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# Mississippian and Pennsylvanian Stratigraphy in Southwest Montana and Adjacent Idaho

U.S. GEOLOGICAL SURVEY BULLETIN 1656

# Mississippian and Pennsylvanian Stratigraphy in Southwest Montana and Adjacent Idaho

*Edited by* William J. Sando

A. Revision of Mississippian Stratigraphy, Northern Tendoy Mountains, Southwest Montana, by William J. Sando, Charles A. Sandberg, and William J. Perry, Jr.

B. New Mississippian-Pennsylvanian Stratigraphic Units in Southwest Montana and Adjacent Idaho, by Bruce R. Wardlaw and William C. Pecora

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# Chapter A –

# Revision of Mississippian Stratigraphy, Northern Tendoy Mountains, Southwest Montana

By William J. Sando, Charles A. Sandberg, and William J. Perry

U.S. GEOLOGICAL SURVEY BULLETIN 1656

MISSISSIPPIAN AND PENNSYLVANIAN STRATIGRAPHY IN SOUTHWEST MONTANA AND ADJACENT IDAHO

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FIGURES

# Revision of Mississippian Stratigraphy, Northern Tendoy Mountains, Southwest Montana

*By* William J. Sando, Charles A. Sandberg, *and* William J. Perry, Jr.

**Abstract**

A complexly faulted and folded sequence of Mississippian carbonate rocks more than 1,000 m thick is exposed in the northern Tendoy Mountains in southwest Montana. These rocks, previously assigned to the Madison Group, Big Snowy Group, and Amsden Formation, are herein referred to the Tendoy Group (new name) and the Snowcrest Range Group (new name, Wardlaw and Pecora, Chapter B, this bulletin). The Tendoy Group comprises, in ascending order, the Paine Limestone (raised in stratigraphic rank), Middle Canyon Formation, Mission Canyon Limestone (previously assigned to Madison Group in this area), and McKenzie Canyon Limestone (new name). The Tendoy Group represents a hitherto unrecognized facies belt near the craton margin. The overlying Mississippian Snowcrest Range Group consists of, in ascending order, the Kibbey Sandstone (reassigned from the Big Snowy Group) and two newly named units, the Lombard Limestone and Conover Ranch Formation (Wardlaw and Pecora, Chapter B, this bulletin).

## INTRODUCTION

A complexly faulted and folded sequence of Devonian to Permian rocks is exposed along the front of the northern Tendoy Mountains in Beaverhead County, Mont. (fig. 1). Rocks of Mississippian age in this area were previously assigned to the Madison Group, Big Snowy Group, and Amsden Formation by Scholten, Keenmon, and Kupsch (1955) and Scholten (1957) (fig. 2). Recent biostratigraphic studies and geologic mapping of the Mississippian sequences by the writers and by B. R. Wardlaw and W. C. Pecora revealed a need for new nomenclature for these rocks. This paper proposes new nomenclature for the sequence previously regarded as Madison Group and incorporates new nomenclature proposed by Wardlaw and Pecora (Chapter B, this bulletin) for the rocks previously assigned to the Big Snowy Group and Amsden Formation.

Complex thrust-faulting and folding in the area make measurement of the Mississippian sequence difficult. However, overlapping stratigraphic sections were measured at Bell Canyon in sec. 17, T. 11 S., R. 10 W., and on the divide between Bell Canyon and McKenzie Canyon in sec. 21, T. 11 S., R. 10 W. (fig. 1). A composite of these two stratigraphic sections characterizes the Mississippian sequence in the northern Tendoy Mountains (fig. 3).

We are indebted to B. L. Mamet for determination of foraminifer zones.

## SUBJACENT ROCKS

### Three Forks Formation

The Mississippian sequence rests disconformably on shallow-water carbonate rocks and terrigenous rocks assigned to the Three Forks Formation, which is exposed at the base of the Bell-McKenzie Divide section (fig. 3). Although the base of the Three Forks is not exposed in this section because the formation rests in fault contact on the Mission Canyon Limestone, all three members (ascending order: Logan Gulch, Trident, and Sappington) present in the Three Forks type section can be identified. The Trident Member contains *Cyrtospirifer monticola* and *Strophopleura raymondi.*

## TENDOY GROUP

The Tendoy Group, named for exposures in the Tendoy Mountains, is proposed for the sequence of Mississippian rocks between the Three Forks Formation of Late Devonian age and the Snowcrest Range Group, which is of Late Mississippian age in this area (see Wardlaw and Pecora, Chapter B, this bulletin).

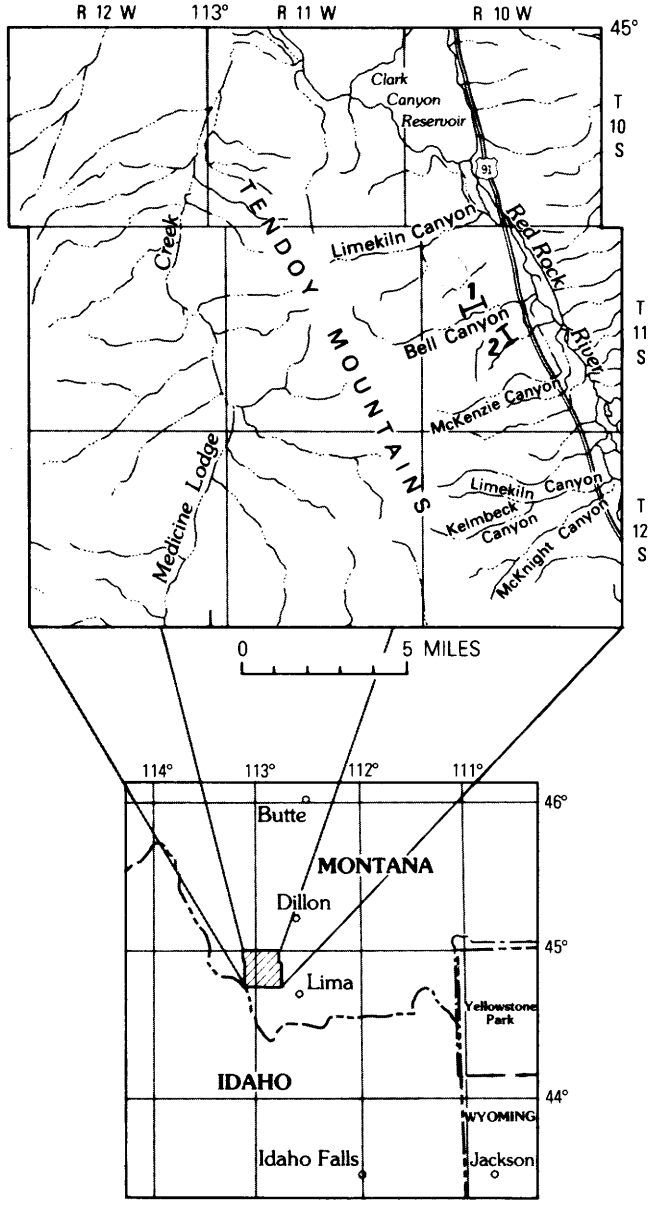



**Figure 1.** Location of northern Tendoy Mountains and Bell Canyon (1) and Bell-McKenzie Divide (2) measured sections of Mississippian rocks.

The Tendoy Group includes, in ascending order, the Paine Limestone, Middle Canyon Formation, Mission Canyon Limestone, and McKenzie Canyon Limestone. This unique combination of stratigraphic units represents a hitherto unrecognized Mississippian facies belt near the craton margin. The type section of the group is the composite section (fig. 3) measured at Bell Canyon (fig. 4) and Bell-McKenzie Divide (fig. 5), where the group is 810 m thick. The known areal extent of the Tendoy Group is the northern Tendoy Mountains between McKnight Canyon and the Clark Canyon Reservoir (fig. 1).

## Paine Limestone

The Paine Limestone was originally described by Weed (1899a,b) as a subdivision ("Paine shale") of the Madison Limestone in the Little Belt Mountains, Mont. Subsequently, the Paine became a member of the Lodgepole Limestone in the Madison Group throughout parts of Montana, Wyoming, Idaho, and Utah (see Sando and Dutro, 1974, p. 2, for historical discussion).

In the northern Tendoy Mountains, the name Paine Limestone is applied to a unit of formational rank at the base of the Tendoy Group (fig. 3). The Paine Limestone has the essential lithologic characteristics and contacts of the Paine Member of the Lodgepole Limestone elsewhere in Montana. It consists of 228 m of thin-bedded, dark-gray, silty micrite and rare crinoidal micrite containing *Zoophycos* and rare horn corals. Shaly partings are a conspicuous

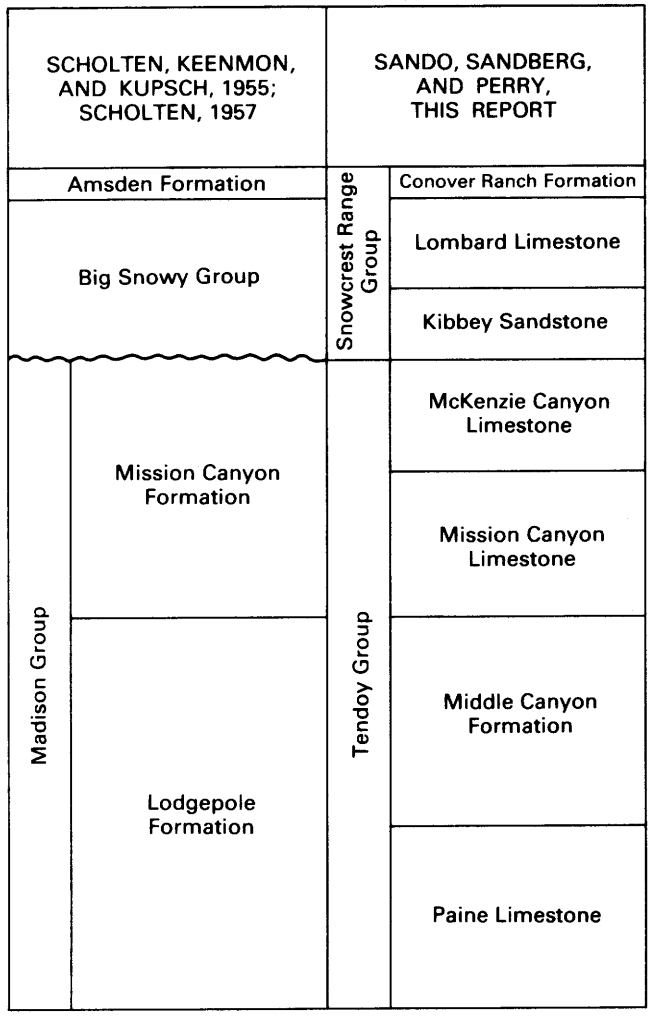



**Figure 2.** Mississippian stratigraphic units recognized in this report compared with stratigraphic units previously recognized in the northern Tendoy Mountains.

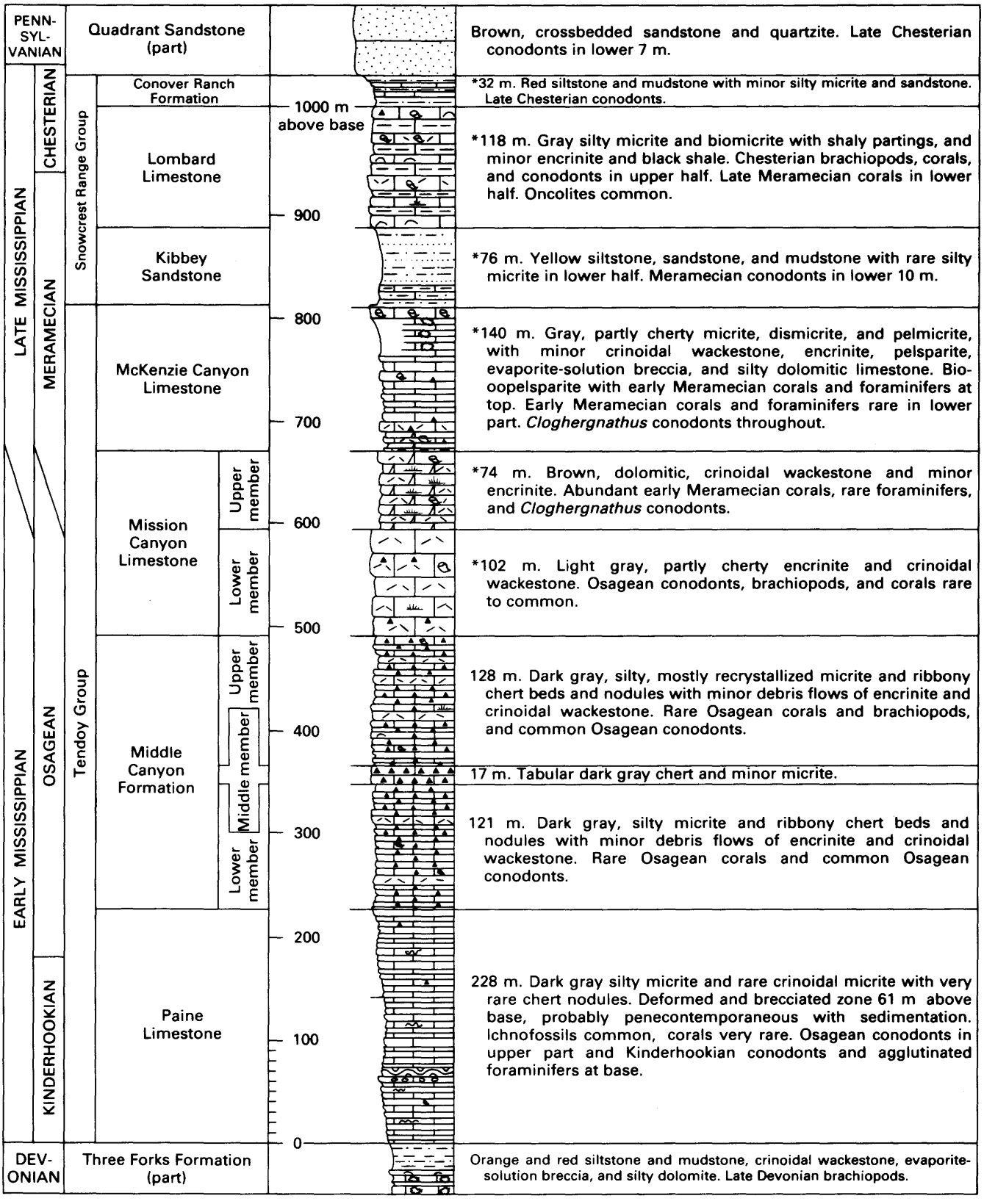
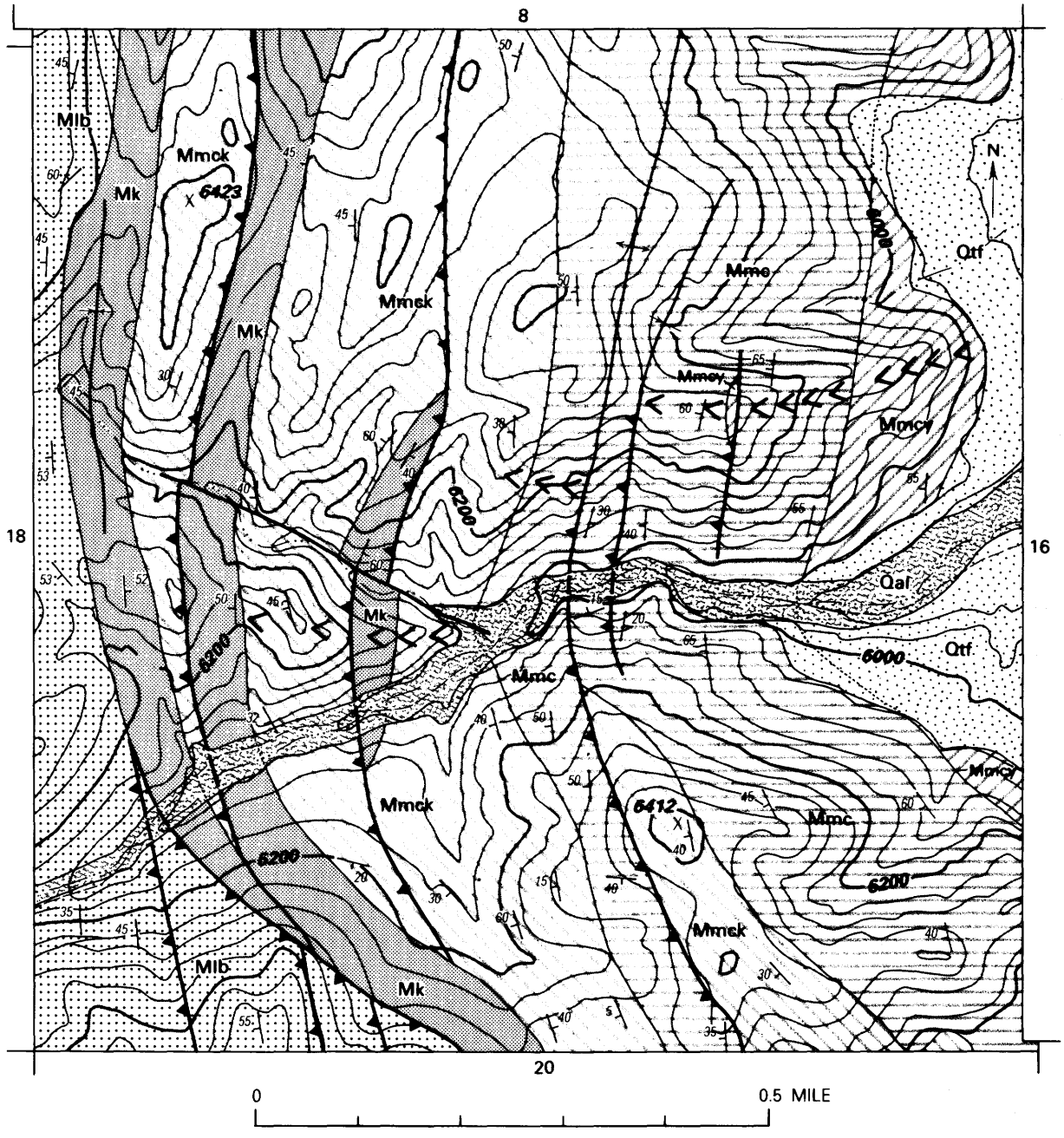



**Figure 3.** Composite section of Mississippian rocks in northern Tendoy Mountains (type section of Tendoy Group) based on measurements at Bell Canyon and Bell-McKenzie Divide. (See fig. 1 for locations of section traverses.) Thicknesses and descriptions of formations of Snowcrest Range Group from B. R. Wardlaw and W. C. Pecora (written commun., 1984). Asterisks indicate thicknesses measured at Bell Canyon; other thicknesses were measured at Bell-McKenzie Divide.




**EXPLANATION**

- Qal — Alluvium (Quaternary)
- Qtf — Terrace gravels and alluvial fans (Quaternary)

Snowcrest Range Group (Upper Mississippian):

- Mlb — Lombard Limestone
- Mk — Kibbey Sandstone

Tendoy Group (Upper and Lower Mississippian):

- Mmck — McKenzie Canyon Limestone
- Mmc — Mission Canyon Limestone
- Mmcy — Middle Canyon Formation

- Contact—Dotted where concealed
- 35 — Strike and dip of bedding
- Thrust fault—Sawteeth on upper plate
- High-angle transverse fault
- Anticline
- Syncline
- Stratigraphic section traverse

feature. The Paine Limestone in this area contains less crinoidal debris, fewer megafossils, and less chert than in other areas of Montana and lacks the crinoidal wackestone that is commonly found at the base. In the Bell-McKenzie Divide section, the Paine contains breccia and folded beds 61 m above the base interpreted as resulting from penecontemporaneous soft sediment deformation (slumping).

The Paine Limestone is regarded as Early Mississippian (Kinderhookian and Osagean) in the northern Tendoy Mountains. Kinderhookian conodonts are present at the base of the Paine, and most of the formation is considered to be Kinderhookian on the basis of correlation with the Paine Member of the Lodgepole Limestone, which has been dated as Kinderhookian only by conodonts and foraminifers elsewhere in the Cordilleran region (see Gutschick, Sandberg, and Sando, 1980), but Osagean conodonts were recovered from the upper 20 m of the Paine at Bell-McKenzie Divide.

## Middle Canyon Formation

The Middle Canyon Formation was originally described by Huh (1967) from exposures in the southern Lemhi Range, Idaho, where it overlies beds now assigned to the McGowan Creek Formation (Sandberg, 1975) and underlies the Scott Peak Formation. The Middle Canyon is recognized as a deep-water foreslope facies in much of south-central Idaho north of the Snake River Plain, where it ranges in age from Early Mississippian (Osagean) to Late Mississippian (Meramecian) (Skipp, Sando, and Hall, 1979), mainly on the basis of conodonts.

The Middle Canyon Formation overlies the Paine Limestone in the northern Tendoy Mountains and consists of 266 m of predominantly dark-gray, thin-bedded, silty, very cherty, mostly recrystallized micrite and minor debris flows of encrinite and crinoidal wackestone (fig. 3) similar to beds assigned to the formation in south-central Idaho. Three informal members are recognized in the northern Tendoy Mountains: a lower member 121 m thick distinguished by ribbony chert beds and nodules, a middle member 17 m thick distinguished by thin, tabular chert beds that make up more than half the unit, and an upper member 128 m thick characterized by ribbony chert beds and nodules like those of the lower member. Top and bottom contacts of the formation are conformable and gradational into the units above and below.

◀ **Figure 4.** Geologic map of the Bell Canyon area in sec. 17, T. 11 S., R. 10 W., Beaverhead County, Mont., showing section traverses. Base from Red Rock and Kidd 7 ½- minute quadrangles.

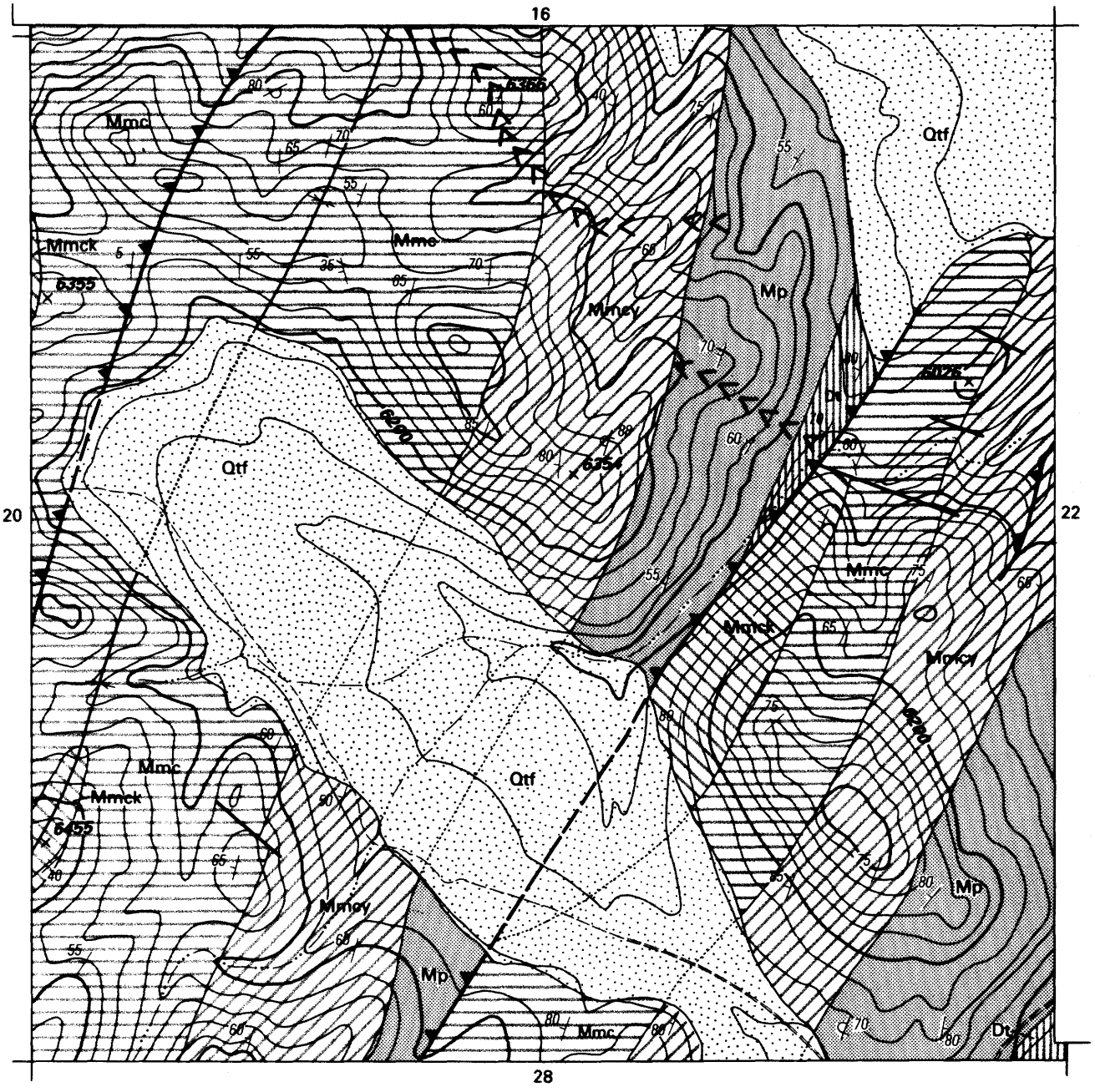
The Middle Canyon Formation is entirely Osagean in age in the northern Tendoy Mountains. The lower member contains conodonts of the Lower *Gnathodus typicus* Zone and rare deep-water horn corals (*Cyathaxonia*, *Rotiphyllum*) and tabulate corals (*Michelinia*). The upper part of the middle member and all of the upper member contain conodonts of the Upper *G. typicus* Zone and rare horn corals (*Vesiculophyllum*) and brachiopods.

## Mission Canyon Limestone

The Mission Canyon Limestone was originally described by Collier and Cathcart (1922) as a formation in the Madison Group in the Little Rocky Mountains, Mont. Subsequently, the formation was recognized over an extensive area in Montana, western Wyoming, and southeast Idaho. The Mission Canyon in that area consists of a complex of shallow-water shelf limestone facies (lithofacies E of Sando, 1980) in the lower part and evaporite facies (lithofacies G of Sando, 1980) in the upper part. Outside of the Tendoy Mountains, the formation is bounded above by a regional unconformity and is overlain by the Snowcrest Range Group as far east as the Horseshoe Hills (Wardlaw and Pecora, Chapter B, this bulletin, fig. 1) or Big Snowy Group in central Montana.

In the area studied, the Mission Canyon conformably overlies the Middle Canyon Formation and consists of 176 m of medium- to thick-bedded, partly cherty encrinite and crinoidal wackestone (fig. 3). It is divided into a lower member consisting of thick-bedded, light-gray, partly cherty encrinite and crinoidal wackestone and an upper member of medium-bedded brown dolomitic, crinoidal wackestone and minor encrinite. The formation is overlain conformably by the McKenzie Canyon Limestone.

The lower member of the Mission Canyon probably is entirely Osagean in age. It contains conodonts of the eotaphrid biofacies of the Upper *Gnathodus typicus* and *Scaliognathus anchoralis-Doliognathus latus* Zones, brachiopods, and corals (*Vesiculophyllum, Sychnoelasma, Syringopora*). The coral *Ankhelasma* occurs together with the conodont *Eotaphrus burlingtonensis* in the upper third of the lower member. The upper member contains the corals *Diphyphyllum*, *Syringopora*, and *Vesiculophyllum* and a *Cloghergnathus* conodont fauna that are compatible with an early Meramecian age. Mamet Zone 12 foraminifers were recovered 0.2 m below the top of the upper member, the first record of such fossils in an uninterrupted carbonate sequence in the western interior region.




**EXPLANATION**

- Qtf — Alluvium and terrace gravels (Quaternary)
- Tendoy Group (Upper and Lower Mississippian):
  - Mmck — McKenzie Canyon Limestone
  - Mmc — Mission Canyon Limestone
  - Mmcy — Middle Canyon Formation
  - Mp — Paine Limestone
- Dt — Three Forks Formation (Devonian)

- Contact—Dotted where concealed
- Strike and dip of bedding
  - 80 — Inclined
  - + — Vertical
  - 70 — Overturned
- Thrust fault—Sawteeth on upper plate
- High-angle transverse fault
- Syncline
- Stratigraphic section traverse

## McKenzie Canyon Limestone

The new name McKenzie Canyon Limestone is proposed for carbonate rocks at the top of the Tendoy Group between the underlying Mission Canyon Limestone and the overlying Kibbey Sandstone of the Snowcrest Range Group. The name is derived from McKenzie Canyon (fig. 1), where the beds are exposed. The type section (fig. 6) is in Bell Canyon (fig. 4).

The McKenzie Canyon is composed of 140 m of mostly gray thin- to medium-bedded sparsely cherty micrite, dismicrite, and pelmicrite with minor crinoidal wackestone, encrinite, pelsparite, evaporite-solution breccia, and silty dolomitic limestone. This combination of lithic features is indicative of intertidal and supratidal deposition (Shinn, 1983). Both the top and the bottom of the formation are conformable with overlying and underlying units.

Shelly benthos are generally rare in the McKenzie Canyon Limestone, but small horn corals (*Hapsiphyllum*) found 34 m above the base and a diversified and abundant coral fauna (*Clisiophyllum, Ekvasophyllum, Canadiphyllum, Hapsiphyllum*?, *Multithecopora*?, *Stelechophyllum banffensis*?) recovered from the upper 12 m indicate a Late Mississippian (early Meramecian) age for the formation. Mamet Zone 12 foraminifers occur 34 m above the base, and a Mamet Zone 12/13 boundary fauna was collected from the upper 10 m of the formation. A *Cloghernathus* conodont fauna occurs throughout the McKenzie Canyon.

The McKenzie Canyon Limestone represents a hitherto unrecognized facies belt deposited near the shoreline of the karst plain formed on the craton during post-Mission Canyon, pre-Snowcrest Range (Big Snowy) time (see Sando, Gordon, and Dutro, 1975, fig. 15; Sando, 1976, fig. 6, cycle III, phase 1; Gutschick, Sandberg, and Sando, 1980, fig. 10). It is the only known record of continuous carbonate deposition from cycle I to cycle III of Sando (1976), a veritable "missing link" in the history of Mississippian sedimentation in the northern Cordilleran region.

Fossils recovered from the McKenzie Canyon (Mamet Zone 12) are younger than any of the highest fossils found in the Charles Formation (Mamet Zones 10 and 11) in the Williston Basin (Sando, 1978; Sando and Mamet, 1981).

◀ **Figure 5.** Geologic map of the Bell-McKenzie Divide area in sec. 21, T. 11 S., R. 10 W., Beaverhead County, Mont., showing section traverses. Base from Kidd 7 ½-minute quadrangle.

## SNOWCREST RANGE GROUP

Wardlaw and Pecora (Chapter B, this bulletin) are proposing the new name Snowcrest Range Group for beds previously assigned to the Big Snowy and Amsden Formations in southwest Montana. The Snowcrest Range Group consists of 226 m of shallow-water carbonate and terrigenous rocks between the Tendoy Group and the Quadrant Sandstone in the area studied. The group includes, in ascending order, the Kibbey Sandstone, Lombard Limestone, and Conover Ranch Formation.

## Kibbey Sandstone

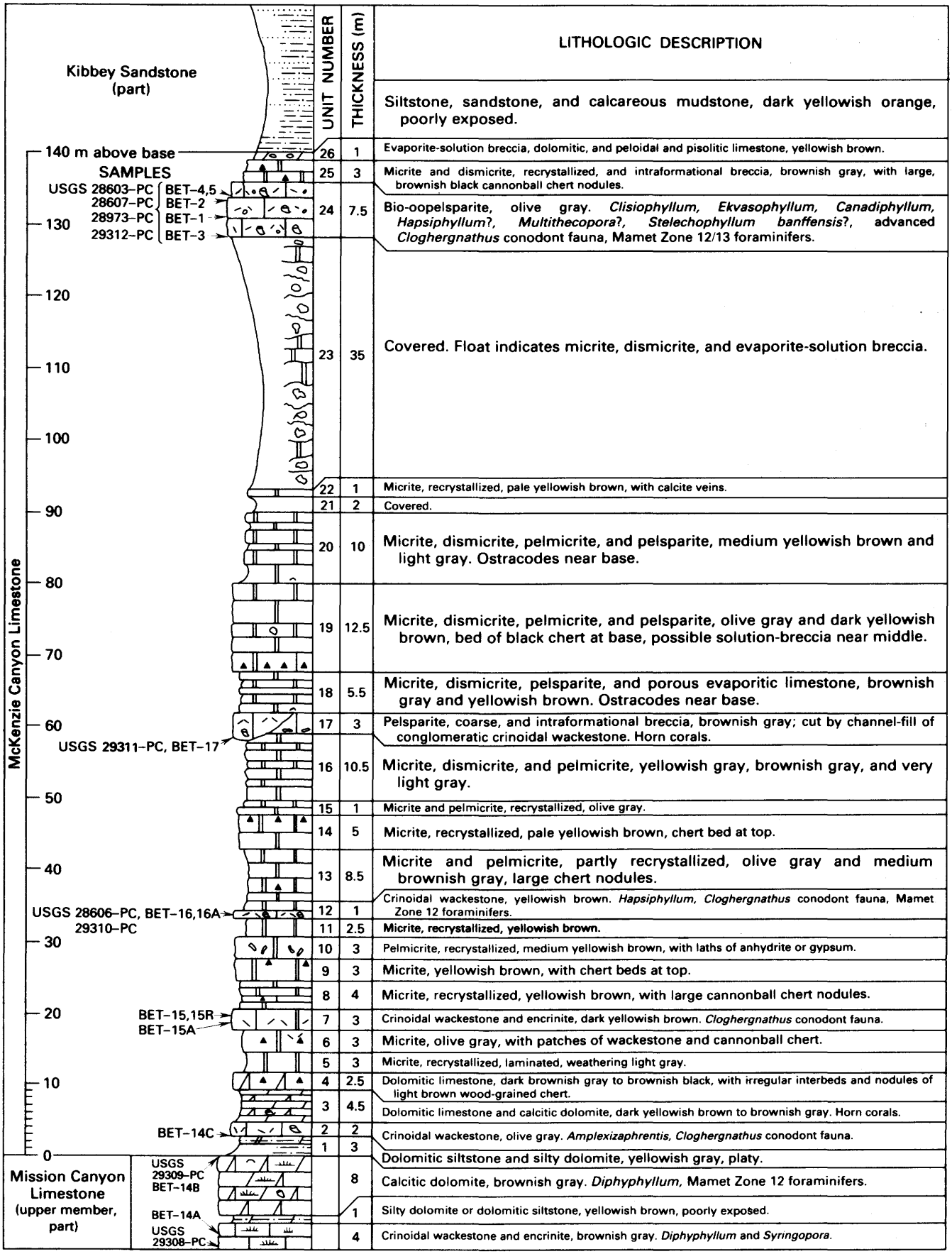
The Kibbey Sandstone was originally proposed by Weed (1899a,b) for exposures in the Little Belt Mountains, Mont., and was later included in the Big Snowy Group by Scott (1935). It is now included in the Snowcrest Range Group by Wardlaw and Pecora (Chapter B, this bulletin) in the area studied.

The Kibbey consists of 76 m of yellow siltstone, sandstone, and mudstone conformably overlying the McKenzie Canyon Limestone and conformably underlying the Lombard Limestone at Bell Canyon (fig. 3). It represents a shallow-water, probably lagoonal, embayment marking the initiation of cycle III eastward transgression of the Cordilleran sea onto the cratonic karst plain during post-Mission Canyon time (see Sando, Gordon, and Dutro, 1975, and Sando, 1976).

Meramecian conodonts recovered by Wardlaw and Pecora from the Kibbey in the Bell Canyon section are the only marine fossils known from the formation, although plant fossils also occur in the lower part at Bell Canyon. The ages of the formations above and below indicate that the Kibbey is probably entirely of middle Meramecian age. This age for the Kibbey is slightly older than the late Meramecian age proposed for the formation in this area by Sando, Gordon, and Dutro (1975, p. A58) on the basis of regional stratigraphic synthesis.

## Lombard Limestone

The name Lombard was originally proposed by Blake (1959) as a facies of the Big Snowy Group in southwest Montana. Wardlaw and Pecora (Chapter B, this bulletin) have applied the name to a formation between the Kibbey Sandstone and the overlying Conover Ranch Formation in the Snowcrest Range Group. The Lombard Limestone consists of 118 m of gray, silty, oncolitic micrite and biomicrite with shaly


Kibbey Sandstone (part)
McKenzie Canyon Limestone
Mission Canyon Limestone (upper member, part)
140 m above base
130
120
110
100
90
80
70
60
50
40
30
20
10
0
SAMPLES
USGS 28603–PC BET–4,5
28607–PC BET–2
28973–PC BET–1
29312–PC BET–3
USGS 29311–PC, BET–17
USGS 28606–PC, BET–16,16A
29310–PC
BET–15,15R
BET–15A
BET–14C
USGS 29309–PC
BET–14B
BET–14A
USGS 29308–PC
UNIT NUMBER
THICKNESS (m)
LITHOLOGIC DESCRIPTION
Siltstone, sandstone, and calcareous mudstone, dark yellowish orange, poorly exposed.
26 1 Evaporite-solution breccia, dolomitic, and peloidal and pisolitic limestone, yellowish brown.
25 3 Micrite and dismicrite, recrystallized, and intraformational breccia, brownish gray, with large, brownish black cannonball chert nodules.
24 7.5 Bio-oopelsparite, olive gray. Clisiophyllum, Ekvasophyllum, Canadiphyllum, Hapsiphyllum?, Multithecopora?, Stelechophyllum banffensis?, advanced Cloghergnathus conodont fauna, Mamet Zone 12/13 foraminifers.
23 35 Covered. Float indicates micrite, dismicrite, and evaporite-solution breccia.
22 1 Micrite, recrystallized, pale yellowish brown, with calcite veins.
21 2 Covered.
20 10 Micrite, dismicrite, pelmicrite, and pelsparite, medium yellowish brown and light gray. Ostracodes near base.
19 12.5 Micrite, dismicrite, pelmicrite, and pelsparite, olive gray and dark yellowish brown, bed of black chert at base, possible solution-breccia near middle.
18 5.5 Micrite, dismicrite, pelsparite, and porous evaporitic limestone, brownish gray and yellowish brown. Ostracodes near base.
17 3 Pelsparite, coarse, and intraformational breccia, brownish gray; cut by channel-fill of conglomeratic crinoidal wackestone. Horn corals.
16 10.5 Micrite, dismicrite, and pelmicrite, yellowish gray, brownish gray, and very light gray.
15 1 Micrite and pelmicrite, recrystallized, olive gray.
14 5 Micrite, recrystallized, pale yellowish brown, chert bed at top.
13 8.5 Micrite and pelmicrite, partly recrystallized, olive gray and medium brownish gray, large chert nodules.
12 1 Crinoidal wackestone, yellowish brown. Hapsiphyllum, Cloghergnathus conodont fauna, Mamet Zone 12 foraminifers.
11 2.5 Micrite, recrystallized, yellowish brown.
10 3 Pelmicrite, recrystallized, medium yellowish brown, with laths of anhydrite or gypsum.
9 3 Micrite, yellowish brown, with chert beds at top.
8 4 Micrite, recrystallized, yellowish brown, with large cannonball chert nodules.
7 3 Crinoidal wackestone and encrinite, dark yellowish brown. Cloghergnathus conodont fauna.
6 3 Micrite, olive gray, with patches of wackestone and cannonball chert.
5 3 Micrite, recrystallized, laminated, weathering light gray.
4 2.5 Dolomitic limestone, dark brownish gray to brownish black, with irregular interbeds and nodules of light brown wood-grained chert.
3 4.5 Dolomitic limestone and calcitic dolomite, dark yellowish brown to brownish gray. Horn corals.
2 2 Crinoidal wackestone, olive gray. Amplexizaphrentis, Cloghergnathus conodont fauna.
1 3 Dolomitic siltstone and silty dolomite, yellowish gray, platy.
8 Calcitic dolomite, brownish gray. Diphyphyllum, Mamet Zone 12 foraminifers.
1 Silty dolomite or dolomitic siltstone, yellowish brown, poorly exposed.
4 Crinoidal wackestone and encrinite, brownish gray. Diphyphyllum and Syringopora.

partings and minor encrinite and black shale in the area studied (fig. 3). It represents shallow-water carbonate deposition in slightly deeper and clearer water than do the sediments of the Kibbey Sandstone.

The lower half of the Lombard contains brachiopods and corals (*Faberophyllum*, *Clisiophyllum*, *Canadiphyllum*?, "*Pseudodorlodotia*") of late Meramecian age. The upper half of the formation contains brachiopods and corals (*Siphonophyllia*, *Amplexizaphrentis*) of Chesterian age. Chesterian conodonts were also recovered from the upper part of the formation by Wardlaw and Pecora.

### Conover Ranch Formation

The new name Conover Ranch Formation is being proposed by Wardlaw and Pecora (Chapter B, this bulletin) for rocks previously assigned to the Amsden Formation in southwest Montana. The Conover Ranch conformably overlies the Lombard Limestone and conformably underlies the Quadrant Sandstone.

The Conover Ranch Formation consists of 32 m of red siltstone and mudstone with minor silty micrite and sandstone in the area studied (fig. 3). It represents increased terrigenous deposition at the craton margin presaging the flood of quartz sand represented by the overlying Quadrant Sandstone.

Wardlaw and Pecora (Chapter B, this bulletin) recovered late Chesterian (Late Mississippian) conodonts from the formation in the Tendoy Mountains. The Conover Ranch is as young as early Morrowan (Early Pennsylvanian) along the Jefferson River, Mont., outside of the Tendoy Mountains.

## QUADRANT SANDSTONE

The Quadrant Sandstone was originally described by Peale (1893) from exposures in the Gallatin Range in the northwest corner of Yellowstone Park, Wyo. Subsequent usage has extended the name over most of Montana for sandstone of Pennsylvanian age between the Amsden Formation and the Phosphoria Formation.

The Quadrant is a resistant unit of brown quartz sandstone and quartzite and minor carbonate beds whose thickness was not measured in the area studied (fig. 3). Wardlaw and Pecora (Chapter B, this bulletin) recovered conodonts of latest Chesterian age from the lower 7 m of the formation.

◀ **Figure 6.** Type section of McKenzie Canyon Limestone measured on north side of Bell Canyon in sec. 17, T. 11 S., R. 10 W., Beaverhead County, Mont. (see figs. 1 and 3 for location of section traverse).

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# CONTENTS



FIGURES

# New Mississippian–Pennsylvanian Stratigraphic Units in Southwest Montana and Adjacent Idaho

*By* Bruce R. Wardlaw *and* William C. Pecora[1]

**Abstract**

The Kibbey Sandstone, Lombard Limestone (new unit), and Conover Ranch Formation (new unit) constitute the Snowcrest Range Group (new unit) in southwest Montana. This nomenclature better describes the rocks that are between the Mississippian Madison Group and related rocks and the Mississippian and Pennsylvanian Quadrant Sandstone. The Railroad Canyon Formation (new unit), found in southwesternmost Montana and adjacent Idaho, is a fine-grained carbonate and terrigenous unit largely equivalent to the Snowcrest Range Group.

## INTRODUCTION

Presently available nomenclature applied to rocks equivalent to the Amsden Formation of Wyoming and to the dominantly clastic rocks of the Big Snowy Group and lower part of the Amsden Group in central Montana (Sando and others, 1975) does not adequately apply to rocks dominated by carbonates in southwest Montana and adjacent Idaho. For this reason, the new name Snowcrest Range Group is proposed for these southwest Montana rocks. This short paper, in which new terminology is defined, is accompanied by a paper by Sando and others (Chapter A, this bulletin) defining new units that underlie the Snowcrest Range Group in the Tendoy Mountains. These two papers together attempt to clarify the Mississippian stratigraphy of southwest Montana and adjacent Idaho. Detailed studies of the Snowcrest Range Group by Wardlaw and Pecora are in progress; these focus on the Mississippian-Pennsylvanian boundary, the lack of unconformities in rocks that include the system boundary in the northern Rocky Mountains, and the stratigraphic and structural relations of the Snowcrest Range Group and Railroad Canyon Formation.

Mississippian limestones were first described in southwest Montana by Hayden (1872). Though the rocks described here do not adequately fit into any previous nomenclature, the units of Upper Mississippian-Pennsylvanian rocks described by Scott (1935) and modified by Maughan and Roberts (1967) have generally been applied to them (fig. 1). Scott (1935) divided the clastic rocks previously referred to the Quadrant Formation in central Montana into the Big Snowy Group (lower part) and Amsden Formation (middle part) and restricted the Quadrant to the upper part. The Big Snowy Group consisted of the Kibbey Sandstone and Otter Formation (previously members of the Quadrant of Weed, 1892, 1899), and the Heath Formation. Maughan and Roberts (1967) raised the Amsden Formation to group status in central Montana and divided the Amsden Group into, in ascending order: Tyler Formation (of Freeman, 1922), Alaska Bench Limestone (of Mundt, 1956), and Devils Pocket Formation (of Gardner, 1959). Maughan and Roberts (1967) also attempted to apply this terminology to southwest Montana by recognizing the Big Snowy Formation and Amsden Formation throughout the area, including Railroad Canyon in adjacent Idaho. Though the rocks included in these two units may vary from author to author, these constitute the previously applied nomenclature. Skipp, Hogan, and others (1979) suppressed the application of Amsden Formation to the Railroad Canyon area of Idaho in preference to the newly named Bluebird Mountain Formation. The Big Snowy Formation was retained for a lack of a better name for thin-bedded argillaceous and limey rocks between the Scott Peak Formation and the Bluebird Mountain Formation.

The Kibbey Sandstone is identified as the lower unit of both the clastic-dominated Big Snowy Group of central Montana and the carbonate-dominated Snowcrest Range Group of southwest Montana. It is

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similar in both areas and represents initial transgressive sedimentation of subtidal to supratidal silt, sand, and evaporites of both groups.

The age relations in this paper are based on conodont, foraminifer, coral, and brachiopod faunas. The conodont data are abundant but, as yet, unpublished. Davis (1983) presented some of the new conodont data and confirmed the age assignments of this study and the more widespread unpublished collections of Wardlaw. Two important points are derived from this information: (1) The Tyler Formation is Late Mississippian throughout most of its regional extent, and (2) the lowest beds of the Quadrant Sandstone range in age from latest Mississippian to Early Pennsylvanian and are generally younger northeastward in southwest Montana. Conodonts of latest Chesterian age were identified from the lower 7 m of the formation.

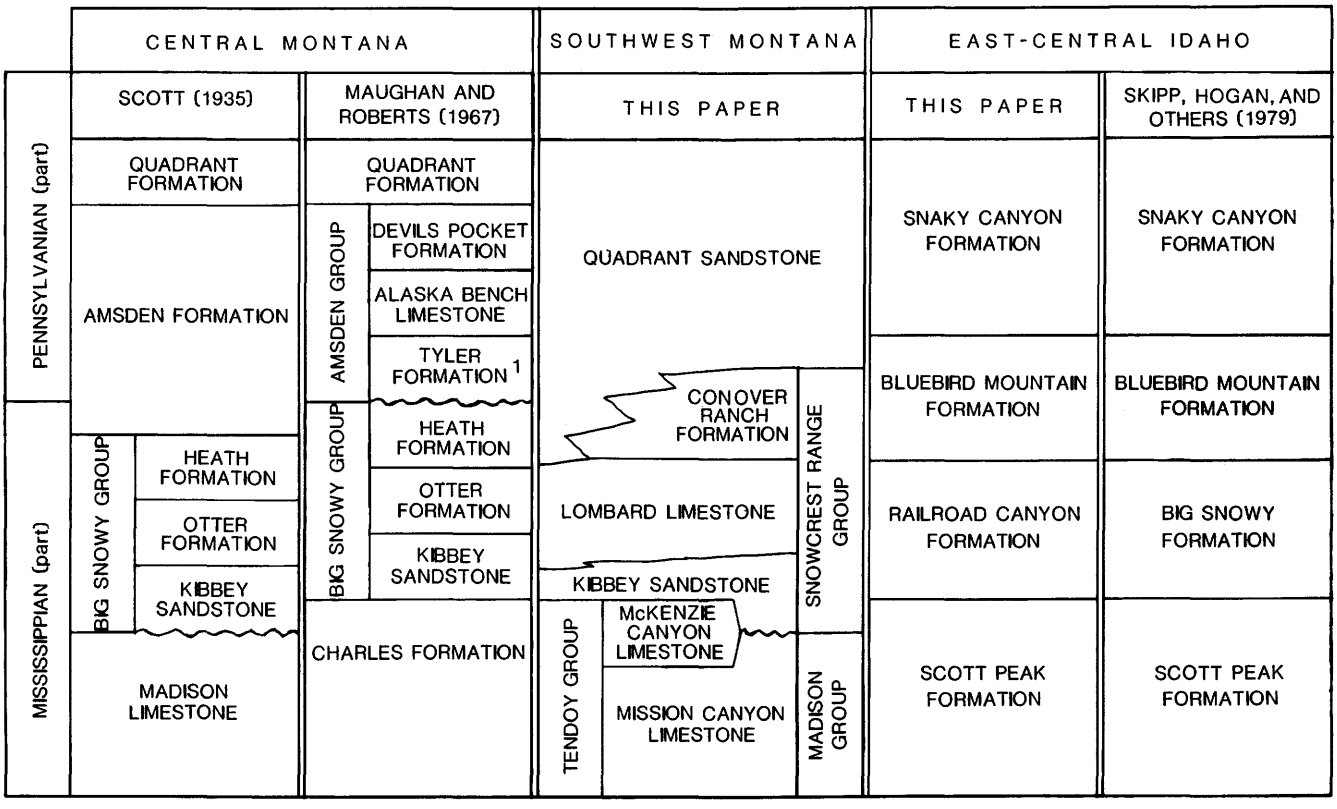
## NEW UNITS

### Snowcrest Range Group

The Snowcrest Range Group, named for the Snowcrest Range in Beaverhead and Madison Counties, Montana, is composed of the Kibbey Sandstone, Lombard Limestone, and Conover Ranch Formation (fig. 1). Exposures of the Kibbey, Lombard, and Conover Ranch in the Snowcrest Range are the type area for the group. The Snowcrest Range Group overlies the Mission Canyon Limestone of the Madison Group east of the Tendoy Mountains and, in the Tendoy Mountains, the McKenzie Canyon Limestone of the Tendoy Group. The Snowcrest Range Group is ordinarily overlain by the Quadrant Sandstone, but, at Arasta Creek, the group is overlain by a thin finger of the Ranchester Limestone Member of the Amsden Formation, which, in turn, is overlain by the Quadrant Sandstone.

### Lombard Limestone

The Lombard Limestone consists of a geographically restricted lower unit of poorly fossiliferous, thin to thick indistinctly bedded lime-mudstone and packstone and an upper unit of fossiliferous, thin- to thick-bedded skeletal lime-mudstone, wackestone, and packstone with thin interbeds and partings of




1 The ages of Maughan and Roberts (1967) have been refined by abundant new data (Davis, 1983, Wardlaw; unpublished data) that indicate the Tyler Formation and units below are Mississippian.

**Figure 1.** Nomenclature applied to Mississippian and Pennsylvanian rocks in central Montana, southwest Montana, and east-central Idaho.

silty limestone, siltstone, and shale. The Lombard Limestone ranges in thickness from 49.7 m to as much as approximately 130 m.

*Geographic Distribution*: The Lombard Limestone crops out throughout most of southwest Montana including the Tendoy Mountains, Pioneer Mountains, Blacktail Mountains, Snowcrest Range, Ruby Range, Tobacco Root Range, northwestern part of the Gravelly Range, Elkhorn Mountains, Horseshoe Hills, and Bridger Range (fig. 2). It is tentatively identified at Targhee Pass. The lower unit is well developed in the Tendoy Mountains, Blacktail Mountains, Pioneer Mountains, Ruby Mountains, and Snowcrest Range.

*Age*: The Lombard Limestone ranges in age from late Meramecian (Mamet Foraminifer Zone 15, Sando and Bamber Coral Zone IV) to late Chesterian (Mamet Foraminifer Zone 19).

*Regional Relations*: The Lombard Limestone is equivalent to the Otter and Heath Formations of the Big Snowy Group and to part of the Tyler Formation of the Amsden Group in central Montana. It is also equivalent to the South Creek and Surrett Canyon Formations in east-central Idaho.

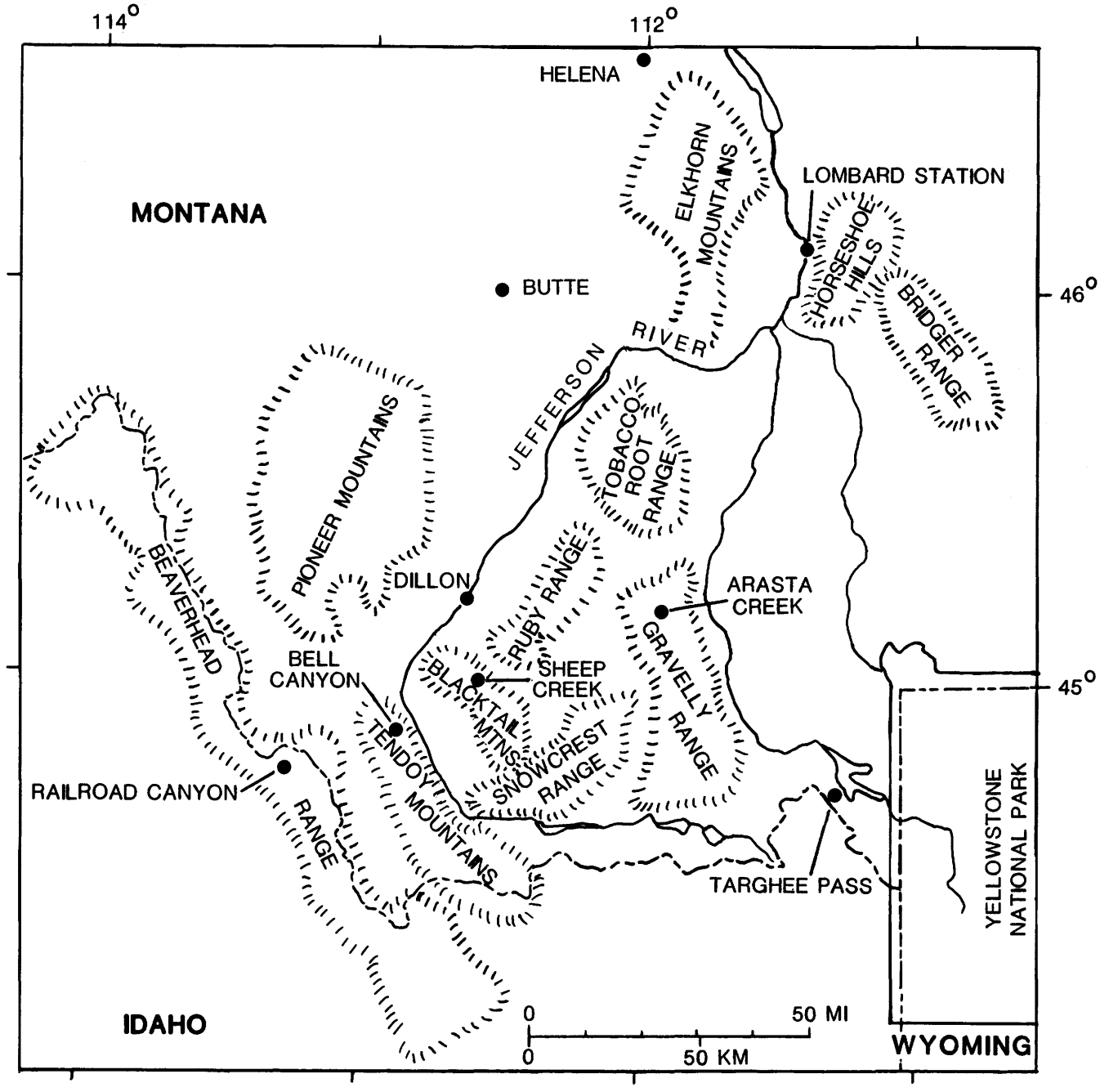



**Figure 2.** Location map showing areas in southwest Montana and adjacent Idaho cited in report.

## Conover Ranch Formation

The Conover Ranch Formation is a heterogeneous unit consisting largely of pale-reddish-brown to pale-reddish-purple mudstone and lesser units of thin-bedded marine limestone and calcareous sandstone and siltstone. Cherty carbonate conglomerate, phosphatic claystone, mottled or nodular calcareous mudstone, and recrystallized grainstone are locally present. The Conover Ranch Formation ranges in thickness from 0 to as much as 33 m.

*Geographic Distribution*: The Conover Ranch Formation crops out discontinuously in the Tendoy Mountains, Blacktail Mountains, Snowcrest Range, northwestern part of the Gravelly Range, Elkhorn-Boulder Mountains, Tobacco Root Range, and part of the Pioneer Mountains (fig. 2).

*Age*: The Conover Ranch Formation is commonly late Chesterian (Mamet Foraminifer Zone 19, Sando and Bamber Coral Zone VI, and part of the *Rhipidomella nevadensis* Brachiopod Zone). The unit is younger to the northeast and is as young as early Morrowan (Early Pennsylvanian) in outcrops along the Jefferson River in southwest Montana; therefore, it includes the Mississippian-Pennsylvanian boundary in these outcrops.

*Regional Relations*: The Conover Ranch Formation is equivalent to part of the Tyler Formation, to part of the Alaska Bench Limestone of the Amsden Group in central Montana, and to part of the Bluebird Mountain Formation in east-central Idaho. It is laterally equivalent to, and a facies of, the uppermost part of the Lombard Limestone and the lowermost part of the Quadrant Sandstone.

## Railroad Canyon Formation

The Railroad Canyon Formation is predominantly thin- to medium-bedded dark shale, lime-mudstone, and clayey calcareous siltstone. Conglomeratic grainstone is locally present. Limestone containing thin chert stringers and nodules is dominant in the upper part.

*Geographic Distribution*: The Railroad Canyon Formation is found only in the Beaverhead Range, where it is a part of the Medicine Lodge Thrust Plate (fig. 2).

*Age*: The Railroad Canyon Formation is Chesterian (Late Mississippian). Brachiopod and conodont faunas, though sparse and generally abraded, indicate a Sando and Bamber Coral Zone V, or younger, age. Conodonts from the overlying Bluebird Mountain Formation indicate a late Chesterian (Mamet Foraminifer Zone 19) age.

*Regional Relations*: The Railroad Canyon Formation is equivalent to the upper unit of the Lombard Limestone and the Conover Ranch Formation of the Snowcrest Range Group and to the Surrett Canyon and Arco Hills Formations of the foredeep carbonate bank sequence of Idaho (Skipp, Sando, and Hall, 1979).

## MEASURED SECTIONS

### Type Section of the Lombard Limestone (fig. 3)

Section located in S½ sec. 7, T. 4 N., R. 3 E., Toston 7.5-minute quadrangle, access by road 1 km north from Lombard Station, Broadwater County, Mont. The Lombard Limestone is underlain by the Kibbey Sandstone and overlain by the Tyler Formation.

| | Thickness | |
|---|---|---|
| | *meters* | *feet* |
| 11. Shale. Fissile, papery, grayish-black -- | 0.6 | 2.0 |
| 10. Claystone. 15μ to 30μ mud-whisps and blebs with sparite grains (5 percent), and spiriferid brachiopod impressions. Light olive gray weathering dusky yellow ---------- | 1.4 | 4.6 |
| 9. Wackestone, cliff-forming, medium bedded. Algal coated grains and filaments (40 percent), poorly washed biosparite, chert stringers in top 7 m. Silicified grains weather in relief. Dark olive gray. *Siphonophyllia* marker beds with corals in life position (40.6 cm thick) begin 7 m below top. Thin interbeds of olive-black bituminous shale and calcareous siltstone. Siltstone has fine (0.3 mm thick) brachiopod spines and debris with platy horizontal orientation and minor, fine-grained dolomite rhombs | 18.0 | 59.0 |
| 8. Concealed, limestone as float ------- | 18.5 | 61.0 |
| 7. Lime-mudstone, thick-bedded. Knobbly texture, grayish-orange clay fills space between 3.5 cm diameter micrite cobblelike grains produced by bioturbation. *Inflatia* sp. (brachiopod) molds. Olive gray weathering light olive gray ---------- | 1.2 | 4.0 |
| 6. Shale, covered, dark-greenish-gray --- | 0.2 | 0.5 |
| 5. Coal and coaly claystone, underlain by clay, laterally continuous in several adits north along river ---------- | 3.1 | 10.0 |
| 4. Concealed, underlain by argillaceous limestone ---------- | 2.4 | 8.0 |
| 3. Wackestone. Sandy, knobby texture on weathered surface. Rugose corals and *Diaphragmus*? sp. Medium gray --- | 1.7 | 5.4 |

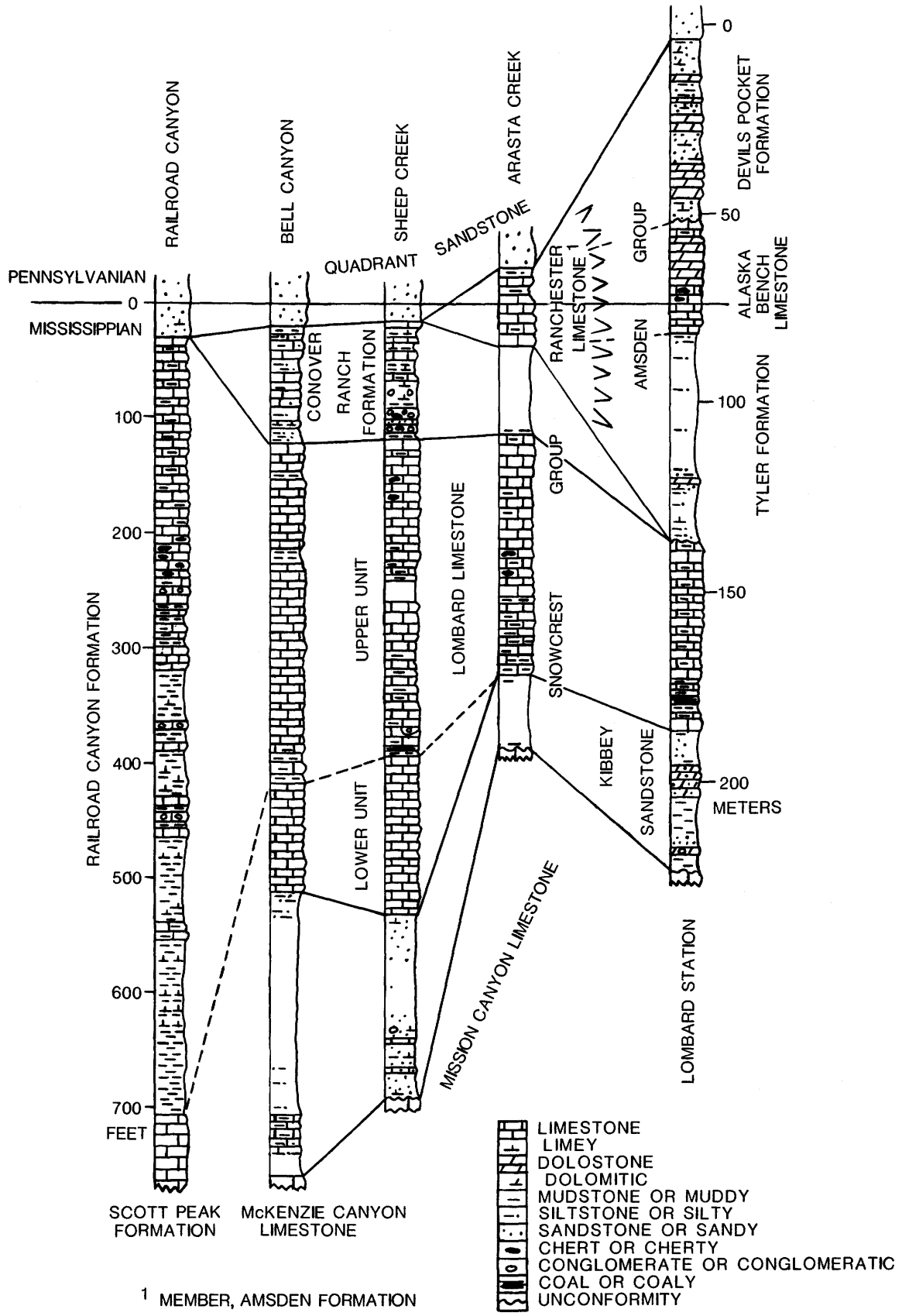



**Figure 3.** Columnar sections of the Snowcrest Range Group and Railroad Canyon Formation showing relationships to the Scott Peak Formation in Idaho and the Amsden Formation and Group in Montana.

Lombard Limestone—*Continued*

| | Thickness (meters) | Thickness (feet) |
|---|---|---|
| 2. Wackestone and packstone, thick-bedded. Abundant brachiopods in coquina zone. Medium gray. Conodont sample USGS D557–PC | 1.1 | 3.6 |
| 1. Wackestone, medium-bedded. Ostracodes and abraded brachiopod debris in sparse biomicrite. Olive gray weathering yellowish gray. Conodont sample USGS D558–PC | 1.5 | 4.8 |
| Total thickness of Lombard Limestone | 49.7 | 162.9 |

## Type Section of Conover Ranch Formation (fig. 3)

Section located 122 m uphill from northwest bank of Sheep Creek, Conover Ranch, Blacktail Mountains, NE¼ NW ¼, sec. 18, T. 9 S., R. 8 W., Gallagher Mountain 7.5-minute quadrangle, Beaverhead County, Mont. The Conover Ranch Formation is underlain by the Lombard Limestone and overlain by the Quadrant Sandstone.

| | Thickness (meters) | Thickness (feet) |
|---|---|---|
| 18. Lime-mudstone, wackestone, and calcareous siltstone, thin-bedded, nodular. Skeletal, sparse biomicrite with ostracodes, brachiopod spines, and indeterminate fossiliferous debris. Edges of some grains pyritized. Light gray. Conodont sample USGS D524–PC | 1.2 | 4.0 |
| 17. Shale, poorly exposed, medium-olive-green to light-brown | 1.2 | 4.0 |
| 16. Lime-mudstone, thin-bedded. Skeletal, brachiopod fragments, similar to 18. Light gray | 0.6 | 2.0 |
| 15. Wackestone and calcareous shale, thin-bedded. Laminations (25–50 mm thick) of alternating micrite and biomicrite with preferred horizontal orientation of shell debris. Minor sparfilled fractures. Light yellowish gray | 1.5 | 5.0 |
| 14. Shale, siltstone, and wackestone, thin-bedded. Complete *Rhipidomella nevadensis* specimens weather from unit. Wackestone contains Mamet Foraminifer Zone 19 foraminifers. Light yellowish brown to light gray | 4.9 | 16.0 |
| 13. Limestone, thin-bedded. Recrystallized biosparite containing brachiopod shells and bryozoan debris. Medium gray. Conodont sample USGS D525–PC | 0.6 | 2.0 |
| 12. Claystone, slumped and poorly exposed. Calcareous, weathered, forming soil. Pale red purple. Thin wackestone interbed, light gray | 3.1 | 10.0 |
| 11. Mudstone, thin-bedded. Sandy (quartz), poorly consolidated, containing silty lime-mudstone. Pale reddish brown. Conodont sample USGS D526–PC | 1.2 | 4.0 |
| 10. Conglomerate and grainstone, medium-bedded. Conglomerate calcareous, abundant crinoid fragments with dark-brown and medium-gray chert grains. Medium gray | 0.4 | 1.2 |
| 9. Siltstone, thin-bedded. Poorly consolidated, sandy calcareous, minor calcareous sandstone and limestone (sparite) interbeds. Pale reddish brown | 4.9 | 16.0 |
| 8. Shale, with fine-grained sandstone at top, medium-olive-green | 1.8 | 6.0 |
| 7. Sandstone, poorly exposed, thin-bedded. Calcareous, poorly to moderately well sorted, subangular to subrounded grains of quartz, chert and crinoids, with interbedded phosphatic mudstone. Moderate brown. Conodont sample USGS D527–PC | 1.2 | 4.0 |
| 6. Shale, poorly exposed, moderate-brown | 2.1 | 7.0 |
| 5. Conglomerate, massive-bedded. Limestone pebble, containing clasts (0.1–2.5 cm) of skeletal lime-mudstone with crinoid columnals and indeterminate hash, silty lime-mudstone, and minor chert. Light to medium gray | 1.5 | 5.0 |
| 4. Grainstone, thin-bedded. Well sorted, subround to subangular carbonate grains with some quartz. Light yellowish brown | 0.6 | 2.0 |
| 3. Conglomerate, thick-bedded. Limestone pebble, containing subround to well-rounded clasts up to 35.5 cm in width, consisting of medium-gray lime-mudstone clasts and minor moderate-yellow-brown chert clasts. Medium gray | 1.4 | 4.5 |
| 2. Wackestone, medium-bedded. Brachiopods (*Diaphragmus*? sp.) weather in relief. Light gray | 1.5 | 5.0 |
| 1. Claystone, poorly exposed, calcareous, greenish-gray | 0.9 | 3.0 |
| Total thickness of Conover Ranch Formation | 30.6 | 100.7 |

Conover Ranch Formation—*Continued*

## Type Section of Railroad Canyon Formation (fig. 3)

Section located in NE¼ sec. 31 and SE¼ sec. 30, R. 27 E., T. 17 S., Bannock Pass 7.5-minute quadrangle northwest of Railroad Canyon, Lemhi County, Idaho. The Railroad Canyon Formation is underlain by the Scott Peak Formation and overlain by the Bluebird Mountain Formation.

| | Thickness | |
|---|---|---|
| | meters | feet |
| 30. Concealed, underlain mainly by thin-to medium-bedded limestone and sandy siltstone having low angle tabular cross-laminations | 16.6 | 54.7 |
| 29. Wackestone, thin-bedded. Biomicrite with broken and abraded brachiopods. Medium dark gray weathering medium gray. Conodont sample USGS D504–PC | 2.6 | 8.8 |
| 28. Covered | 9.1 | 30.0 |
| 27. Wackestone, poorly exposed. Abundant brachiopod fragments weathering out. Medium dark gray and grayish brown weathering grayish red, medium gray, and yellowish orange | 6.5 | 21.5 |
| 26. Wackestone, thin-bedded. Sparry biomicrite with *Orbiculoidea* sp. brachiopods abundant along bedding planes. Medium gray weathering medium dark gray | 6.3 | 20.9 |
| 25. Packstone and wackestone, medium-bedded. Fetid on fresh break, abundant brachiopod debris and conodonts in very thin beds, preferential orientation of bioclasts. Dark gray weathering medium gray. Conodont sample USGS D505–PC | 11.9 | 39.3 |
| 24. Packstone and siltstone, rhythmically thin- to medium-bedded, dark-gray chert lenses (2 to 15 mm long) in middle of unit. Silty dismicrite with graded laminations (0.25 to 0.75 cm thick), quartz silt and fine sand well rounded. Disseminated kerogen (?) (fetid smell in hand sample, amorphous blebs in thin section) and abundant light-gray oval *Orbiculoidea* brachiopods on bedding surfaces. Unit has increasing abundance of 2–9 cm thick beds of siltstone near base. Limestone is medium dark gray weathering medium gray, siltstone is brownish gray weathering yellowish gray. Conodont sample USGS D506–PC | 18.4 | 60.4 |
| 23. Packstone and conglomerate, thin-bedded, lenticular. Phosphatic gravel grains and micrite clasts. Dusky yellow and light gray | 0.6 | 2.0 |
| 22. Lime-mudstone and siltstone, thin-bedded, fissile, platy, and flaggy. Ball-and-pillow compaction fabric to bedding. Disseminated clay whisps and dark fine grains, microspar cement. Lime–mudstone is medium dark gray weathering pale red to yellowish gray | 12.8 | 42.0 |
| 21. Float, same as above | 17.3 | 57.0 |
| 20. Siltstone, very fine sandstone, poorly exposed. Calcareous, microspar cement with 25–35 percent angular to subangular quartz grains with 30 percent blebs and clasts. Several generations of anastomosing veinlets of dark amorphous material and calcite. Dark gray with very light gray fractures of sparite on surface, weathering light olive gray | 4.0 | 13.0 |
| 19. Lime-mudstone, thin-bedded, flaggy. Silty, angular to sub-angular, medium sorted (50–20μ) quartz grains (20 percent) in micrite matrix. Disseminated dark grains. Medium dark gray weathering light olive gray | 1.7 | 5.4 |
| 18. Grainstone (top of bed), mudchip, bioclastic conglomerate (base), thick-bedded. Poorly sorted, very coarse grained, subangular micritic grains, silty micritic, phosphatic, and brachiopod (spiriferid) grains and clasts. Clay-silt hematite cement (very dusky purple). Mudchip conglomerate (base) has oblate clasts (chips) up to 3.2 x 0.4 cm of dark gray silty, calcareous claystone. Platy fabric with fractures normal to bedding. Second grain mode (0.5–1.0 mm) of subround, more spherical micritic grains. Some micritic clasts have quartz silt grains, other micritic clasts are pelloidal. Very dusky purple weathering dark greenish gray to grayish olive. Conodont sample USGS D507–PC | 3.2 | 10.2 |
| 17. Shale, fissile to papery, brownish gray and grayish back | 2.0 | 6.6 |
| 16. Wackestone, thin-bedded. Silty sparse biomicrite with brachiopod debris, and subangular quartz silt (15 percent). Medium light gray weathering grayish orange | 2.0 | 6.6 |
| 15. Lime–mudstone, massive, finely laminated. Pelloidal ghosts, churned texture, void space (5 percent) filled | | |

Railroad Canyon Formation—*Continued*

| | Thickness meters | Thickness feet |
|---|---|---|
| with single calcite crystals (0.25–1.0 mm). Brachiopod biomicritic packstone near base. Fragmental brachiopods, disseminated subangular quartz silt grains (15 percent), echinoid plates (10 percent). Light brownish gray to pale brown, weathering medium gray | 9.2 | 30.0 |
| 14. Claystone, flaggy, with papery shale interbeds. Slightly silty and calcareous, disseminated hematite grains (5 percent), and lenticular olive-gray lime-mudstone. Claystone is olive gray weathering olive gray, shale is brownish gray to grayish black | 3.7 | 12.0 |
| 13. Conglomerate. Heterogeneous grain types: Lime-mudstone, phosphate, intraclastic claystone, and brachiopod fragments; very poorly sorted with platy clasts as much as 6 mm in length, average less than 3 mm in length. Generally well rounded grains, but with some oblate laths subparallel to bedding; sparite matrix. Medium gray to medium dark gray weathering pale yellowish brown | 3.3 | 11.0 |
| 12. Calcareous siltstone, thin-bedded to flaggy. Quartz silt (20–40μ) with hematitic clay matrix, calcite cement. Pale yellowish brown weathering pale red to grayish orange | 1.6 | 5.2 |
| 11. Calcareous siltstone. Friable, pale-red fossil fragments, *Inflatia* and *Antiquatonia* | 0.6 | 2.1 |
| 10. Lime-mudstone, massive bedded. Skeletal. Medium dark gray weathering pale yellowish brown | 0.9 | 3.2 |
| 9. Claystone and interbedded shale, laminated, platy and flaggy. Hairlike veins of spar (0.5 mm), clay whisps as long as 1.1 mm, filamentous-spicular sparite grains. Dark olive gray weathering light olive gray and pale red | 3.0 | 9.6 |
| 8. Calcareous shale and interbedded lime-mudstone, flaggy to papery. Claystone lamellae form wavy, gradational partings. Dark gray, olive gray, and medium gray, weathering light olive gray to yellowish gray | 21.9 | 72.0 |
| 7. Lime-mudstone, laminated, thick-bedded. Skeletal, abundant brachiopod impressions, brachiopod spines (15 percent) in micrite matrix, clay whisps. Moderate to dark yellowish brown weathering yellowish gray | 1.0 | 3.3 |

Railroad Canyon Formation—*Continued*

| | Thickness meters | Thickness feet |
|---|---|---|
| 6. Shale and claystone, thin and papery at base and top, conchoidal fracture pattern in middle. In part, laminated and calcareous, 5 percent quartz grains, 20–110μ in size. Shale is black to dark gray, claystone is dark gray to brownish black | 12.4 | 40.8 |
| 5. Siltstone, poorly exposed. Calcareous, disseminated hematite, brecciated. Grayish red purple weathering light brown | 2.0 | 6.7 |
| 4. Shale, dark gray, like unit 6 | 7.5 | 24.6 |
| 3. Claystone, poorly exposed. Wavy laminated, in part low-angle planar laminated, 15 percent fine quartz silt grains, disseminated opaques 5 percent. Grayish red purple weathering pale red purple to grayish orange | 18.4 | 60.4 |
| 2. Claystone, as float. Weakly calcareous, in part laminated. Grayish red purple weathering pale red purple | 2.1 | 7.0 |
| 1. Siltstone, float. Angular to subround quartz grains (40 percent) in calcareous, hematite clay matrix, well laminated. Yellowish brown weathering grayish orange | 3.1 | 10.0 |
| Total thickness of Railroad Canyon Formation | 205.7 | 676.3 |

## CONCLUSIONS

The sedimentary succession and age relations (fig. 3) represent a transgressive-regressive sedimentary package that forms the Snowcrest Range Group. The transgression was in the northeast direction and is represented by Kibbey Sandstone and Lombard Limestone deposition. The Conover Ranch Formation generally represents regressive sedimentation. The Snowcrest Range Group is largely Mississippian and equivalent to the Amsden Formation in western Wyoming, which shows diachronous transgressive deposition. The Snowcrest Range Group is also equivalent to the Big Snowy Group and only the Tyler Formation of the Amsden Group of central Montana.

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