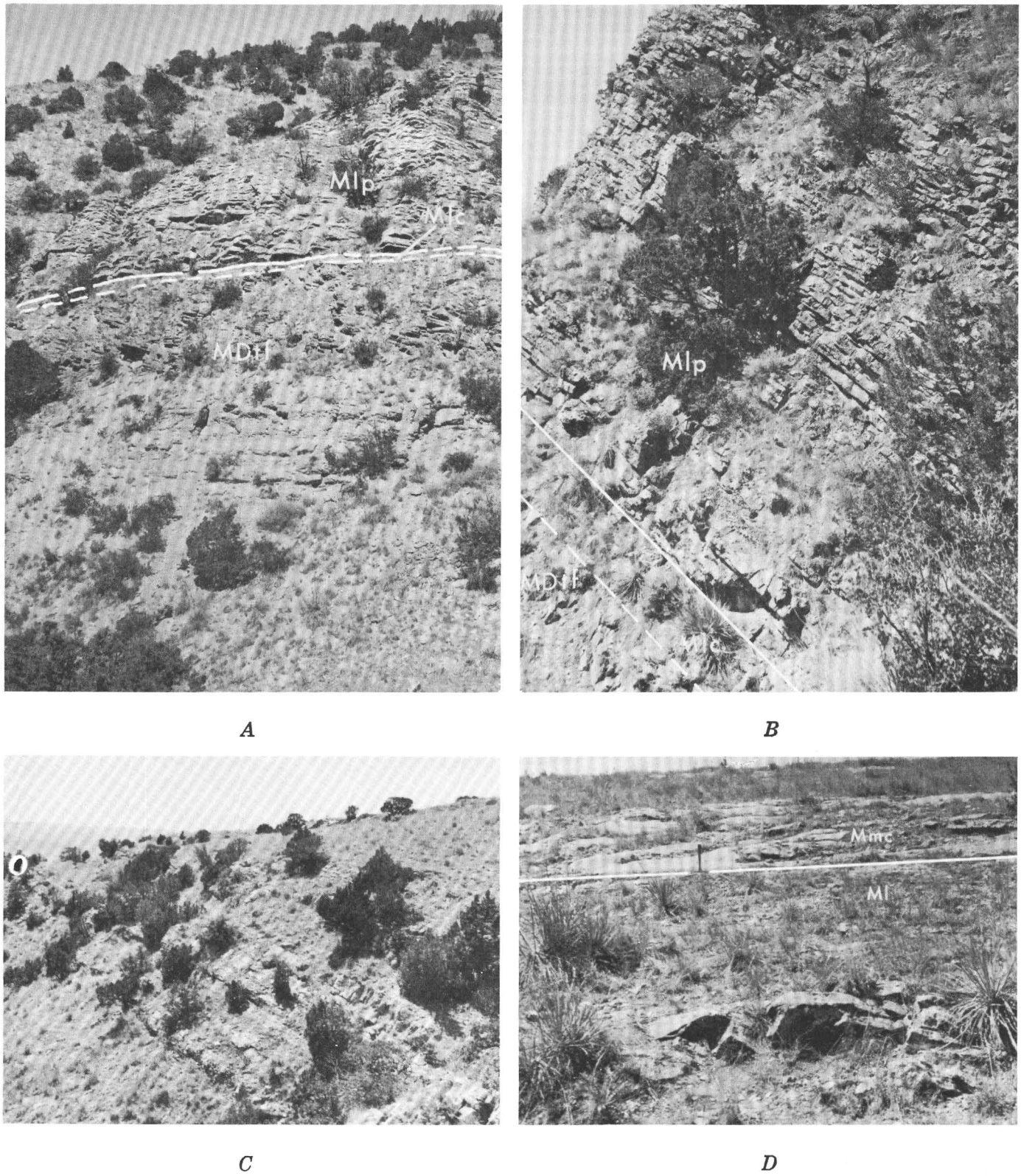


FIGURE 1.—Geologic sketch map of Logan section. Geology by W. J. Sando and J. T. Dutro, Jr. Base from U.S. Geol. Survey Manhattan quadrangle, Montana, scale 1:62,500.

	Thickness (feet)
Big Snowy Formation (Kibbey equivalent):	
41. Quartz sandstone, dolomitic, fine- to medium-grained, grayish-yellow; weathers pale yellowish orange; contains dolomite pebbles as much as 0.2 ft in diameter; beds 0.5–1 ft thick; poorly exposed	12.0
40. Covered; occupied by swale	88.5
Madison Group:	
Mission Canyon Limestone:	
39. Dolomitic limestone, like unit 38 but many beds weathered more yellowish; brown and gray chert as in unit 38 about 10–15 percent; beds 0.2–2 ft thick; unit forms ridge and dip slope. Fossils rare or absent	176.0
38. Dolomitic limestone, fine- to medium-grained, mostly olive gray to light olive gray; weathers yellowish gray, some beds weather medium gray and mottled medium gray and yellowish gray; bioclastic debris scattered throughout and in concentrated zones; about 15 percent milky-gray aphanitic chert concentrated mostly in upper half; beds 0.2–2 ft thick; forms massive outcrops. Brachiopods and solitary and colonial corals. USGS 17387–PC from upper 10 ft	79.0
37. Covered; lower half contains platy fragments of dolomitic limestone in float; very little chert	64.3
36. Dolomitic limestone; like unit 35 but more calcareous; rock appears to be made up of fine nonbioclastic sand- and silt-sized carbonate in very fine grained dolomite matrix; chert about same as in unit 35	11.5
35. Dolomitic limestone; like unit 22 but forms massive beds; much brecciation and flowage of finely laminated structure; about 20 percent brown punky-weathered chert in nearly continuous zones of thin irregular lenses	11.5
34. Dolomitic limestone, fine-grained; like unit 22; poorly exposed; weathers to platy fragments	35.2
33. Limestone, interbedded fine-grained (60 percent), pelletal or oolitic (30 percent), and dolomitic (10 percent); beds 1–3 ft thick; chert less than 5 percent. Brachiopods and bryozoans occur in pelletal beds. USGS 17385–PC 28.8 ft above base, USGS 17386–PC 49.2 ft above base	80.0
32. Dolomitic limestone, fine-grained; like unit 22; less than 5 percent brown chert lenses and orange-weathered jasperoid chert; poorly exposed; weathers to platy fragments	52.8
31. Limestone, mostly fine grained (70–80 percent) but contains interbedded pelletal limestone (5 percent) in beds about 1 ft thick and medium-grained bioclastic limestone (15 percent); also a few dolomitic beds; orange-weathering jasperoid chert in large masses and forming reticulate networks about 15–20 percent. Fauna dominantly brachiopods and bryozoans and a few large solitary corals. USGS 17382–PC 31.5 ft above base, USGS 17383–PC 44.5 ft	



A *B*

C *D*

FIGURE 2.—Madison Group in the Logan section. *A*, *B*, Lower part of Madison Group; Three Forks Formation (MDtf), Cottonwood Canyon Member of Lodgepole Limestone (Mlc), and Paine Member of Lodgepole Limestone (Mlp). *C*, Ledges of Woodhurst Member of Lodgepole Limestone (units 10–14 of measured section). *D*, Contact between Lodgepole Limestone (Ml) and Mission Canyon Limestone (Mmc). Note light-colored, smooth-weathered thicker beds of basal Mission Canyon Limestone. Smooth-surfaced outcrops of lower part of Mission Canyon continue to top of hill.

	Thickness (feet)
Madison Group—Continued	
Mission Canyon Limestone—Continued	
above base, USGS 17384–PC 59.2 ft above base	60.5
30. Covered, and a few outcrops or loose blocks of dolomitic limestone like unit 22; very little chert in float; possible solution breccia interval	47.2
29. Limestone, pisolitic and oolitic with fine-grained matrix, light-olive-gray to light-brownish-gray; weathers medium light gray	.7
28. Limestone, fine-grained; beds 2–3 ft thick in lower 67 ft, 5–8 ft thick in upper part; a few lenses of chert in upper 37 ft	104.0
27. Limestone, mostly medium grained (some coarser); bioclastic, composed mainly of crinoid, ostracode, and brachiopod remains; brownish gray; weathers medium gray; beds 1–3 ft thick, with some partings spaced 0.1–0.3 ft; about 5–10 percent light-brown- to dark-yellowish-orange-weathered jasperoid chert in masses as much as 2 ft thick. USGS 17379–PC 4.9 ft above base; USGS 17380–PC 30.3 ft above base, USGS 17381–PC 84 ft above base	88.5
26. Limestone, fine-grained; like unit 25 but more massive; beds 1–5 ft thick; about 20 percent brown punky-weathered chert in irregular masses and mostly thin lenses, although some are as much as 0.5 ft thick. No fossils	33.7
25. Limestone, fine-grained, olive-gray to brownish-gray; weathers medium gray; beds 0.5–1 ft thick, with thinner, laminated interbeds (60 percent); no chert. No fossils	35.7
24. Dolomitic limestone, fine-grained; like unit 22	18.3
23. Limestone, crinoidal; like unit 21 but contains no chert	16.2
22. Dolomitic limestone, fine-grained; like unit 19 but contains no lenses of bioclastic debris; poorly exposed	21.0
21. Limestone, coarse to very coarse grained, crinoidal, brownish-gray to olive-gray; weathers medium-gray; beds 2–5 ft thick; reticulate network of chert in upper 10 ft. Corals rare. USGS 17378–PC 16.2 ft above base	52.0
20. Limestone, mostly coarse-grained, crinoidal, partly oolitic, brownish- to olive-gray; weathers medium gray; beds 2–3 ft thick; no chert	10.5
19. Dolomitic limestone, fine-grained with thin lenses of bioclastic debris, olive-gray; weathers yellowish gray; beds 0.1–0.3 ft thick; weathers to platy fragments	7.1
18. Limestone, medium-grained, crinoidal, brownish-gray to olive-gray; weathers medium gray; beds 2–5 ft thick, but some partings spaced a few inches apart; 5 percent yellowish-white-weathering chert, making fuzzy envelopes around limestone "nodules." Fossils rare. USGS 17377–PC 19.7 ft above base	44.4
Total Mission Canyon Limestone	1,050.1
Lodgepole Limestone:	
Woodhurst Member:	
17. Limestone, interbedded fine- and coarse-grained; like unit 13; no chert. USGS 17376–PC 6 ft above base	27.0
16. Limestone, fine-grained, brownish-gray; weathers medium light gray; thin layers of coarse bioclastic debris; beds 1–2 ft thick	6.0
15. Limestone, interbedded fine- and coarse-grained; like unit 13; chert less than 5 percent. USGS 17375–PC 3 ft below top	12.0
14. Limestone, interbedded fine- and coarse-grained; like unit 13; chert less than 5 percent; lower 55 ft almost entirely covered, upper 43 ft about 60 percent covered	98.0
13. Limestone, very fine to fine grained (micrite and calcisiltite) with scattered thin lenses and beds of coarse bioclastic debris; mostly olive gray; weathers medium gray to medium light gray; beds 0.1–0.4 ft thick, irregular to nodular, separated by silty partings; about 5–10 percent punky-weathered brown chert lenses, concentrated in upper half of unit. USGS 17373–PC 3 ft below top, USGS 17374–PC from float at top	20.0
12. Limestone; interbedded calcarenite, calcisiltite, and coarse crinoidal limestone; like unit 10. Fauna similar to that of underlying units. USGS 17371–PC 5 ft above base (float), USGS 17372–PC 1 ft below top	17.0
11. Limestone, medium- to very coarse grained, crinoidal, brownish-gray to olive-gray; weathers medium-dark-gray to light-gray; beds 1–2 ft thick with a few silty partings and small-scale crossbedding. Abundant corals and brachiopods. USGS 17370–PC from upper 2 ft	12.0
10. Limestone, mostly interbedded fine-grained calcarenite and lime siltstone (many laminated beds) that weather medium dark and medium gray, and	

	Thickness (feet)
Madison Group—Continued	
Lodgepole Limestone—Continued	
Woodhurst Member—Continued	
medium to coarse-grained crinoidal sand; minor (10 percent) micrite like that in unit below; chert less than 5 percent. Fauna similar to that of underlying units. USGS 17365–PC 26 ft above base (float), USGS 17366–PC 39.5 ft above base, USGS 17367–PC 52.5 above base, USGS 17368–PC 65.5 ft above base, USGS 17369–PC 18 ft below top	212.0
9. Limestone, interbedded, fine- and coarse-grained; like unit 8 but with about 15–20 percent brown punky-weathered chert in irregular masses and lenses mostly 0.3 ft or less thick; upper 10 ft contains about 50 percent lime siltstone. USGS 17362–PC from lower 0.5 ft, USGS 17363–PC 16 ft above base, USGS 17364–PC 22 ft above base	31.0
8. Limestone, interbedded fine-grained, like unit 6 (about 70 percent), and coarse-grained, like unit 4, with silty partings; beds 0.2–0.4 ft thick, nodular bedded in part; a lens of brown jaspery chert as much as 2 ft thick 15 ft above base. Fossiliferous throughout; fossils in coarse-grained beds and and lenses. USGS 17361–PC from lower 10 ft (float)	25.0
7. Limestone breccia and conglomerate; tabular fragments of brownish-weathered silty limestone as much as 0.2 ft diameter in coarse to very coarse bioclastic calcarenite matrix composed of crinoidal and brachiopod debris. Bed weathers brownish	.8
Total Woodhurst Member	460.8
Paine Member:	
6. Limestone, very fine to fine grained (micrite and calcisiltite), mostly olive gray to dark gray; weathers medium light gray to light gray; beds 0.1–0.3 ft thick, cobbly and nodular; abundant thin lenses of coarse bioclastic debris; beds separated by thin buff-weathered silty partings. Brachiopods, bryozoans, and some spaghettilike ichnofossils as in unit 5. USGS 17360–PC from throughout unit	10.0
5. Limestone, argillaceous, fine-grained, olive- and dark-gray; weathers light gray and very light gray with buff cast; faintly laminated; beds 0.2–0.8 ft thick, separated by buff-weathered shaly and silty partings as much as 0.2 ft thick; no chert seen. Only fossils seen were abundant spaghettilike ichnofossils, a few fenestrate bryozoans, and crinoid stems. USGS 17359–PC 80 ft above base	241.0
4. Limestone, medium to very coarse grained, crinoidal, medium-dark-gray with some brownish hues; weathers medium gray to medium light gray; beds 0.2–0.6 ft thick with silty partings. 3–4 mm thick; brownish jaspery chert weathering punky, mostly in irregular masses 0.1 ft or less in diameter, comprising 5 percent or less of unit; a zone of irregular chert lenses at top. Small brachiopods and horn corals rare. USGS 17356–PC from lower 5 ft, USGS 17357–PC 10 ft above base, USGS 17358–PC from upper 1.5 ft	15.0
Total Paine Member	266.0
Cottonwood Canyon Member	
3. Quartz sandstone, like unit 1	1.4
2. Clay shale, carbonaceous, grayish-black fresh; poorly exposed, forms reentrant in cliff. USGS 24979–PC	1.5
Total Cottonwood Canyon Member	2.9
Total Lodgepole Limestone	729.7
Total Madison Group	1,779.8
Three Forks Formation (Sappington Member)	
1. Quartz sandstone, fine-grained, calcareous, light-moderate-yellowish-brown; weathers dark yellowish orange; thin, moderately resistant beds.	

MONARCH–U.S. 89 SECTION

This reference section for the Mission Canyon Limestone was chosen because it is the closest complete outcrop section to the type section, which is incomplete by virtue of pre-Jurassic truncation. The section traverse begins at the Lodgepole-Mission Canyon contact exposed in a roadcut on the east side of U.S. Highway 89, 1.8 highway miles north of the road intersection at Monarch and about 100 yards north of a sign marking the boundary of the national forest (figs. 3, 4*A*, *B*). This location is in SW¼ NE¼ sec. 27, T. 16 N., R. 7 E., Cascade County, Mont. The traverse proceeds northward in the hill slopes east of the highway (fig. 4*C*) across SE¼ sec. 22 into NE¼ sec. 22, where the section is terminated at the highest beds exposed on a dip slope overlain by a red soil interval that represents the basal

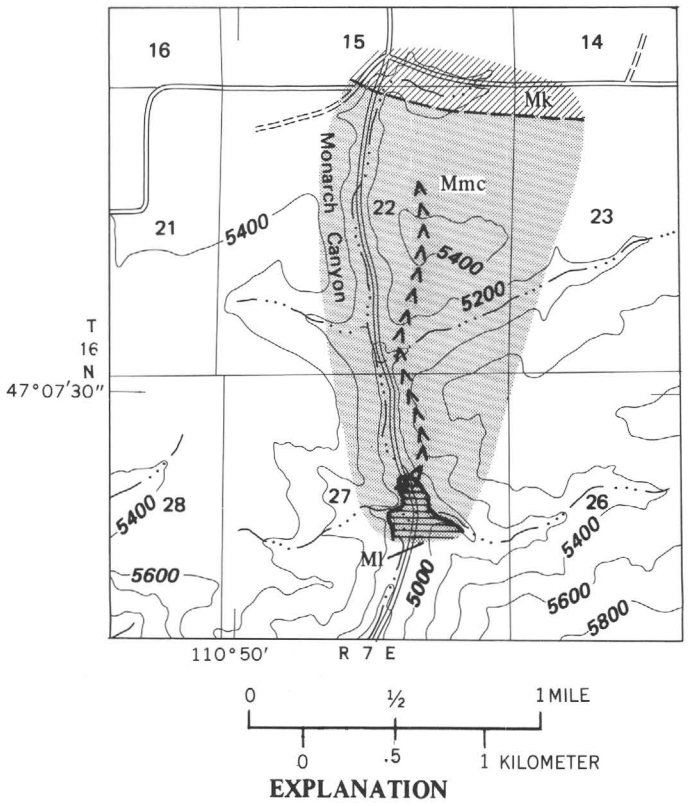
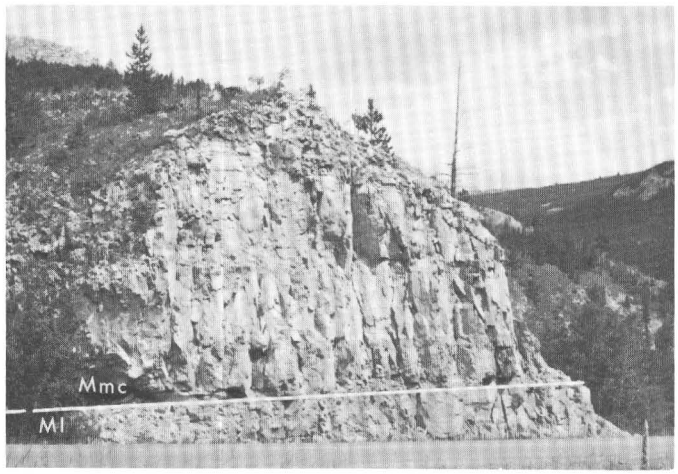


FIGURE 3.—Geologic sketch map of Monarch–U.S. 89 section. Geology by W. J. Sando and J. T. Dutro, Jr. Base from U.S. Geol. Survey Monarch and Monarch NE quadrangles, Montana, scale 1:24,000.

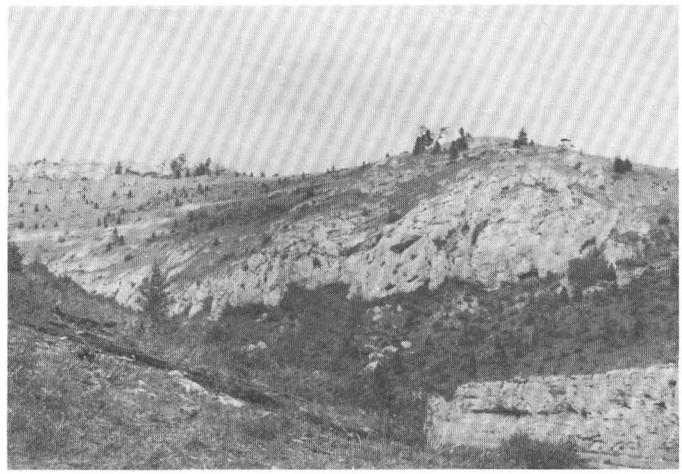
beds of the Kibbey Formation. The beds dip 4°–5° N. The section was measured in 1962 with a Jacob staff and 8-foot steel tape. A columnar section is shown on plate 1.

A more completely exposed section of the upper 121 feet of the Mission Canyon Limestone was measured in the cliffs above Belt Creek about 150 yards south of the bridge at Riceville in NE¼NW¼ sec. 26, T. 17 N., R. 6 E., Cascade County, Mont. At this locality, only the lower 10 feet of the Kibbey Formation are covered by the highway. Comparison of this section with the Monarch–U.S. 89 section suggests that the latter may lack as much as the upper 10 feet of the Mission Canyon Limestone, but this may be due to variation in position of the post-Madison, pre-Big Snowy erosion surface.

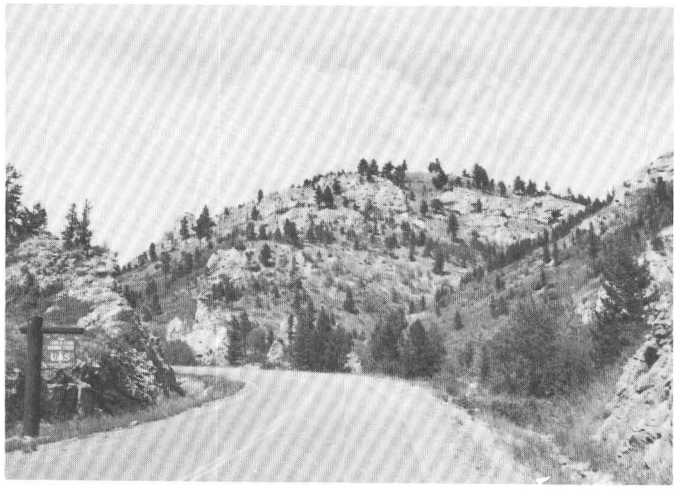
	Thickness (feet)
Big Snowy Group:	
Kibbey Formation:	
Represented by red soil on dip slope; erosional relief on top of Madison appears to be as much as 20 ft.	
Madison Group:	
Mission Canyon Limestone:	
47. Limestone, fine-grained (micrite), dark-yellowish-brown; weathers medium light gray to light gray; beds 0.5–1.5 ft thick	5.0
46. Covered, like unit 44; some chert as in unit 45 in float as well as fine-grained limestone and calcareous siltstone	13.0
45. Limestone, fine-grained; like unit 35; about 50 percent large brown-weathered chert lenses	2.0
44. Covered; float consists of red-, yellow-, and orange-weathered platy calcareous siltstone and fine-grained limestone like unit 36; no chert	8.0
43. Limestone, fine-grained; like unit 36; no chert	1.0
42. Covered; small pieces of pink- and dark-yellowish-orange-weathered siltstone and fine-grained limestone breccia with pink and orange matrix (clasts 0.05 ft or less in diameter)	7.0
41. Limestone, mostly fine grained; like unit 36; about 10–20 percent large nodules of brown- to orange-weathered chert	13.0
40. Covered by talus from unit 41	3.0
39. Limestone, mostly fine grained; like unit 36; about 10 percent chert	4.0
38. Limestone, fine-grained; like unit 30	5.0
37. Limestone, mostly fine grained; like unit 36 but with about 20–30 percent brown- to orange-weathered chert nodules, sheets, and lenses. Rare brachiopods and disarticulated colonial corals. USGS 20806–PC 3 ft above base	13.0
36. Limestone, predominantly fine grained; micrite and fine-grained calcarenite with about 20 percent scattered medium to coarse crinoidal and other bioclastic debris; dark yellowish brown; weathers medium light gray to light gray; beds regular, 1–3 ft thick; about 5 percent small orange-weathered chert nodules	12.0
35. Limestone, fine-grained (micrite), dark-yellowish-brown; weathers medium gray to very light gray; beds regular, some laminated, 0.3–0.5 ft thick; one intraformational conglomerate 0.5 ft thick in upper half; about 5 percent orange-weathered chert in thin sheets	9.0
34. Covered by talus from unit above	25.0
33. Covered; terrace level	30.0
32. Limestone, fine-grained; like unit 30; about 20–30 percent fine- to medium-grained bioclastic debris (ostracodes?)	8.0
31. Limestone, oolitic; like unit 26; beds 0.5–	



A



C



B

FIGURE 4.—Madison Group in the Monarch–U.S. 89 section, Little Belt Mountains. *A*, Contact between Lodgepole Limestone (Ml) and Mission Canyon Limestone (Mmc) exposed in roadcut at base of section. *B*, Lower part of Mission Canyon Limestone exposed in hills along U.S. 89 north of Monarch (measured section units 1–19 in hill in center of photograph). *C*, Mission Canyon Limestone: lower cliff is unit 19; units 22 and 23 form rounded cliffs in center of photograph.

	Thickness (feet)
Madison Group—Continued	
Mission Canyon Limestone—Continued	
2 ft thick; about 10–20 percent orange- and brown-weathered chert nodules and lenses. Algal oncolites in lower ft. USGS 20805–PC from lower ft	8.0
30. Limestone, fine-grained; like unit 28 but beds are 0.3–0.5 ft thick and unit contains only about 5–10 percent chert	9.0
29. Covered; terrace level	20.0
28. Limestone, fine-grained; predominantly micrite with a few beds of very fine grained calcarenite; dark yellowish brown; weathers medium to very light gray; beds 0.3–1 ft thick; about 40 percent orange-weathered reticular, nodular, and lenticular chert	30.0
27. Covered; medium- to coarse-grained crinoidal limestone in float	8.0
Madison Group—Continued	
Mission Canyon Limestone—Continued	
26. Limestone, predominantly medium grained, oolitic, dark-yellowish-brown; weathers medium light gray to light gray; beds regular, 1–3 ft thick, bedding planes poorly defined; about 5–10 percent small spongy orange-weathered chert nodules. Colonial corals. USGS–20804–PC 3 ft above base	14.0
25. Limestone; like unit 24 but predominantly fine grained inorganic calcarenite, with chert about 10 percent in small orange-weathered nodules; beds 1–2 ft thick	10.0
24. Limestone, predominantly fine grained; micrite and fine inorganic calcarenite with about 5 percent fine organic debris; a few beds of coarse crinoidal limestone; pale to dark yellowish brown; weathers medium light gray to light gray; beds regular, 1–3 ft thick; bedding planes poorly defined; about 30–40 percent orange- to brown-weathered chert in large and small nodules and lenses; some beds slightly rotated in lower half	45.0
23. Breccia; clasts consist of fine- to medium-grained dark-yellowish-brown	

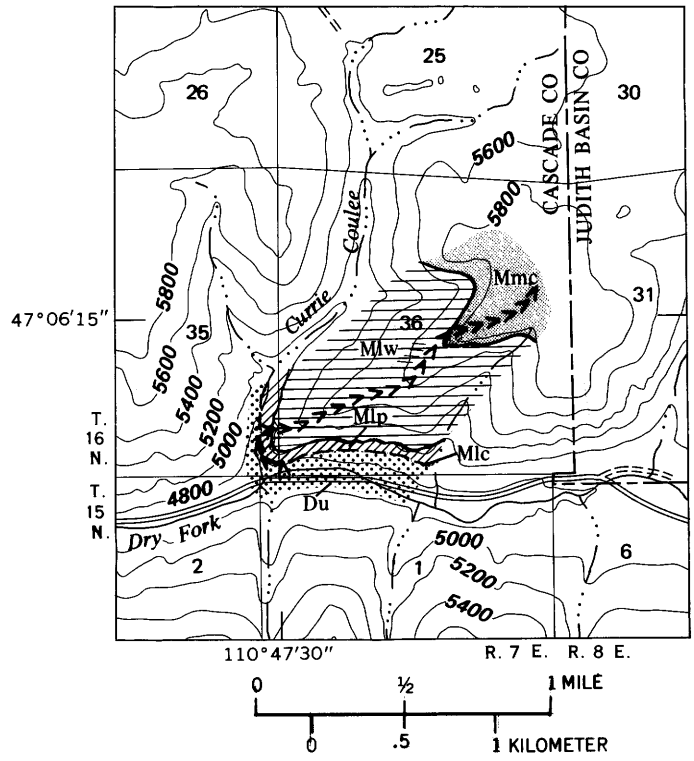
	Thickness (feet)
Madison Group—Continued	
Mission Canyon Limestone—Continued	
cherty crinoidal limestone (40 percent crinoidal debris in micrite matrix) that weathers medium light gray to light gray. Clasts are large rotated blocks as much as 10 ft in diameter, some nearly in original position, especially in upper 20 ft. Unit is interpreted as a collapse breccia overlying a solution zone. Clasts contain abundant brachiopods and solitary and colonial corals. USGS 20800–PC from lower 5 ft; USGS 20801–PC 20–25 ft above base; USGS 20802–PC 40–42 ft above base; USGS 20803–PC 65–70 ft above base	110.0
22. Breccia; clasts consist of fine-grained dark-yellowish-brown limestone that weathers medium light gray to light gray and of about 5 percent chert that weathers brown and orange. Clasts are angular blocks mostly 0.5 ft in diameter or less in a matrix of fine-grained yellowish- to pinkish-weathering calcareous rock flour. Unit is interpreted as a solution zone	25.0
21. Covered; small chips of fine- to coarse-grained partly crinoidal dolomitic limestone that weathers pale yellowish brown	15.0
20. Limestone, fine- to medium-crystalline, dark-yellowish-brown to cream-colored; weathers medium light gray mottled grayish orange; beds irregular, 0.5–1 ft thick, seemingly partly brecciated; large colonial coral at base	15.0
19. Limestone, predominantly fine grained; micrite with 5 percent or less fine bioclastic debris and pellets and oolites in upper 20 feet; dark yellowish brown; weathers medium light gray to light gray; beds 5–10 ft thick, bedding planes poorly defined; irregular sparry calcite flecks, some parallel to bedding but mostly at random. Small gastropods in upper 20 ft. Top of unit is top of prominent cliff, which was walked northward around hill to next big draw to north; section continued up nose above cliffs above and on east side of highway and north of draw	62.0
18. Limestone, fine grained; like unit 13 but beds about 1–2 ft thick	13.0
17. Limestone, predominantly fine grained; like unit 16 but beds are 1–4 ft thick and contain about 20 percent punky brown-weathered chert lenses and nodules. Brachiopods and corals. USGS 20799–PC 7–8 ft above base	18.0
16. Limestone, predominantly fine grained with about 20–30 percent scattered coarse crinoidal and other bioclastic debris, dark-yellowish-brown; weathers medium light gray to light gray; beds 1–3 ft thick. Brachiopods and solitary corals rare. USGS 20798–PC from lower 5 ft	20.0
15. Limestone, fine-grained; like unit 13 but a little coarser grained	10.0
14. Limestone, fine-grained; like unit 13 but with about 20–30 percent spongy brown-weathered chert lenses and sheets; two beds each 4 ft thick	8.0
13. Limestone, fine-grained; 20–30 percent sand-size bioclastic debris (ostracodes?) in micrite matrix; beds regular, 1–5 ft thick, poorly defined; a few small spongy brown chert nodules in lower 5 ft	31.5
12. Limestone, fine-grained, moderate-brown; weathers medium light gray to light gray; beds regular, 0.3–0.5 ft thick, faintly laminated; about 40 percent irregular sheets and lenses of orange-weathered brown chert	5.5
11. Covered by talus from unit 12	19.0
10. Mostly covered, with a few ledges of cherty dolomitic limestone and limestone like units 3 and 4; about 20–30 percent scattered crinoidal debris in exposed beds. Brachiopods rare	20.0
9. Limestone, medium- to coarse-grained; like unit 8 but contains about 30 percent interbedded fine-grained limestone and beds are 1–2 ft thick; 5 percent or less small spongy incipient brown-weathered chert nodules. Corals and brachiopods rare. Unit forms bench on top of cliff. USGS 20797–PC from throughout unit	20.0
8. Limestone, medium- to coarse-grained, crinoidal, dark-yellowish-brown; weathers medium light gray to light gray; beds regular, 2–5 ft thick, poorly defined; large lenses of pink- to brown-weathered porous chert at top. Rare solitary corals and brachiopods	47.5
7. Covered; lower 20 ft seemingly like units 2–6; upper 33 ft covered completely by talus from unit 8	53.0
6. Dolomitic limestone, fine-grained; like unit 4	2.5
5. Limestone, fine- to medium-crystalline; like unit 3	4.0
4. Dolomitic limestone, fine-grained; like unit 2; about 30 percent irregular reticular and sheetlike varicolored chert, some jasperoid	3.7
3. Limestone, fine- to medium-crystalline, grayish-orange; weathers medium light gray; about 10–20 percent reticular varicolored chert	3.5

	Thickness (feet)
Madison Group—Continued	
Mission Canyon Limestone—Continued	
2. Dolomitic limestone, fine-grained with about 30 percent scattered coarse crinoidal debris, olive-gray; weathers light olive gray and yellowish gray; beds 0.3–0.5 ft thick; about 10 percent reticular varicolored chert; both contacts fuzzy	3.0
1. Limestone, predominantly coarse grained, crinoidal with thin interbeds of fine-grained limestone, dark-yellowish-brown; weathers medium light gray to light gray; beds regular, 0.5–2 ft thick; less than 5 percent small brown-weathered incipient chert nodules. Corals and brachiopods. USGS 20796–PC 35–40 ft above base	50.0
Total Mission Canyon Limestone	861.2
Lodgepole Limestone: Upper 10 ft consists of thin-bedded fine- and coarse-grained limestone like that at the top of the Lodgepole in the Dry Fork section.	

DRY FORK SECTION

The Dry Fork section is the type section of the Paine and Woodhurst Members of the Lodgepole Limestone. The section traverse begins at the base of a cliff above the road along the Dry Fork of Belt Creek at the intersection of Currie Coulee with Dry Fork at the SE. cor. sec. 35, T. 16 N., R. 7 E., Cascade County, Mont. (figs. 5–7). The Cottonwood Canyon Member and lowermost beds of the Paine Member of the Lodgepole were studied by digging a trench about 5 feet deep at the base of the cliff. The traverse proceeds around and up the cliff in SE¼ SE¼ sec. 35 to the top of the Paine Member at the top of the cliff, then northeastward across SW¼ sec. 36 up a long spur to cliffs composed of Mission Canyon Limestone in NW¼SE¼ sec. 36. The traverse was terminated on top of these cliffs in SE¼NE¼ sec. 36, where a long dip slope prevents further measurement. The section was measured in 1962 with a Jacob staff and 8-foot steel tape. The beds dip about 8° N. A columnar section is shown on plate 1.

	Thickness (feet)
Madison Group:	
Mission Canyon Limestone (incomplete):	
61. Limestone predominantly fine grained; like unit 60 but with about 50 percent networks and nodules of varicolored jasperoid chert	30.0



EXPLANATION

- Mmc — MISSION CANYON LIMESTONE
- Mlw — WOODHURST MEMBER OF LODGEPOLE LIMESTONE
- Mlp — PAINE MEMBER OF LODGEPOLE LIMESTONE
- Mlc — COTTONWOOD CANYON MEMBER OF LODGEPOLE LIMESTONE (COVERED)
- Du — DEVONIAN ROCKS, UNDIVIDED
- ——— Contact
- <<<<< Measured section traverse

FIGURE 5.—Geologic sketch map of Dry Fork section. Geology by W. J. Sando and J. T. Dutro, Jr. Base from U.S. Geol. Survey Monarch quadrangle, Montana, scale 1:24,000.

	Thickness (feet)
Madison Group—Continued	
Mission Canyon Limestone—Continued	
60. Limestone, predominantly fine grained with a few thin interbeds of coarse crinoidal limestone and about 10 percent scattered coarse bioclastic debris, moderate-yellowish-brown; weathers medium light gray to grayish orange; beds regular, 0.1–0.3 ft thick; about 5 percent incipient orange- and brown-weathered chert nodules; unit poorly exposed on knob. Same fauna as unit 59. USGS 20795–PC from lower 5 ft	9.0

FIGURE 6.—Cliffs at Currie Coulee on Dry Fork of Belt Creek, Little Belt Mountains, showing exposures of Lodgepole Limestone (Ml) and basal beds of Mission Canyon Limestone (Mmc).

	Thickness (feet)
Madison Group—Continued	
Mission Canyon Limestone—Continued	
59. Limestone, medium- to coarse-grained, crinoidal, pale - yellowish - brown; weathers medium light gray to light gray; beds fairly regular, 0.1–0.5 ft thick; about 5 percent incipient chert nodules as in unit 58; unit poorly exposed on nose above cliff, about 50 percent covered. Abundant solitary and colonial corals. USGS 20793–PC from float 15 ft above base, USGS 20794–PC 20–22 ft above base	25.0
58. Limestone, interbedded fine- and coarse-grained, crinoidal; lower half about 60 percent fine-grained limestone, upper half about 80 percent crinoidal limestone; pale yellowish brown; weathers medium light gray to light gray; beds regular, 0.5–2 ft thick; 5 percent or less small incipient punky brown-weathered chert nodules; unit measured in cliff. Brachiopods, and solitary and colonial corals common. USGS 20791–PC 3-4 ft above base, USGS 20792–PC from upper 10 ft	45.0
Mission Canyon Limestone (incomplete)	109.0
Lodgepole Limestone:	
Woodhurst Member:	
57. Limestone, interbedded fine- and coarse-grained (about 50 percent each); like unit 15; beds nodular to lenticular, 0.1–0.5 ft thick; yellowish- to pink-weathered partings about 20–30 percent. *Zoophycos* ichnofossils	5.0

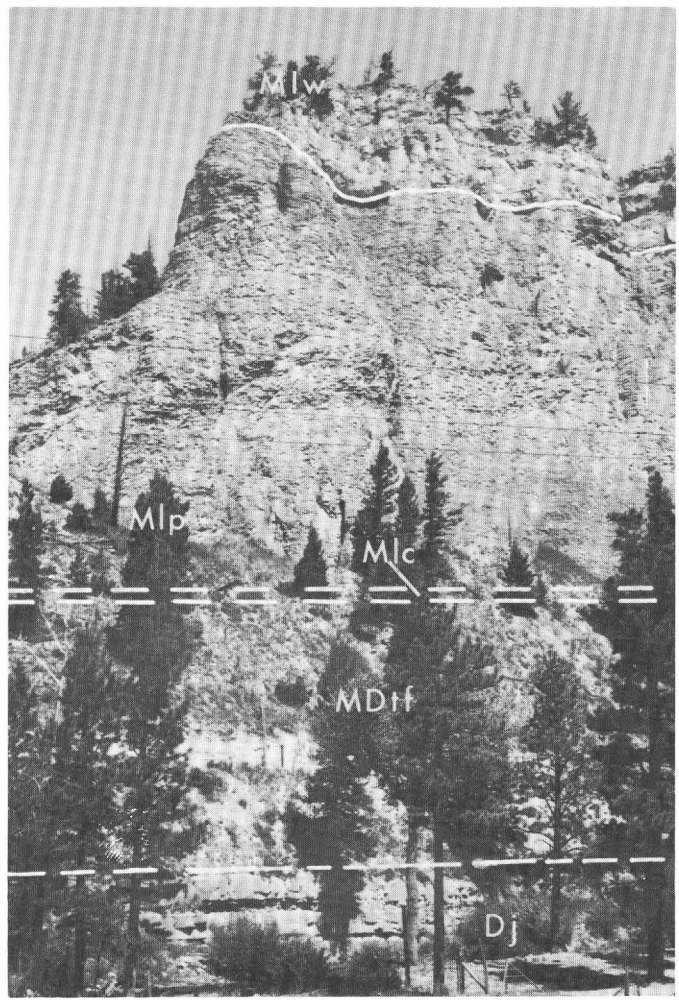


FIGURE 7.—Cliff face at Currie Coulee on Dry Fork of Belt Creek, Little Belt Mountains, showing basal beds of Woodhurst Member of Lodgepole Limestone (Mlw), Paine Member of Lodgepole Limestone (Mlp), Cottonwood Canyon Member of Lodgepole Limestone (Mlc), Three Forks Formation (MDtf), and uppermost beds of Jefferson Formation (Dj).

	Thickness (feet)
Madison Group—Continued	
Lodgepole Limestone—Continued	
Woodhurst Member—Continued	
56. Limestone, predominantly fine grained with about 10–20 percent scattered medium to coarse crinoidal debris and yellowish-weathered partings, dark-yellowish-brown; weathers medium light gray to light gray; beds regular, 0.3–0.5 ft thick; about 10 percent small brown- and orange-weathered chert nodules	6.0
55. Dolomitic limestone, fine-grained; like unit 53	4.5
54. Limestone, medium- to coarse-grained crinoidal; like unit 52 but no dolomitic limestone interbeds; about 5 percent	

	Thickness (feet)
Madison Group—Continued	
Lodgepole Limestone—Continued	
Woodhurst Member—Continued	
small brown-weathered chert nodules. Brachiopods and solitary corals. USGS 20790–PC from upper 2 ft	3.0
53. Dolomitic limestone or dolomite, fine-grained, olive-gray; weathers light brownish gray to yellowish gray; beds blocky, 0.1–0.3 ft thick, regular to lenticular; about 5 percent small orange- to brown-weathered subspherical chert nodules	4.5
52. Limestone (60 percent) and dolomitic limestone (40 percent); limestone is predominantly medium to coarse grained, crinoidal with some fine-grained layers, dark yellowish brown, weathers medium light gray, in beds 0.3–1 ft thick; dolomitic limestone is fine grained, silty, olive gray, weathers light olive gray to yellowish gray, in platy beds 0.05–0.1 ft thick. Contacts of unit irregular, fuzzy. Brachiopods and solitary corals	8.5
51. Limestone, interbedded fine- and coarse-grained; like unit 15 but no chert; much scattered coarse crinoidal debris in upper half	5.5
50. Limestone, medium- to coarse-grained, crinoidal; like unit 24. USGS 20789–PC from upper ft	2.5
49. Limestone, predominantly fine grained; like unit 15 but no chert; thin crinoidal interbeds about 50 percent of unit in upper half. *Zoophycos* and abundant brachiopods. USGS 20788–PC from float throughout unit	16.0
48. Limestone, medium- to coarse-grained, crinoidal; like unit 24	2.0
47. Limestone, predominantly fine grained; like unit 15 but no chert. Brachiopods abundant, corals rare. USGS 20787–PC from float throughout unit	8.5
46. Limestone, medium- to coarse-grained, crinoidal; like unit 24	2.5
45. Limestone, predominantly fine grained; like unit 15; a few chert nodules in lower half. *Zoophycos* ichnofossils. USGS 20785–PC from lower ft, USGS 20786–PC from upper 4 ft	7.0
44. Limestone, medium- to coarse-grained, crinoidal; like unit 24	2.0
43. Limestone, predominantly fine grained; like unit 15 but no chert	6.5
42. Limestone, coarse - grained, crinoidal; like unit 24	1.5
41. Covered, and a few ledges of predominantly fine grained limestone like unit 15	10.0
40. Limestone, coarse-grained, crinoidal; like unit 38 but contains fewer brachiopods	1.0
39. Covered, and a few ledges of predominantly fine grained limestone like unit 15	15.0
38. Limestone, coarse-grained, crinoidal; brachiopod coquina. USGS 20784–PC	.5
37. Covered, and a few ledges of predominantly fine grained limestone like unit 15; no chert	9.5
36. Limestone, coarse-grained, crinoidal; like unit 24	1.5
35. Limestone, predominantly fine grained; like unit 15 but no chert	3.5
34. Limestone, predominantly fine to medium grained; interbedded micrite and oolite with about 10–20 percent medium- to coarse-grained crinoidal and other bioclastic debris (about 40–50 percent in upper 2 ft); pale yellowish brown to dark yellowish brown; weathers medium light gray to light gray; beds regular, 0.5–2 ft thick; oolitic beds begin with sharp basal discontinuity and grade upward into fine sediment. Brachiopods	8.0
33. Limestone, predominantly fine grained; like unit 15 but no chert. USGS 20783–PC from throughout unit	4.0
32. Limestone, coarse-grained, crinoidal; like unit 24	2.5
31. Limestone, predominantly fine grained; like unit 15 but no chert	3.5
30. Limestone, coarse-grained, crinoidal; like unit 24; beds 0.1–1 ft thick	4.0
29. Limestone, predominantly fine grained; like unit 15 but no chert. USGS 20782–PC from throughout unit	9.5
28. Limestone, coarse-grained, crinoidal; like unit 24	1.5
27. Limestone, predominantly fine grained; like unit 15 but no chert	6.5
26. Limestone, coarse-grained, crinoidal; like unit 24	4.0
25. Limestone, predominantly fine grained; like unit 15 but no chert	4.0
24. Limestone, medium- to coarse-grained, crinoidal; like unit 6; beds 0.3–0.5 ft thick, some crossbedded and conglomeratic	3.5
23. Limestone, predominantly fine grained; like unit 15 but no chert	8.0
22. Limestone, medium- to coarse-grained, crinoidal; like unit 6; beds 0.3–0.5 ft thick	1.0
21. Limestone, predominantly fine grained; like unit 15 but no chert	3.0
20. Limestone, coarse-grained, crinoidal; like unit 6; conglomeratic.	1.0
19. Limestone, predominantly fine grained; like unit 15 but no chert; thin crinoi-	

	Thickness (feet)
Madison Group—Continued	
Lodgepole Limestone—Continued	
Woodhurst Member—Continued	
dal beds contain pebbles of fine-grained limestone. *Zoophycos*, brachiopods, and solitary and colonial corals. USGS 20780–PC from lower 10 ft (float), USGS 20781–PC from upper 5 ft	27.0
18. Limestone, medium- to coarse-grained, crinoidal; like unit 6; beds 0.3–1.5 ft thick. Abundant solitary and colonial corals. USGS 20779–PC from throughout unit	5.0
17. Limestone, predominantly fine grained; like unit 15; beds 0.05–0.3 ft thick. USGS 20778–PC 5 ft above base	13.0
16. Covered, and a few ledges of predominantly fine grained limestone like unit 15. USGS 20776–PC from float in lower 50 ft, USGS 20777–PC 57 ft above base (float)	85.0
15. Limestone, predominantly fine grained; silty micrite with about 10 percent scattered coarse bioclastic debris and 5–10 percent pink-stained lenses of conglomeratic crinoidal limestone; dark yellowish brown; weathers medium light gray; beds lenticular, 0.1–0.3 ft thick; 10–20 percent yellowish-weathered silty partings 0.05–0.2 ft thick; 10–20 percent small punky orange-weathered chert lenses and nodules; unit forms small cliff protruding from long slope. *Zoophycos* ichnofossils, brachiopods, bryozoans, solitary and colonial corals. USGS 20773–PC 15 ft above base, USGS 20774–PC 20 ft above base, USGS 20775–PC 21 ft above base	33.0
14. Covered; float and a few ledges of limestone suggest an interval of limestone like unit 15. USGS 20772–PC from float in lower half	75.0
13. Limestone, predominantly fine grained with about 30 percent scattered medium to coarse bioclastic debris and thin lenses of coarse crinoidal limestone; dark yellowish brown; weathers medium light gray; beds nodular to lenticular, 0.3–0.5 ft thick; about 20 percent yellowish- to pink-weathered silty partings 0.05–0.1 ft thick; unit forms bench on top of cliff. Abundant *Zoophycos* and other ichnofossils, brachiopods, and solitary and colonial corals. USGS 20771–PC 5–8 ft above base	13.0
12. Limestone, medium- to coarse-grained, crinoidal; like unit 6; crossbedded, beds 0.5–2 ft thick; about 20 percent punky orange- and brown-weathered irregular chert nodules; top of unit is top of first main cliff. Abundant brachiopods and corals. USGS 20769–PC 5 ft above base; USGS 20770–PC 3–5 ft above base	7.0
11. Limestone, predominantly fine grained; like unit 5. Corals. USGS 20768–PC from float in lower half	6.0
10. Limestone, medium- to coarse-grained, crinoidal; like unit 6; beds 0.5–1 ft thick	5.5
9. Limestone, predominantly fine grained; like unit 5	10.0
8. Limestone, medium- to coarse-grained, crinoidal; two lenticular beds separated by silty partings	2.5
7. Limestone, predominantly fine grained with about 20 percent coarse bioclastic debris, light-olive-gray; weathers medium light gray; beds 0.1–0.3 ft thick, nodular to lenticular; about 30 percent yellowish silty partings 0.1–0.3 ft thick. Brachiopods and bryozoans	3.5
6. Limestone, medium- to coarse-grained, crinoidal, dark-yellowish-brown to pale-yellowish-brown; weathers medium light gray to light gray; beds 0.5–3 ft thick, crossbedded. Brachiopods, bryozoans, solitary and colonial corals. USGS 20765–PC 3.5 ft above base; USGS 20766–PC 9 ft above base; USGS 20767–PC 15–20 ft above base	23.0
5. Limestone, predominantly fine grained, micrite with about 20–30 percent scattered coarse bioclastic debris in thin lenses and partings and a few thin lenses of crinoidal limestone; dark yellowish brown; weathers medium light gray; beds nodular to lenticular 0.05–0.1 ft thick; about 10 percent yellowish- to pink-weathered silty partings 0.05–0.1 ft thick. Abundant brachiopods. USGS 20764–PC 6–9 ft above base	10.5
4. Limestone, coarse-grained, crinoidal, dark-yellowish-brown to pale-yellowish-brown; weathers medium light gray to light gray; beds regular, 1–3 ft thick. Brachiopods and solitary corals. USGS 20763–PC from upper half	9.5
3. Limestone, fine-grained, shaly, cherty, with about 30 percent coarse bioclastic debris; like uppermost part of unit 2 but with about 50 percent lenticular interbeds (0.3–1.5 ft thick) of medium- to coarse-grained crinoidal limestone. Abundant brachiopods and bryozoans	7.0
Total Woodhurst Member	526.0

	Thickness (feet)
Madison Group—Continued	
Lodgepole Limestone—Continued	
Paine Member:	
2. Limestone, fine-grained, silty and argillaceous; micrite with about 5 percent scattered coarse bioclastic debris in lower half increasing to about 10–15 percent throughout most of upper half but becoming 20–30 percent from 170 ft above base to top; dark yellowish brown to olive gray; weathers medium light gray to yellowish gray; lenticular to nodular cherty hard beds 0.3–1.5 ft thick in matrix of hackly, shaly limestone; about 40 percent large orange-weathered chert nodules and lenses, many of which have irregular limestone cores; hard beds are mostly limestone reinforced with incipient chert. Small spaghettilike ichnofossils, bryozoans, brachiopods, gastropods, and rare solitary corals. USGS 20752–PC 7–9 ft above base, USGS 20753–PC 28–31 ft above base, USGS 20754–PC 35–38 ft above base, USGS 20755–PC 62–65 ft above base, USGS 20756–PC 98–105 ft above base, USGS 20757–PC 115 ft above base, USGS 20758–PC 125–135 ft above base, USGS 20759–PC 137–142 ft above base, USGS 20760–PC 171 ft above base, USGS 20761–PC 180 ft above base, USGS 20762–PC 190–195 ft above base	195.0
1c. Limestone, medium-grained, crinoidal, light-olive-gray; weathers medium light gray to dark yellowish orange; beds irregular, 0.3–1 ft thick; measured in trench. USGS 20751–PC 1.5 ft above base	6.0
Total Paine Member	201.0
Cottonwood Canyon Member:	
1b. Clay shale, black, weathered yellowish in in upper 0.3 foot; measured in trench. Conodonts. USGS 24978–PC	1.5
1a. Quartz sandstone, fine-grained, black; measured in trench. Conodonts. USGS 24977–PC	.5
Total Cottonwood Canyon Member	2.0
Total Lodgepole Limestone	729.0
Madison Group (incomplete)	838.0
Three Forks Formation (covered).	

MISSION CANYON SECTION

The Mission Canyon section is the type section of the Mission Canyon Limestone. The base of the formation is exposed in cliffs that form the north wall of Mission Canyon on Peoples Creek, above the road along the southern boundary of SE¼NW¼ sec. 32, T. 26 N., R. 24 E., Blaine County, Mont. (figs. 8 and 9). The beds dip 13°–15° NW. The base of the formation was traced down the canyon to a point where it intersects the road at a culvert that carries the creek under the road. The formation was measured with a Jacob staff in 1962 by traversing along the road through the narrow, steep-walled canyon and observing the rocks in the south wall of the canyon (fig. 10). The section was terminated at the top of the highest limestone bed exposed on a dip slope at the west entrance to the canyon. A columnar section is shown on plate 1.

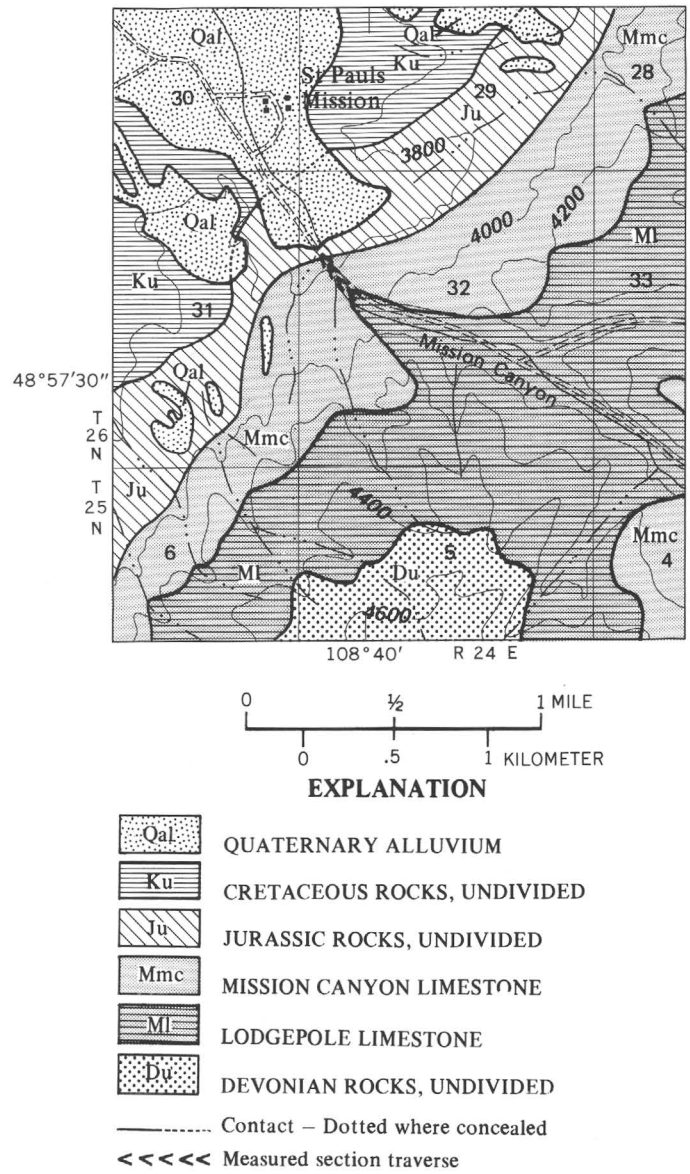


FIGURE 8.—Geologic sketch map of Mission Canyon section. Geology and base from Knechtel (1959, pl. 52).

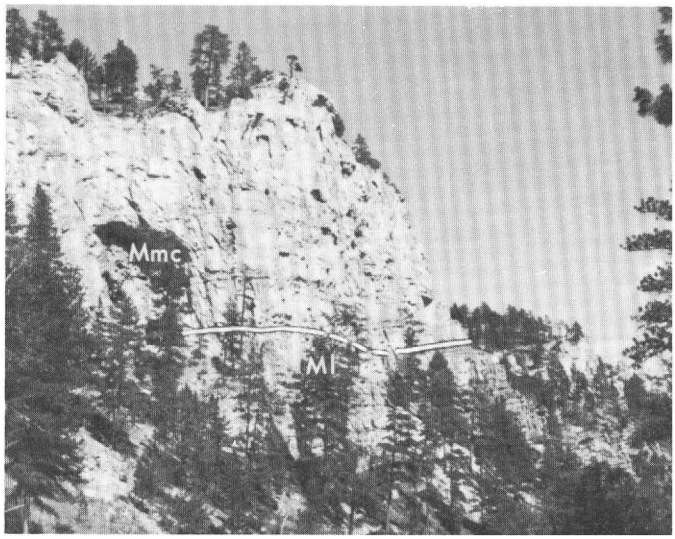


FIGURE 9.—Cliffs on north side of Mission Canyon, Little Rocky Mountains, showing contact between Mission Canyon Limestone (Mmc) and Lodgepole Limestone (Ml).

FIGURE 10.—View northwest down Mission Canyon, Little Rocky Mountains, showing thick beds of lower 100 feet of Mission Canyon Limestone exposed in vertical canyon walls.

	Thickness (feet)
Rierdon Formation of Ellis Group (covered).	
Madison Group:	
Mission Canyon Limestone:	
7. Limestone, medium- to coarse-grained, crinoidal; like unit 3; a zone of small nodules of gray and brown chert 45 ft above base. Brachiopods and solitary and colonial corals. USGS 20749–PC 45 ft above base, USGS 20750–PC from upper 10 ft	70.0
6. Limestone, mostly medium to coarse grained, crinoidal, interbedded with fine-grained limestone; beds 0.3–0.5 ft thick; yellowish- to reddish-weathered silty partings 0.05–0.1 ft thick; about 20 percent small irregular nodules and lenses of brown jasperoid chert. Brachiopods and solitary and colonial corals. USGS 20748–PC 20–25 ft above base (at natural bridge)	40.0
5. Limestone, medium- to coarse-grained, crinoidal; like unit 3. Brachiopods and solitary corals. USGS 20746–PC 10 ft above base, USGS 20747–PC 40 ft above base	90.0
4. Limestone, medium- to coarse-grained, crinoidal; like unit 3 but contains large lentils and nodules of gray to brown chert. Brachiopods. USGS 20745–PC at base	20.0
3. Limestone, medium- to coarse-grained, crinoidal, light-olive-gray; weathers medium light gray to light gray; beds 1–5 ft thick; contains many solution cavities	60.0
2. Limestone, mostly medium to coarse grained, crinoidal, interbedded with nodular to lenticular fine-grained limestone (about 30 percent), light-olive-gray; weathers medium light gray to light gray; beds 0.2–0.5 ft thick. Brachiopods and solitary corals. USGS 20744–PC 10–15 ft above base	15.0
Total Mission Canyon Limestone	295.0
Lodgepole Limestone:	
Woodhurst Member:	
1. Limestone, fine-grained, pale-yellowish-brown; weathers medium light gray; beds nodular to lenticular, 0.1–0.3 ft thick; yellowish-weathered silty partings	3.0

LITTLE CHIEF CANYON SECTION

The Little Chief Canyon section is the type section of the Lodgepole Limestone. The section traverse begins at the base of the Lodgepole Limestone exposed in the bed of a tributary of Lodgepole Creek in Little Chief Canyon in NE¼NW¼ sec. 30, T. 26 N., R. 25 E., Blaine County, Mont., and extends across SE¼ sec. 19 into SW¼NW¼ sec. 20 (fig. 11; Knechtel and others, 1954, fig. 2a). The beds dip 12°–16° NE.

The section was measured in 1962 with a Jacob staff and an 8-foot steel tape, but it was necessary to combine five overlapping traverses as follows:

Subsection A: From the base of the Lodgepole Limestone up the southeast slope of the canyon; units 1 through 12.

Subsection B: About a quarter mile downstream from subsection A, from the base of unit 5 up the

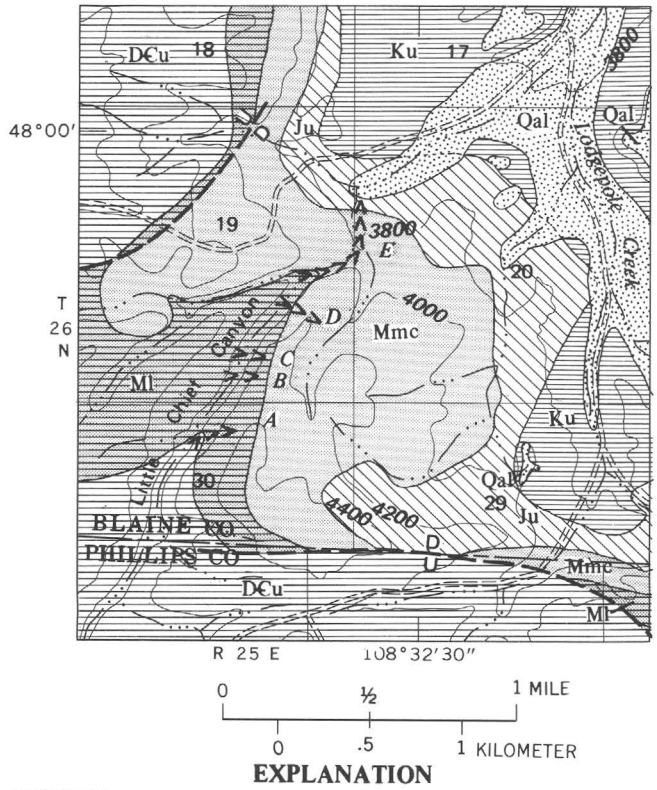


FIGURE 11.—Geologic sketch map of Little Chief Canyon section. Geology and base from Knechtel (1959, pl. 52).

southeast slope of the canyon in a small draw just southeast of prominent cliffs; units 5 through 16.

Subsection C: About 100 yards downstream from subsection B, from the base of unit 11 up the southeast slope of the canyon in a prominent draw on the south side of a prominent red cliff; units 11 through 45. Careful work was required to neutralize the effect of small normal faults that disrupt the sequence.

Subsection D: About a quarter mile downstream from subsection C, from the base of unit 43 up the southeast slope of the canyon on the north side of a draw on the south side of a red cliff; units 43 through 60.

Subsection E: About an eighth of a mile downstream from subsection D, where the stream bed intersects the base of the Mission Canyon Limestone, which was measured in the canyon with a Jacob staff observing the rocks exposed on both walls of the canyon; units 60 and 61. The section was terminated at the mouth of the canyon at the highest limestone beds exposed on a dip slope. A columnar section is given on plate 1. Small discrepancies between locations of fossil collections in the Lodgepole Limestone on plate 1 and locations given in the measured section result from difficulties in correlating and compositing of subsection units of variable thickness.

	Thickness (feet)
Rierdon Formation of Ellis Group (covered).	
Madison Group:	
Mission Canyon Limestone:	
61. Limestone, medium- to coarse-grained, crinoidal, light-olive-gray; weathers medium light gray to light gray; beds 1–5 ft thick, bedding planes indistinct; many caves and solution breccias. Brachiopods and solitary corals. USGS 20742–PC 15 ft above base, USGS 20743–PC 35 ft below top	160.0
60. Limestone, predominantly medium to coarse grained, crinoidal, with a few fine-grained beds, light-olive-gray; weathers medium light gray to light gray; beds 1–5 ft thick except for lower 2 ft in which they are 0.3–0.5 ft thick, bedding planes indistinct; whitish- to brownish-weathered (some jasperoid) chert nodules and lenses several feet in diameter 50–60 ft above base; many caves and solution cavities throughout, a large solution breccia 50–60 ft above base composed of angular blocks of limestone and chert as much as 2 by 4 ft. Brachiopods, gastropods, and solitary corals. USGS 20739–PC from float at base, USGS 20740–PC 30–35 ft above base, USGS 20741–PC 50–55 ft above base	155.0
Total Mission Canyon Limestone	315.0
Lodgepole Limestone:	
Woodhurst Member:	
59. Limestone, fine-grained; like unit 57	2.5
58. Limestone, interbedded fine- and coarse-grained; like unit 51	4.0
57. Limestone, fine-grained, light-olive-gray; weathers medium light gray; beds nodular to lenticular, 0.1–0.4 ft thick;	

	Thickness (feet)
Madison Group—Continued	
Lodgepole Limestone—Continued	
Woodhurst Member—Continued	
yellowish-weathered silty partings 0.05–0.1 ft thick which do not weather in relief; very little coarse bioclastic debris, no crinoidal beds	20.0
56. Limestone, medium- to coarse-grained, crinoidal; like unit 52. Solitary corals	1.5
55. Limestone, interbedded fine- and coarse-grained; like unit 51. USGS 20738–PC 8 ft above base	27.0
54. Limestone, medium- to coarse-grained, crinoidal; like unit 52. USGS 20737–PC	1.5
53. Limestone, interbedded fine- and coarse-grained; like unit 51. Colonial corals. USGS 20736–PC from float throughout unit	8.0
52. Limestone, medium- to coarse-grained, crinoidal, pale-yellowish-brown; weathers medium light gray	1.0
51. Limestone, predominantly fine grained; like unit 47 but contains about 20 percent interbeds of coarse-grained crinoidal limestone in lenses and beds 0.5 ft thick or less. *Zoophycos* ichnofossils, brachiopods, gastropods, and solitary corals. USGS 20735–PC from float throughout	18.0
50. Limestone, interbedded fine- and coarse-grained; like unit 48; upper ft consists of crossbedded, very coarse crinoidal limestone	4.0
49. Limestone, predominantly fine grained; like unit 47	3.5
48. Limestone, fine- to coarse-grained; about 50 percent crinoidal bioclastic layers alternating with micrite layers; pale yellowish brown; weathers medium light gray; beds 0.5–1 ft thick; about 10 percent white-weathered chert nodules. Brachiopods abundant, solitary corals rare	3.6
47. Limestone, predominantly fine grained with about 20 percent scattered coarse bioclastic debris in lenses and on bedding planes, light-olive-gray; weathers medium light gray; beds regular to lenticular, 0.1–0.4 ft thick; about 30 percent silty partings weathering yellowish gray. Abundant *Zoophycos* and brachiopods	7.0
46. Limestone, medium- to coarse-grained crinoidal; like unit 40	.6
45. Limestone, predominantly fine grained with about 10–20 percent scattered coarse bioclastic debris, light-olive-gray; weathers medium light gray; beds regular, 0.3–0.5 ft thick; about 20 percent white-weathered chert nodules. USGS 20734–PC 3 ft above base	4.0
44. Limestone, medium- to coarse-grained, crinoidal; like unit 40. Brachiopods abundant, solitary and colonial corals rare. USGS 20733–PC	.8
43. Limestone, fine-grained, silty; like unit 41. USGS 20732–PC throughout unit	4.0
42. Limestone, medium- to coarse-grained crinoidal; like unit 40. USGS 20731–PC from float	1.5
41. Limestone, fine-grained; like unit 39 but contains about 50 percent yellowish-weathered silty and shaly partings; beds nodular to lenticular, mostly 0.2 ft thick or less. *Zoophycos* ichnofossils and brachiopods abundant in partings. USGS 20730–PC from throughout unit	3.0
40. Limestone, medium- to coarse-grained, crinoidal, pale-yellowish-brown; weathers medium light gray; beds regular, 0.5–2 ft thick	5.0
39. Limestone, fine-grained; micrite with less than 5 percent bioclastic debris; light olive gray; weathers medium light gray; beds nodular to lenticular, 0.1–0.3 ft thick; yellowish-weathered shaly partings rare	4.5
38. Limestone, medium- to coarse-grained, crinoidal; like unit 36	2.0
37. Limestone, fine-grained; like unit 35	4.0
36. Limestone, medium- to coarse-grained, crinoidal; like unit 19 but light olive gray weathering medium light gray. USGS 20729–PC	.7
35. Limestone, fine-grained; micrite with 10 percent or less coarse bioclastic debris, mostly brachiopods; pale yellowish brown mottled dusky red; beds nodular to lenticular, 0.1–0.4 ft thick; about 20–30 percent silty shaly partings weathering pale red and very pale orange. USGS 20728–PC from lower 3 ft	7.5
34. Limestone, medium- to coarse-grained, crinoidal; like unit 19 but with a few thin beds of fine-grained limestone interbedded (about 10–20 percent); beds 0.2–0.5 ft thick; about 30 percent red shaly and silty partings. Brachiopods abundant, corals rare. USGS 20727–PC from upper 2 ft	14.0
33. Limestone, predominantly fine grained; like unit 25	5.0
32. Limestone, medium- to coarse-grained, crinoidal; like unit 19	1.5

	Thickness (feet)
Madison Group—Continued	
Lodgepole Limestone—Continued	
Woodhurst Member—Continued	
31. Limestone, predominantly fine grained; like unit 25	6.0
30. Limestone, medium- to coarse-grained, crinoidal; like unit 19	.5
29. Limestone, predominantly fine grained; like unit 25	4.0
28. Limestone, medium- to coarse-grained crinoidal; like unit 19	1.0
27. Limestone, predominantly fine grained; like unit 25. USGS 20726–PC from upper foot	6.0
26. Limestone, medium- to coarse-grained, crinoidal; like unit 19	.5
25. Limestone, predominantly fine grained; like unit 18; about 55 percent fine-grained limestone, 5 percent crinoidal limestone, and 40 percent shaly silty partings; fossils relatively scarce above lower 5 ft. USGS 20724–PC from lower 6 ft, USGS 20725–PC from float 10 ft above base	31.0
24. Limestone, medium- to coarse-grained, crinoidal; like unit 19 but with a few thin beds of fine-grained limestone like unit 18; very irregular basal bedding plane	8.0
23. Limestone, predominantly fine grained; like unit 18	4.0
22. Limestone, medium- to coarse-grained crinoidal; like unit 19	1.0
21a. Limestone, predominantly fine grained; like unit 18	8.0
21. Limestone, medium- to coarse-grained, crinoidal; like unit 19	2.5
20. Limestone, predominantly fine grained; like unit 18. USGS 20723–PC 3–5 ft above base	15.5
19. Limestone, medium- to coarse-grained, crinoidal, grayish-red to olive-gray; weathers medium light gray; beds 0.4–0.8 ft thick; contains pebbles of fine-grained limestone as much as 0.1 ft in diameter	1.5
18. Limestone, predominantly fine grained; micrite with about 20 percent bioclastic debris in thin lenses and on bedding planes and about 10 percent medium- to coarse-grained crinoidal limestone in lenses less than 0.5 ft thick; pale brown; weathers medium light gray; beds nodular to lenticular, 0.05–0.4 ft thick; about 20–30 percent shaly silty partings weathered pale red to moderate red. *Zoophycos* and linear ichnofossils abundant on bedding planes, brachiopods abundant. Base of unit is base of red-stained cliff. USGS 20722–PC 4 ft above base	5.5
17. Limestone, predominantly fine grained with about 20 percent coarse bioclastic debris mostly in silty partings and 10–20 percent interbeds of crinoidal limestone, medium-dark to olive-gray; weathers medium light gray; beds nodular to lenticular, 0.1–0.5 ft thick; about 20 percent silty partings weathered grayish yellow; forms slope between cliffs. Abundant brachiopods and *Zoophycos*. USGS 20720–PC from float throughout unit	9.0
16. Limestone, medium- to coarse-grained, crinoidal and bioclastic; like unit 7	4.0
15. Limestone, predominantly fine grained; micrite with about 10–20 percent scattered coarse bioclastic debris; light olive gray; weathers medium light gray; beds 0.5–2 ft thick, irregular; silty partings. Bryozoans and solitary and colonial corals. USGS 20719–PC from upper half of unit	7.5
14. Limestone, medium- to coarse-grained, crinoidal and bioclastic in lower 2 ft grading up into thin bioclastic beds; silty partings. Abundant brachiopods	7.5
13. Limestone, predominantly fine grained; like unit 9; nodular bedded; silty partings 0.05–0.1 ft thick	6.0
12. Limestone, medium- to coarse-grained, crinoidal and bioclastic; like unit 7. USGS 20718–PC from upper 2 ft	6.5
11. Limestone, predominantly fine grained; like unit 9 but with thin silty partings. USGS 20721–PC from float 14 ft below top, USGS 20715–PC from float throughout	21.0
10. Limestone, medium- to coarse-grained, crinoidal and bioclastic; like unit 7; upper 3 ft predominantly brachiopod coquina in lenses and beds. Brachiopods abundant, corals rare	6.5
9. Limestone, predominantly fine grained; micrite with about 20 percent scattered coarse bioclastic debris, mostly on bedding planes; dark yellowish brown; weathers medium light gray; beds regular to lenticular, 0.1–0.5 ft thick; thin silty partings. Brachiopods common in thin lenses and on bedding planes. USGS 20713–PC 4 ft above base, USGS 20714–PC from float in upper half	14.0
8. Limestone, interbedded fine- and coarse-grained; like unit 6. Brachiopods and solitary corals abundant. USGS 20712–PC from upper ft	8.0
7. Limestone, medium- to coarse-grained, crinoidal and bioclastic, dark-yellowish-brown; beds regular, 0.3–2 ft thick,	

	Thickness (feet)
Madison Group—Continued	
Lodgepole Limestone—Continued	
Woodhurst Member—Continued	
separated by silty partings; upper 2 ft is brachiopod coquina. Abundant brachiopods and bryozoans; corals rare. USGS 20710–PC from lower ft, USGS 20711–PC from upper 2 ft	5.0
6. Limestone, interbedded fine- and coarse-grained; fine-grained limestone (50 percent) is micrite with about 10–20 percent scattered coarse bioclastic debris, olive gray, weathers medium light gray, in regular to nodular beds 0.1–0.3 ft thick; coarse-grained limestone (30 percent) is crinoidal and bioclastic like unit 5, in beds 0.3–0.5 ft thick; platy silty limestone partings (20 percent). Abundant brachiopods and bryozoans, rare corals. USGS 20707–PC from float in lower 5 ft, USGS 20708–PC from float 10–15 ft above base, USGS 20709–PC from float in upper half, USGS 20716–PC from float in lower half, USGS 20717–PC from float probably from unit 9	33.5
5. Limestone, coarse-grained, crinoidal and bioclastic, pale- to dark-yellowish-brown; weathers medium light gray to light gray; beds slightly irregular, 0.3–1 ft thick; about 20 percent punky brown-weathered chert lenses. Brachiopods abundant, corals rare. USGS 20706–PC from throughout unit	8.0
Total Woodhurst Member	391.2
Paine Member:	
4. Limestone, predominantly fine grained; like unit 3 but contains about 10–20 percent coarse crinoidal debris (columnals as much as 0.05 ft in diameter) and 20–30 percent punky brown-weathered chert nodules and lenses	35.0
3. Limestone, argillaceous and silty, fine-grained (micrite), olive-gray; weathers medium light gray to yellowish gray; consists of regular, hackly, hard beds 0.3–1 ft thick separated by platy more silty soft beds 0.3–0.5 ft thick; many hard beds faintly laminated; about 10–20 percent punky brown- to orange-weathered incipient chert lenses in lower 60 ft. Linear ichnofossils abundant; brachiopods and bryozoans rare in shaly partings, becoming more abundant upward in unit. USGS 20702–PC 70–73 ft above base, USGS 20703–PC 87 ft above base, USGS 20704–PC from float 85–90 ft above base, USGS 20705–PC 101 ft above base	122.0
Madison Group—Continued	
Lodgepole Limestone—Continued	
Paine Member—Continued	
2. Limestone, predominantly medium grained, crinoidal, silty, glauconitic, medium-dark- to olive-gray; weathers medium light gray to dark yellowish orange; beds 0.1–0.3 ft thick. Corals and cephalopods rare. USGS 20700–PC 1–2 ft above base, USGS 20701–PC 5 ft above base	7.0
Total Paine Member	164.0
Total Lodgepole Limestone	555.2
Total Madison Group	870.2
Bakken Formation:	
1. Shale, fissile, pyritic, black; exposed at edge of stream bed at low water. Conodonts. USGS 11238–PC	1.0

AGE AND CORRELATION

Stratigraphic relationships of the five type sections described in this report are shown on plate 1, which shows the positions of fossil collections, the boundaries of lithic units and faunal zones recognized in the Madison Group, and the ages of the rock units in terms of provincial series established in the type area of the Mississippian System. Two paleontological zonation schemes are shown on the diagram: a megafaunal scheme, based mainly on corals and brachiopods and originally proposed by Sando and Dutro (1960); and a microfaunal scheme, based mainly on Foraminifera and developed by Mamet and Skipp (1970, 1971). The criteria for recognition of the faunal zones and their interrelationships are described by Sando, Mamet, and Dutro (1969), who also dealt with the correlation of the Madison Group with the type Mississippian.

REFERENCES CITED

Andrichuk, J. M., 1955, Carboniferous stratigraphy in mountains of northwestern Montana and southwestern Alberta, *in* Lewis, P. J., ed., Billings Geol. Soc. Guidebook, 6th Ann. Field Conf., Sept. 1955: p. 85–95, 4 figs.

Chamberlain, V. R., 1955, Subsurface carbonates of the Madison group in the Sweetgrass Arch area [Montana], *in* Lewis, P. J., ed., Billings Geol. Soc. Guidebook, 6th Ann. Field Conf. Sept. 1955, p. 78–84.

Collier, A. J., and Cathcart, S. H., 1922, Possibility of finding oil in laccolithic domes south of the Little Rocky Mountains, Montana: U.S. Geol. Survey Bull. 736–F, p. 171–178.

Deiss, C. F., 1933, Paleozoic formations of northwestern Montana: Montana Bur. Mines and Geology Mem. 6, 51 p., 3 pls.

——— 1941, Structure of central part of Sawtooth Range,

Montana [abs.]: Geol. Soc. America Bull., v. 52, no. 12, pt. 2, p. 1896–1897.

——— 1943, Stratigraphy and structure of southwest Saypo quadrangle, Montana: Geol. Soc. America Bull., v. 54, no. 2, p. 205–262, 5 pls., 3 figs.

Goddard, E. N., chm., and others, 1948, Rock-color chart: Washington, Natl. Research Council (repub. by Geol. Soc. America, 1951), 6 p.

Gutschick, R. C., 1964, Transitional Devonian to Mississippian environmental changes in western Montana, *in* Symposium on cylic sedimentation: Kansas Geol. Survey Bull. 169, v. 1, p. 172–181, 5 figs.

Hague, Arnold, Weed, W. H., and Iddings, J. P., 1896, Yellowstone National Park [Wyoming]: U.S. Geol. Survey Geol. Atlas, Folio 30, [6] p., 11 figs., 8 maps.

Holland, F. D., Jr., 1952, Stratigraphic details of Lower Mississippian rocks of northeastern Utah and southwestern Montana: Am. Assoc. Petroleum Geologists Bull., v. 36, no. 9, p. 1697–1734, 17 figs.

Iddings, J. P., and Weed, W. H., 1894, Livingston, Montana: U.S. Geol. Survey Geol. Atlas, Folio 1, [5] p., 4 maps.

Knechtel, M. M., 1959, Stratigraphy of the Little Rocky Mountains and encircling foothills, Montana. U.S. Geol. Survey Bull. 1072–N, p. 723–752, pls. 52, 53, figs. 32, 33. [1960]

Knechtel M. M., Smedley, J. E., and Ross, R. J., Jr,. 1954, Little Chief Canyon Member of Lodgepole Limestone of Early Mississippian age in Montana: Am. Assoc. Petroleum Geologists Bull., v. 38, no. 11, p. 2395–2400. 2 figs.

Mamet, B. L., and Skipp, B. A., 1970, Preliminary foraminiferal correlations of early Carboniferous strata in the North American Cordillera, *in* Colloque sur la stratigraphie du carbonifère: Liège Univ. Cong. et Colloques, v. 55, p. 327–348, 3 figs.

——— 1971, Lower Carboniferous calcareous Foraminifera—preliminary zonation and stratigraphic implications for the Mississippian of North America: Internat. Cong. of Carboniferous Stratigraphy and Geology, 6th, Sheffield, England, 1967, Compte rendu, v. 3, p. 1129–1146, 10 figs.

Mudge, M. R., 1972, Pre-Quarternary rocks in the Sun River Canyon area, northwestern Montana: U.S. Geol. Survey Prof. Paper 663–A, 142 p., 3 pls., 40 figs., 9 tables.

Mudge, M. R., Sando, W. J., and Dutro, J. T., Jr., 1962, Mississippian rocks of Sun River Canyon area, Sawtooth Range, Montana: Am. Assoc. Petroleum Geologists Bull., v. 46, no. 11, p. 2003-2018, 6 figs.

Nordquist, J. W., 1953, Mississippian stratigraphy of northern Montana, *in* Parker, J. M., ed., Billings Geol. Soc. Guidebook, 4th Ann. Field Conf., Sept. 1953: p. 68–82, 8 figs.

Peale, A. C., 1893, The Paleozoic section in the vicinity of Three Forks, Montana: U.S. Geol. Survey Bull. 110, 56 p.

Perry, E. S., and Sloss, L. L., 1943, Big Snowy Group—lithology and correlation in the northern Great Plains: Am. Assoc. Petroleum Geologists Bull., v. 27, no. 10, p. 1287–1304, 7 figs.

Roberts, A. E., 1966, Stratigraphy of Madison Group near Livingston, Montana, and discussion of karst and solution-breccia features: U.S. Geol. Survey Prof. Paper 526–B, 23 p., 10 figs.,1 table.

Rodriguez, Joaquin, and Gutschick, R. C., 1970, Late Devonian–early Mississippian ichnofossils from western Montana and northern Utah, *in* Crimes, T. P., and Harper, J. C., eds., Trace fossils: Geol. Jour., Spec. Issue 3, p. 407–438, 10 pls. 6 figs.

Sandberg, C. A., and Klapper, Gilbert, 1967, Stratigraphy, age, and paleotectonic significance of the Cottonwood Canyon Member of the Madison Limestone in Wyoming and Montana: U.S. Geol. Survey Bull. 1251–B, 70 p., 5 figs. 3 tables.

Sandberg, C. A., and Mapel, W. J., 1967. Devonian of the Northern Rocky Mountains and Plains, *in* Oswald, D. H., ed., Internat. symposium on the Devonian System, Calgary, 1967 [Proc.]: Calgary, Alberta Soc. Petroleum Geologists, v. 1, p. 843–877, 10 figs. [1968]

Sando, W. J., 1960, Distribution of corals in the Madison Group and correlative strata in Montana, western Wyoming, and northeastern Utah. in Geological Survey research 1960. U.S. Geol. Survey Prof. Paper 400–B, p. B225–B227, figs. 100.1–100.3.

Sando, W. J., and Dutro, J. T., Jr., 1960, Stratigraphy and coral zonation of the Madison Group and Brazer Dolomite in northeastern Utah, western Wyoming, and southwestern Montana, *in* Wyoming Geol. Assoc. Guide-Book, 15th Ann. Field Conf., Overthrust belt of southwestern Wyoming and adjacent areas, 1960: p. 117–126, 1 pl., 3 figs.

Sando, W. J., Mamet, B. L., and Dutro, J. T., Jr., 1969, Carboniferous megafaunal and microfaunal zonation in the northern Cordillera of the United States: U.S. Geol. Survey Prof. Paper 613–E, 29 p., 1 pl., 7 figs. 1 table.

Seager, O. A., 1942, Test on Cedar Creek anticline, southeastern Montana: Am. Assoc. Petroleum Geologists Bull., v. 26, no. 5, p. 861–864.

Sloss, L. L., 1952, Introduction to the Mississippian of the Williston Basin, *in* Sonneberg, F. P., ed., Billings Geol. Soc. Guidebook, 3rd Ann. Field Conf., Sept. 1952: p. 65–69, 2 figs.

Sloss, L. L., and Hamblin, R. H., 1942, Stratigraphy and insoluble residues of Madison Group (Mississippian) of Montana. Am. Assoc. Petroleum Geologists Bull., v. 26, no. 3, p. 305–335, 11 figs.

Weed, W. H., 1899a, Description of the Fort Benton quadrangle [Montana]: U.S. Geol. Survey Geol. Atlas, Folio 55, [9] p., 4 maps.

——— 1899b, Description of the Little Belt Mountains quadrangle [Montana]: U.S. Geol. Survey Geol. Atlas, Folio 56, [11] p., 4 maps.

——— 1900, Geology of the Little Belt Mountains, Montana: U.S. Geol. Survey 20th Ann. Rept., pt. 3, p. 257–461, pls. 36–77, figs. 36–79.

Wilmarth, M. G., 1938, Lexicon of geologic names of the United States (including Alaska): U.S. Geol. Survey Bull. 896, 2396 p.

* U.S. GOVERNMENT PRINTING OFFICE: 1974 O—543–586/146