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PENNSYLVANIAN ROCKS AND FUSULINIDS OF EAST UTAH AND NORTHWEST COLORADO CORRELATED WITH KANSAS SECTION

BY

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ABSTRACT

Stratigraphic sections of Pennsylvanian rocks in the eastern Uinta Mountains of Utah and Colorado and of the lowermost Pennsylvanian in the eastern White River uplift area of northwestern Colorado are illustrated and discussed. Parts of the fusulinid faunas from these sections are described and illustrated. Largely on the basis of them, correlations are made with the stratigraphic section of the midcontinent region.

The Belden shale of the White River uplift is described as the Belden formation and limestones and shales of the Uinta Mountains, formerly referred to the upper part of the Brazer formation, are referred to it. The Pennsylvanian rocks in the eastern Uinta Mountains are divided, in ascending order, into the Belden formation, Hell's Canyon formation, Youghall formation, and Weber sandstone.

Four species of *Millerella* are described and illustrated from the Belden formation and several others are identified. As this fauna is composed entirely of *Millerella,* the Belden formation is referred to the Zone of *Millerella* and is correlated with the type section of the Morrowan of Arkansas and the Kearny formation of Kansas.

Species from the Hell's Canyon formation belonging to *Millerella, Pseudostaffella, Eoschubertella,* and *Fusulinella* are identified, 5 of them being described and illustrated. The Hell's Canyon formation is referred to the uppermost part of the Zone of *Fusulinella.* The Youghall formation contains an abundant fauna of *Wedekindellina* and *Fusulina,* 10 forms of which are described and illustrated. The Youghall formation is referred to the Zone of *Fusulina* and is correlated with the Cherokee of Kansas and Iowa.

No fossils were found in the Weber sandstone. Its age was not determined.

INTRODUCTION

During the field season of 1944, Pennsylvanian rocks exposed in parts of Wyoming, northern Colorado, and eastern Utah were studied for the Phillips Petroleum Company. Numerous fusulinid foraminifers were obtained and a study of them has given much additional information concerning stratigraphy and paleogeography of the Pennsylvanian system in that region. The field work was carried on around the north, south, and east flanks of the Uinta Mountains of eastern Utah and northwestern Colorado and in the White River uplift area of northwestern Colorado. The geographic locations of the stratigraphic sections discussed specifically in this report are shown on the accompanying index map (Fig. 1).

The Pennsylvanian rocks of northwestern Colorado and easternmost Utah are treated in numerous publications, including reports by Powell (1876), Hague and Emmons (1877), Girty

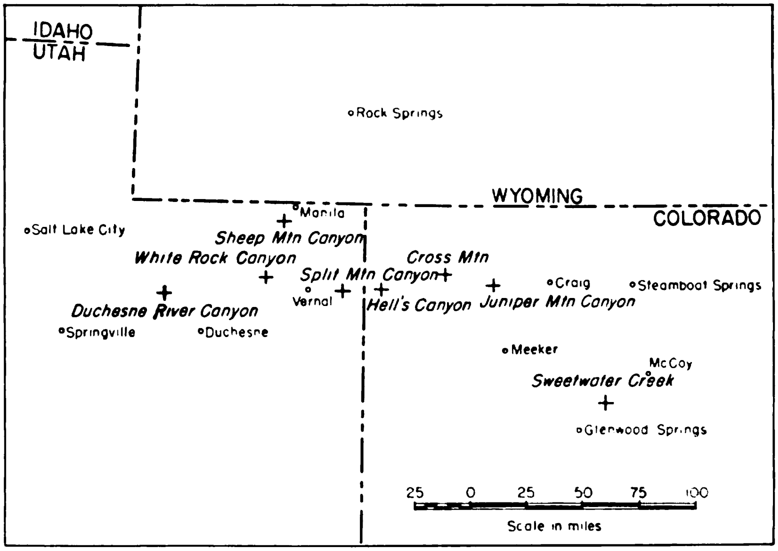

FIG. 1. Index map of east Utah and northwest Colorado.

(1903), Berkey (1905), Emmons (1907), Weeks (1907), Schultz (1918), Reeside (1923), Sears (1924), and Forrester (1937). Few of these papers discuss the Pennsylvanian in detail, however. Brill (1942) has described the Pennsylvanian rocks in the Gore area of north-central Colorado between Climax and Piney River and has extended his study (Brill, 1944) northwestward into the White River uplift and the southeastern flanks of the Uinta Mountains. Williams (1943) described Pennsylvanian and Mississippian rocks in the Uinta and Wasatch Mountains of Utah, including the type sections of the Brazer, Morgan, Weber, and Wells formations. He measured two sections on the south margin of the Uinta Mountains, one from the canyon of the North Fork of Duchesne River northwest of Duchesne, Utah, and the other from Brush Creek Canyon north of Vernal, Utah.

I had opportunity to examine the section in the Uinta Mountains discussed by Williams and Brill and some of the sections in the White River uplift discussed by Brill. I also had opportunity to examine the Pennsylvanian sections exposed in Sheep Mountain Canyon south of Manila on the north side of the Uinta Mountains, in White Rock Canyon northwest of Vernal, in Split Mountain Canyon east of Vernal, in Hell's Canyon on the southeast flank of the Uinta Mountains, at Cross Mountain east of Hell's Canyon, at Juniper Mountain Canyon of the Yampa River west of Craig, Colo., and in the region near McCoy, Colo. Fusulinid foraminifers are abundant in many of these sections. They furnish information for correlation of the Pennsylvanian rocks of northwestern Colorado and eastern Utah with those of Kansas and throw light on Pennsylvanian paleogeography west of Kansas.

Acknowledgments.—I express sincere thanks to the many geologists of the Rocky Mountain area who aided in locating important localities, in supplying information about local and regional geology, or who made work possible in some regions by hospitality of living quarters. Among these are especially Henry Ley, W. T. Nightingale of the Mountain Fuel Supply Company, Harry Baldwin and J. H. Turner of the Phillips Petroleum Company, Harry Oborne, Warren Thompson, and J. Stewart Williams. Thanks are extended also to O. T. Hayward, a student at the University of Kansas, who assisted me in the field work.

STRATIGRAPHIC CLASSIFICATION

Morrowan Series

Belden formation.—The Belden shale was named by Brill (1942) as a member of the Battle Mountain formation in the Gore area, Colorado. The type locality was given as the north side of Rock Creek valley along U.S. Highway 24, 0.2 mile north of Gilman, Colo. Later, Brill (1944) proposed that the Belden shale be recognized as the basal formation of the Pennsylvanian in the region from Gore Creek to the White River uplift and substituted the older name Maroon formation for all Pennsylvanian rocks above the Belden shale. In this report I propose to refer to the Belden formation the Belden shale of Brill and limestones of equivalent age in the Uinta Mountains of northwestern Colorado and eastern Utah.

The Belden formation is more than 125 feet thick at the type section which is composed largely of interbedded dark-gray limestone and black fissile to dark-gray blocky shale and at least one thin coal seam. All the type section is not well exposed, as Brill pointed out, large intervals being covered by talus. The formation is about 200 feet thick near Minturn, Colo., about 4 miles north of the type section.

The best exposed section of Belden beds observed in the White River uplift is about one-fourth of a mile west of the junction of Sweetwater Creek and Colorado River. Here the formation is well exposed throughout and is about 346 feet thick. This section is similar in lithology to the type section and is composed largely of dark-gray earthy to light-gray crystalline limestone interbedded with dark-gray to black fissile to blocky shale. However, limestone beds are more common and thicker than at the type locality. Also, several thin conglomerates and sandstones occur in the middle and upper parts of the formation, and sandstones are abundant in the upper part. The lithology and some of the fusulinid faunas of the Belden formation at Sweetwater Creek are indicated on the accompanying diagram (Fig. 2). Detailed descriptions are given at the end of this report.

The Belden formation contains abundant thick ledges of gray limestone in the central and western part of the White River uplift, and is composed predominantly of limestone. This westward increase of limestone in the Belden was also observed by Brill (1944, p. 626).

Many of the calcareous shales and limestones at Sweetwater Creek are highly fossiliferous. Microscopic examination of thin sections of the limestones and of washed residues of the shales reveals an abundant fusulinid fauna composed entirely of species of *Millerella*. This fauna is similar to that of the Kearny formation of southwestern Kansas and the type section of the Morrowan of Arkansas (Thompson, 1944). Furthermore, an examination of numerous fusulinid-bearing shales and limestones from the Sweetwater Creek section has not demonstrated the presence of the more highly developed fusulinids that are so commonly associated with *Millerella* in the post-Morrowan Derryan series of New Mexico and Lampasan series of Texas. It is, therefore, believed that the Belden formation is of Morrowan age.[1] However, Morrowan fusulinids have not been studied in sufficient detail to determine if the Belden is early or late Morrowan in age or if it represents all the Morrowan of other areas.

Williams (1943) identified as Brazer formation 500 feet of limestones, sandstones, and shales in the canyon of North Fork

[1] The undescribed Morrowan fossils reported by Moore, *et al.*, (1944) from the Colorado River valley west of Minturn probably are from the Belden formation.

of Duchesne River on the south flank of the Uinta Mountains. He also identified as Brazer formation 700 feet of rocks of similar lithology in Brush Creek Canyon on the south margin of the Uinta Mountains. He concluded that all the Brazer may be of Mississippian Meramecian to Chesterian age.

Brill (1944) described the section above the "Mississippian limestone" near Disappointment Creek southeast of Hell's Can-

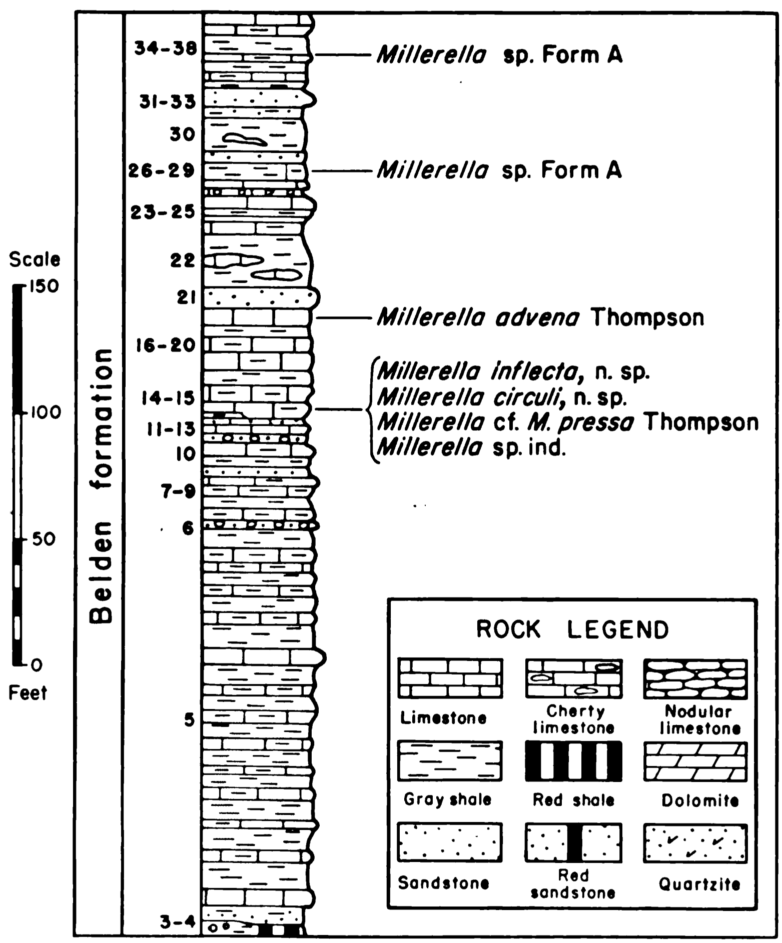

FIG. 2. Diagram and fusulinid faunas of the Belden formation, Section P-15, Sweetwater Creek.

Numbers to left refer to beds of described section. Rock legend same as used in all following diagrammatic sections.

yon. He referred 941 feet of rocks exposed in this area to the Morgan formation and stated that the Morgan rests on Mississippian limestone. The Weber quartzite above the Morgan formation, as the Morgan was thus defined, is about 880 feet thick. Brill considered all of the Morgan formation at Disappointment Creek Desmoinesian in age. A restudy of the section in the general region of Disappointment Creek indicates that Brill included at least 225 feet of limestone in the basal part of the Morgan formation that corresponds in age to the upper part of the Brazer formation as defined by Williams in Brush Creek and Duchesne River Canyons.

Detailed measurements and numerous collections were made of the limestones and interbedded thin gray to red shales that occur just beneath the rocks referred to the Morgan formation by Williams in the Uinta Mountains. At many localities the lower part of these limestones and thin shales is covered by talus, and the basal beds were studied in detail at only a few places. At Juniper Mountain they seemingly are unconformable on older rocks. The contact with overlying rocks was observed at numerous localities, and in many of them it is unconformable. Heavy basal conglomerates in the overlying beds occur on an irregular surface at the top of the limestones and include chert and limestone pebbles believed to have been derived from the rocks below.

Most of this limestone and thin shale sequence is highly fossiliferous. Fusulinid foraminifers referable to *Millerella* are exceedingly abundant at many localities, including Sheep Mountain Canyon, White Rock Canyon, Duchesne River Canyon, Split Mountain Canyon, Hell's Canyon, and Juniper Mountain Canyon. Many of the species of *Millerella* found in this part of the section in the Uinta Mountains are also present in the Belden formation of the Sweetwater Creek section. Furthermore, as at Sweetwater Creek, in spite of the great abundance of forms of *Millerella*, numerous thin sections of limestones and washed shale samples have not yielded any of the more advanced forms of fusulinids that occur in the Derryan of New Mexico. Therefore, these limestones and thin interbedded shales in the Uinta Mountains are referred to the Pennsylvanian Morrowan series.

The fusulinids indicate that the type section of the Belden formation is identical in age to at least part of these Morrowan limestones in the Uinta Mountains. This conclusion is further substantiated by the fact that in the White River uplift westward from Sweetwater Creek, the Belden formation is gradually replaced by more and more limestone. East of Meeker, the Belden formation is highly calcareous and resembles closely the Morrowan limestones of the Juniper Mountain section, about 40 miles north by northwest. Therefore, I propose to extend the Belden formation from central Colorado to the Uinta Mountains. The lithologic change from shales and interbedded limestones in the Gore area to predominantly limestones and thin interbedded shales in the Uinta Mountains is a gradual one.

Work by Girty (Mansfield, 1927, pp. 63-71; Richardson, 1941, pp. 23, 24) and others (Blackwelder, 1910, p. 530; Williams, 1943) indicates that part of the Brazer limestone of Utah and Idaho is of Spergen to Chester (Mississippian) age. Accordingly, it seems that at least a part of the typical Brazer formation west and northwest of the Uinta Mountains in Utah probably includes rocks older than the Belden formation of the Uinta Mountains. Morrowan rocks, however, probably were also included in the typical Brazer of Richardson (1913). Until a more definite correlation can be made with the Wasatch Mountain section, I prefer to use the term Belden formation for the Morrowan rocks of the Uinta Mountains.[1a]

The Belden formation is more than 335 feet thick at Sheep Mountain Canyon, south of Manila on the north side of the Uinta Mountains. There it is composed predominantly of fossiliferous limestones and a few thin interbedded shales. The lithology and some of the fusulinid faunas are indicated in the accompanying diagram (Fig. 3). Descriptions of the individual beds are given at the end of the report.

The upper 235 feet of limestone of the Belden formation was measured at Split Mountain Canyon on Yampa River. Its lithology and some of the fusulinids are indicated in the accompanying diagram (Fig. 4). At least 50 feet of limestones of the Belden formation occur at Split Mountain below the base of this measured section.

Only the upper 126 feet of the Belden formation was measured in detail in Hell's Canyon but about 175 feet of poorly exposed limestones and interbedded shales below the measured section

[1a] After this paper was in press, J. Stewart Williams and James S. Yolton (Am. Assoc. Petroleum Geologists Bull., vol. 29, pp. 1143-1155, 1945) identified Morrowan rocks in the lower part of the "Wells formation" at Dry Lake, Logan Quadrangle, northern Utah.

probably should be referred to the Belden. The upper surface of the Belden formation here is slightly irregular and the basal unit of the overlying Hell's Canyon formation is a coarse conglomerate composed of chert and limestone pebbles and yellow to red sandstone. The relations indicate an unconformity. The chert and limestone pebbles are believed to have been derived from the Belden formation.

At Juniper Mountain Canyon the Belden formation is slightly more than 225 feet thick. It is composed largely of fossiliferous limestones and thin beds of red and gray shale. The general lithology and part of the fusulinid faunas are indicated in the accompanying diagram (Fig. 5). Detailed descriptions of the individual units are given at the end of the report.

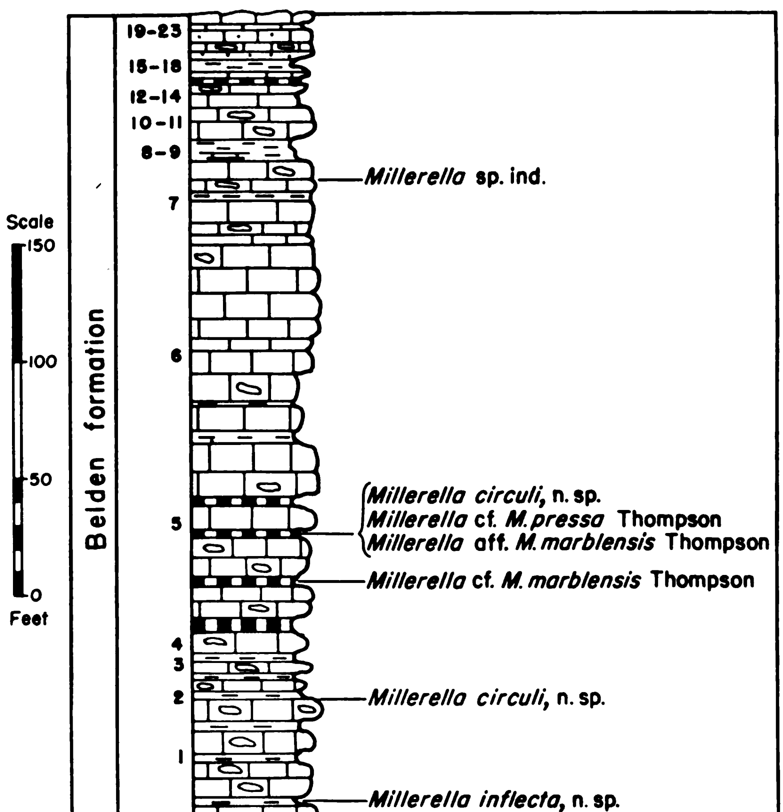

FIG. 3. Diagram and fusulinid faunas of the Belden formation, Section P-9, Sheep Mountain Canyon.

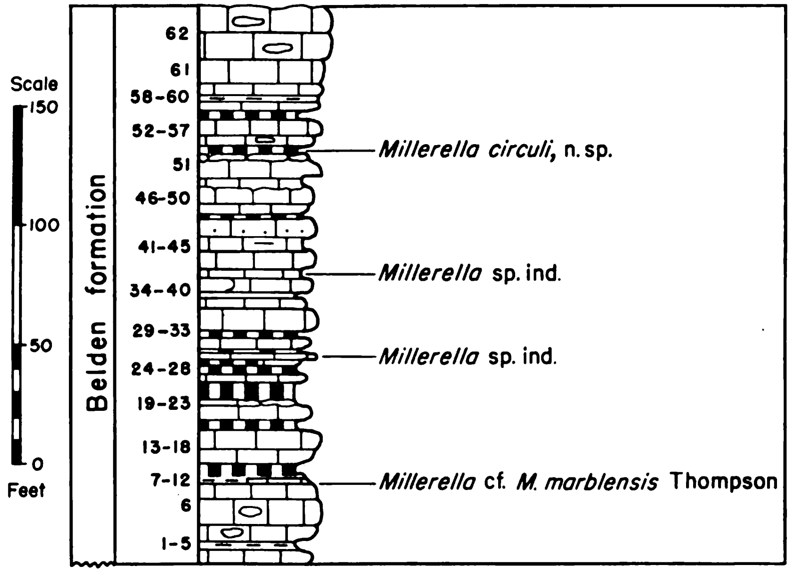

FIG. 4. Diagram and fusulinid faunas of the Belden formation, Section P-10, Split Mountain Canyon.

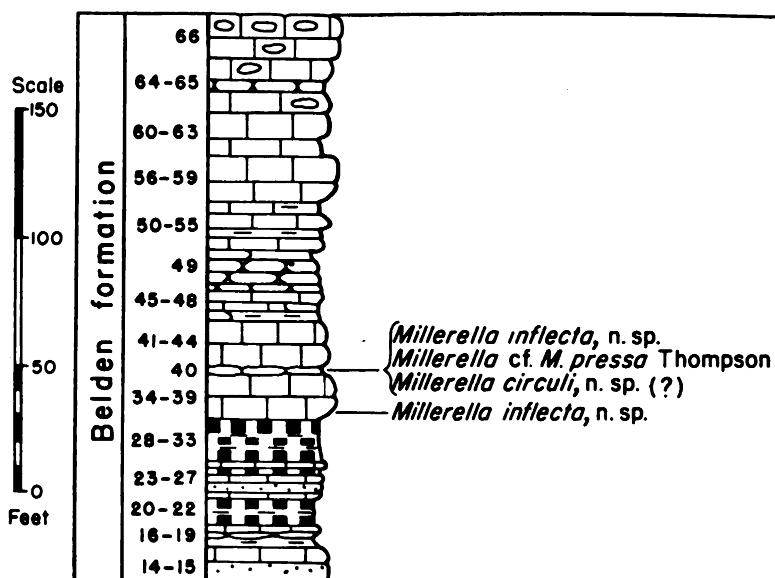

FIG. 5. Diagram and fusulinid faunas of the Belden formation, Section P-13, Juniper Mountain Canyon.

Post-Morrowan Pennsylvanian

General.—Rocks of Desmoinesian age are widespread in north-central Colorado, Wyoming, and eastern Utah. Roth and Skinner (1931) have described a large fauna of foraminifers, including fusulinids, from the McCoy formation at McCoy, Colo., which demonstrates that at least part of the McCoy formation is of Desmoinesian age. These workers also described a fusulinid species, *Fusulina? hartvillensis* Roth and Skinner, from the Hartville area of eastern Wyoming, possibly of Desmoinesian age. Thompson (1936) described 7 species of Desmoinesian fusulinids from the Hartville area. Branson (1939) reported Desmoinesian fusulinids in the "Tensleep sandstone" at Big Horn Canyon south of Thermopolis, Wyo. I have collections of Desmoinesian fusulinids from limestones immediately below the massive to cross-bedded sandstones of the type section of the Tensleep sandstone in Tensleep Canyon. Thompson and Scott (1941) described Desmoinesian fusulinids from the upper part of the type section of the Quadrant formation in northwestern Wyoming. Several thousand feet of rocks of Desmoinesian age are known to be present in the middle part of the Oquirrh formation in the Wasatch Mountains of eastern Utah.

Rocks of Pennsylvanian Derryan age are widespread in south-central United States. However, few occurrences of Derryan rocks have been recorded from central or northern United States. Derryan fusulinids have been described from the Hartville area of southeastern Wyoming and the Black Hills of South Dakota (Thompson, 1936). Middle Derryan rocks, stratigraphically near the junction of the Zone of *Profusulinella* and the Zone of *Fusulinella*, are represented in the Hartville region of eastern Wyoming by part of the Reclamation group. The lower part of the Minnelusa formation in the Black Hills of South Dakota contains highly developed species of the genus *Fusulinella*, *F. furnishi* Thompson and *F. dakotensis* Thompson, which indicate that the lower part of the Minnelusa formation is late Derryan in age.

Species of *Fusulinella* are widespread geographically in central Wyoming, northern Colorado, and eastern Utah. Species of this genus have been discovered in the lower part of the Pennsylvanian exposed at McCoy, Colo.; along the southeast side of the Uinta Mountains of Colorado and Utah; in the Absaroka Range of northwestern Wyoming (Love, 1939); and in the Wasatch

Mountains of Utah. Four species of *Fusulinella* are described below from rocks here referred to the Hell's Canyon formation in the eastern part of the Uinta Mountains. Detailed studies of them indicate they are more highly developed biologically than the species of *Fusulinella* in the Derryan of New Mexico, the Atoka formation of Oklahoma, the Big Saline group of Texas, and the lower part of the Reclamation group of eastern Wyoming. In the immediate area considered in this report, species of *Fusulinella* occur only a short distance above the top of the Morrowan Belden formation. The lowermost of these forms, *F. iowensis* var. *leyi*, n. var., is closely similar biologically to the typical variety of this species from near the base of the type Desmoinesian section of Iowa and the varieties of the species from the Mercer limestone of Ohio. Closely similar forms occur in the Warmington limestone member of the Elephant Butte formation of south-central New Mexico and in the Sandia formation of central New Mexico.

Two species of *Wedekindellina* and 8 species of *Fusulina* are described from the Youghall formation in the eastern part of the Uinta Mountains. *Fusulina prima*, n. sp., from the basal part of the Youghall formation, is more or less transitional in nature between typical species of *Fusulinella* and typical species of *Fusulina*. The middle and upper parts of the Youghall formation contain species of *Fusulina* and *Wedekindellina* closely similar to species in the Cherokee formation of Iowa, Missouri, Kansas and Oklahoma.

No fossil was found in the Weber sandstone of the Uinta Mountains, and its age is not known. However, the Weber may all be of Desmoinesian age.

Numerous lithologic units between the Belden formation below and the Weber sandstone above are traceable along the flanks of the eastern part of the Uinta Mountains but it does not now seem advisable to propose formational or member names for all of them. Two major lithologic and faunal units can be mapped throughout much of this area. The lower is here named the Hell's Canyon formation and the upper is named the Youghall formation. The Hell's Canyon formation is about 300 feet thick along the southeast flank of the Uinta Mountains and is composed of highly fossiliferous limestones, fossiliferous gray shales, red to purple shales, gray fissile shales, purplish siltstones, and thin beds of gray to red fine-grained sandstone. Fusulinids referable to *Miller-*

ella, Eoschubertella, Pseudostaffella, and *Fusulinella* are abundant throughout much of the formation.

The term Youghall formation is proposed for the fossiliferous limestones, thin shales, and thick interbedded highly cross-bedded sandstones between the Hell's Canyon formation below and the Weber sandstone above. Fusulinid foraminifers assigned to *Millerella, Pseudostaffella, Fusulina,* and *Wedekindellina* occur in the Youghall formation, and the latter two genera occur throughout most of the formation along the south-central, southeastern, eastern, and northeastern margins of the Uinta Mountains. The Youghall formation is 530 to 650 feet thick. It retains an essentially uniform thickness and lithology over larger areas than the underlying Hell's Canyon formation.

The nomenclature of Pennsylvanian rocks of post-Morrowan age in eastern Utah, northern Colorado, and central to southern Wyoming is not stabilized. In central and south-central Wyoming the term Tensleep sandstone is applied to the thick sandstone at the top of the Pennsylvanian. The term Amsden has been applied to the sandstones, limestones, and shales between the Tensleep and the Mississippian Madison limestone. The Amsden has been reported as including rocks of Pennsylvanian and Mississippian ages. It is possible that rocks equivalent in age to the Belden formation may also have been included in the Amsden at its type locality. Love (1939) discovered a species of *Fusulinella* in the upper part of rocks which he referred to the Amsden formation in the Absaroka Range, Wyoming. Therefore, it may be that rocks equivalent in age to and older than the Belden formation, Hell's Canyon formation, and Youghall formation have been referred to the Amsden. In any case, the uncertainty in correlation between the Uinta Mountain region and the type section of the Amsden formation, more than 200 miles to the northeast, makes it inadvisable to apply the term Amsden to any rocks in the Uinta Mountains region.

The term Morgan formation was published by Blackwelder (1910) for 500 to 2,000 feet of red sandstone and shale exposed in Weber Canyon, Utah, between the "dark Mississippian limestones" below and the Weber quartzite above. If the upper limestones of the Brazer formation of Weber Canyon are equivalent in age to the Belden formation of the Uinta Mountains, part of the Morgan formation of Weber Canyon may be equivalent in age to limestones and shales in the eastern part of the Uinta Mountains included in the Hell's Canyon formation. Only a few fossils have been reported from the type section of the Morgan formation. Therefore, its age is not definitely known. Also, the lithology of the type section of the Morgan formation is considerably different from that of the Hell's Canyon formation.

Williams (1943) applied the term Morgan formation to reddish shales and reddish sandstones 215 to 385 feet thick that occur along the southwestern and south-central margins of the Uinta Mountains, stratigraphically between the Belden formation below and the "Weber formation"[2] above. At Brush Creek Canyon, he recognized a species of *Fusulinella* in the upper part of the Morgan formation. It seems probable that rocks at Duchesne River and Brush Creek, referred to the Morgan formation by Williams, are equivalent in age, at least in part, to beds on the southeastern flanks of the Uinta Mountains here referred to the Hell's Canyon formation.

Several formational terms have been proposed for Pennsylvanian rocks in north-central Colorado that are equivalent in age to at least part of the rocks between the Belden formation and the Weber sandstone. These terms include Maroon formation (as defined by Brill, 1944), McCoy formation (Roth and Skinner, 1931), and Battle Mountain formation (Brill, 1942). However, the rocks of the type sections of all these formations are markedly different in lithology from the fusulinid-bearing post-Morrowan rocks of the Uinta Mountains. It is not advisable to apply any of these terms to rocks in the Uinta Mountains.

Hell's Canyon formation.—The Hell's Canyon formation is about 294 feet thick at the type locality in Hell's Canyon, west bluff Hell's Canyon, sec. 31, T. 6 N., R. 102 W, a tributary canyon of the Yampa River in Moffat County, Colo. The type section is composed of highly fossiliferous limestones and gray shales, red to purplish shales, gray fissile shales, purplish siltstones, and thin beds of gray to red fine-grained sandstones. The lower 10 feet of the type section is a coarse conglomerate of limestone and chert pebbles and yellowish to red coarse quartz sand. The next 125 feet consists largely of purplish shale, interbedded with irregular argillaceous limestone zones, purplish siltstone, and

[2] The Weber formation as defined by Williams in the Uinta Mountains includes part of the Youghall formation and all the Weber sandstone of this report.

argillaceous limestone. Fossils are abundant in several zones of this interval, especially about 50 feet below the top, but no fusulinid has been discovered in this part of the section. The upper 159 feet of the type section is composed largely of highly fossiliferous cherty limestone, fossiliferous shale, scattered thin beds of red to purple shale, and gray to purple fine-grained sandstone. Fusulinids referable to *Fusulinella, Pseudostaffella, Eoschubertella,* and *Millerella* are abundant from the base to within 29 feet of the top of this upper interval. The lithology and some of the fusulinid faunas of the type section are indicated in the accompanying diagram (Fig. 6). Detailed descriptions are given at the end of this report.

The Hell's Canyon formation is exposed throughout most of the northeast wall of the canyon of Yampa River at Juniper Mountain. Thrust faults that more or less parallel the northeast-dipping strata repeat large parts of the section at some places. The most nearly complete exposure of the Hell's Canyon formation at Juniper Mountain was found near the east end of the canyon. The total thickness of the formation at Juniper Mountain is more than 165 feet. However, rock flowage caused by thrusting probably has eliminated large parts of the shale beds and possibly limestone beds. At Juniper Mountain the formation is composed largely of highly fossiliferous limestones and interbedded fossiliferous gray shales, red to purple shales, and thin sandstone. Fusulinid foraminifers are abundant throughout the Hell's Canyon formation at Juniper Mountain; in fact, several beds are composed largely of shells of *Fusulinella, Pseudostaffella,* and *Millerella.* Many species found at this locality are also present at the type section.

The lithology and fusulinid fauna of the Hell's Canyon formation at Juniper Mountain are indicated in the accompanying diagram (Fig. 7). Detailed descriptions of individual beds are given at the end of the report. A comparison of this diagram and detailed descriptions with those representing the type section indicates that the formation is more highly marine at Juniper Mountain than at Hell's Canyon. Also, red shales and siltstones are less abundant at Juniper Mountain than at Hell's Canyon. The section exposed at Cross Mountain, west by north of Juniper Mountain, indicates that this lateral lithologic change is a gradual one.

At Split Mountain and in the area farther west along the south flank of the Uinta Mountains, rocks believed to be equivalent in

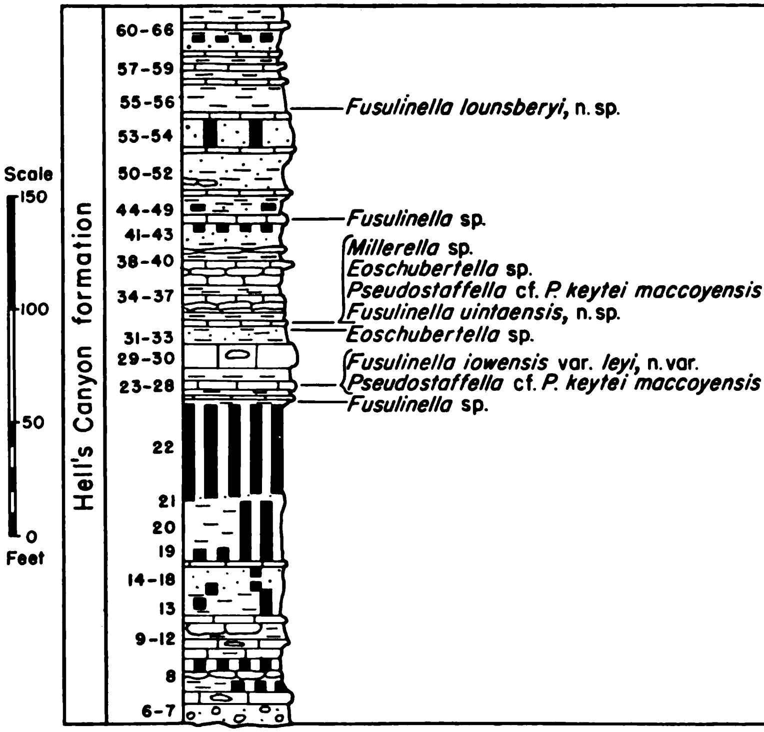

FIG. 6. Diagram and fusulinid faunas of the Hell's Canyon formation, Section P-17, Hell's Canyon.

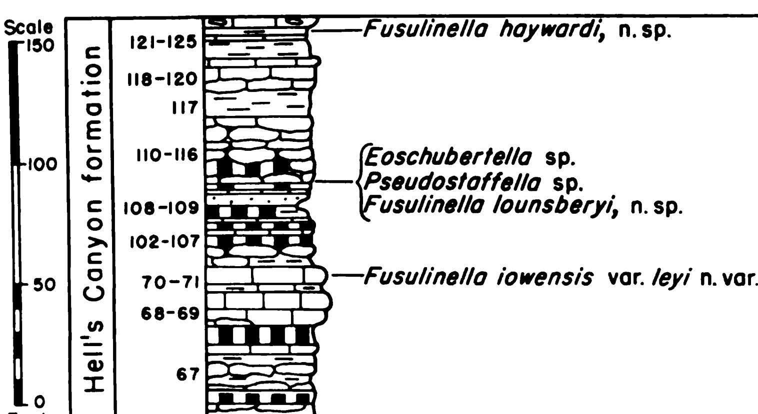

FIG. 7. Diagram and fusulinid faunas of the Hell's Canyon formation, Section P-13, Juniper Mountain Canyon.

age to the type section of the Hell's Canyon formation are largely reddish to brown fine-grained sandstone and siltstone and red shales, with a few interbedded thin argillaceous and sandy fossiliferous limestones. The total thickness of rocks equivalent in age to the Hell's Canyon formation was not determined at Split Mountain or in the region farther west. It seems probable that rocks of the same age as the Hell's Canyon formation are replaced by red sandstones and shales of the Morgan formation (Williams, 1943) west of Split Mountain.

Youghall formation.—Several hundred feet of cross-bedded sandstone and interbedded fossiliferous limestones and shales occur around the margins of the Uinta Mountains below the Weber sandstone and stratigraphically above the Hell's Canyon formation. The faunas, especially the fusulinids, demonstrate that these rocks are all of Desmoinesian age. The type section of the Weber quartzite (King, 1876; Hague and Emmons, 1877; Williams, 1943) includes several fossiliferous limestones in the lower one-third. It is possible that the lower part of the type Weber is equivalent in age to part of these Desmoinesian rocks. However, in the Uinta Mountains area I restrict the term Weber to the thick cross-bedded to massive buff sandstones above the limestone-bearing part of the section. As the Weber is thus defined for this region, the limestones, sandstones, and thin shales stratigraphically between the Hell's Canyon formation and the Weber sandstone are without a formational name. I propose the name Youghall formation for them.

The term is derived from the old stage station of Youghall, east of Hell's Canyon. However, the type locality is here designated as the exposures on the west side of Hell's Canyon in sec. 31, T. 6 N., R. 102 W. and along the east side of the head of Hell's Canyon in the W½ sec. 7, T. 5 N., R. 102 W., Moffat County, Colo. The base of the type section and its contact with the underlying Hell's Canyon formation can best be seen on the west wall of Hell's Canyon in the east face of the cliff near the center of the east-facing rounded hill of section 31, mentioned above. The upper part of the formation is best exposed about one-fourth mile northwest and down Hell's Canyon from its head at the creek fork in the south part of section 7.

The type section of the Youghall formation is approximately 625 feet thick and is composed of cross-bedded to massive buff to reddish-brown sandstone and interbedded highly fossiliferous limestone. The lithology and fusulinid faunas of the type section are indicated in the accompanying diagram (Fig. 8), and detailed descriptions of individual units are given at the end of the report. The accompanying diagrams indicate the lithology and some of the fusulinid faunas of the formation at Juniper Mountain (Fig. 9) and at Sheep Mountain Canyon (Fig. 10). This formation is also well exposed at many other localities on the eastern and southern margins of the Uinta Mountains, including Cross Mountain, Split Mountain Canyon, and White Rock Canyon.

At Juniper Mountain the Youghall formation is at least 650 feet thick, but its contact with the overlying Weber sandstone was not observed. Northward and northwestward the formation decreases in thickness. At Split Mountain it is more than 500 feet thick, at White Rock Canyon at least 600 feet thick, and at Sheep Mountain Canyon about 530 feet thick. On the south and southeast margins of the Uinta Mountains the Youghall formation overlies the Hell's Canyon formation; on the southwest margin it lies on the Morgan formation (as defined by Williams); and on the north margin it rests on the Belden formation.

At Juniper Mountain more than 50 percent of the Youghall formation comprises fossiliferous and cherty limestones but at Cross Mountain slightly less than 50 percent is limestone. At Hell's Canyon the formation is made up of only about 20 percent limestone, and at White Rock Canyon it contains only about 10 percent limestone and dolomitic limestone. Thus, the limestone content of the formation decreases westward from Juniper Mountain. Also, the limestones become more highly dolomitic in the area from White Rock Canyon to Duchesne River Canyon west of Vernal, Utah. At Sheep Mountain Canyon, on the north side of the Uinta Mountains, limestones make up only about 10 percent of the formation. Thus, the limestone content decreases northwestward from Cross and Juniper Mountains.

Fusulinids are abundant in many of the limestones throughout most of the Youghall formation but they have not been found in the uppermost limestone of the formation at any locality around the margins of the Uinta Mountains. Fusulinids occur in the next to highest limestone at most localities, including the type section. At several places *Fusulina* and *Wedekendellina* have been found in the lower part of the formation and species of these genera also

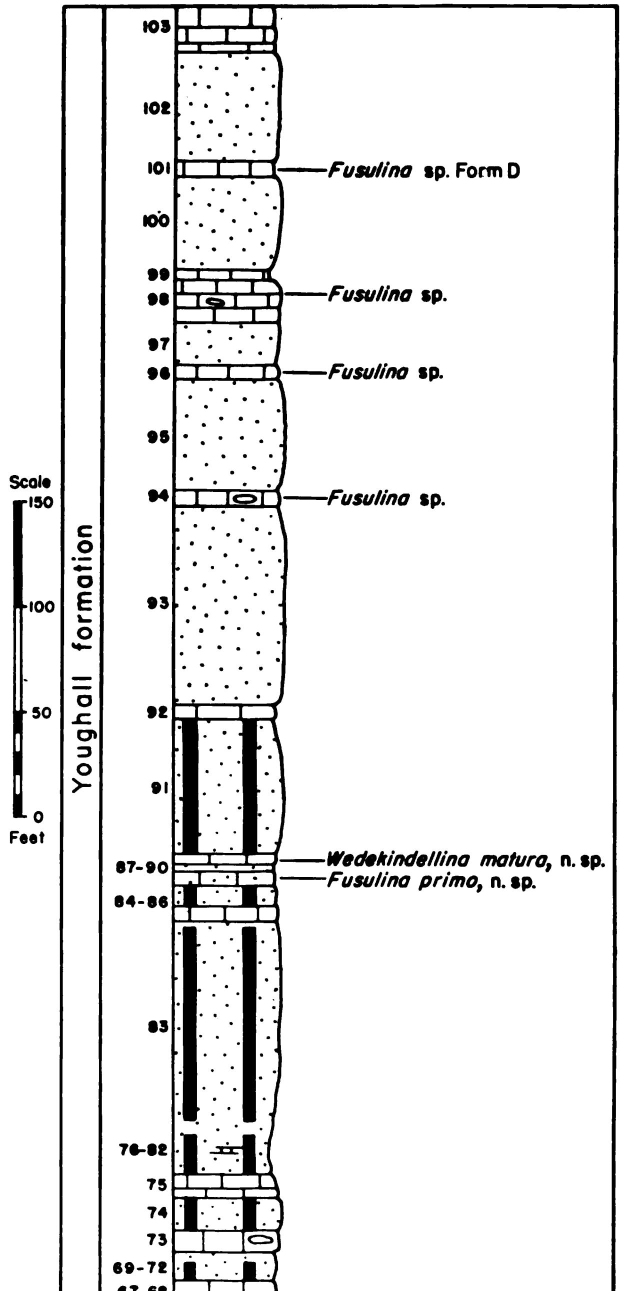

FIG. 8. Diagram and fusulinid faunas of the **Youghall formation**, Section P-17, Hell's Canyon.

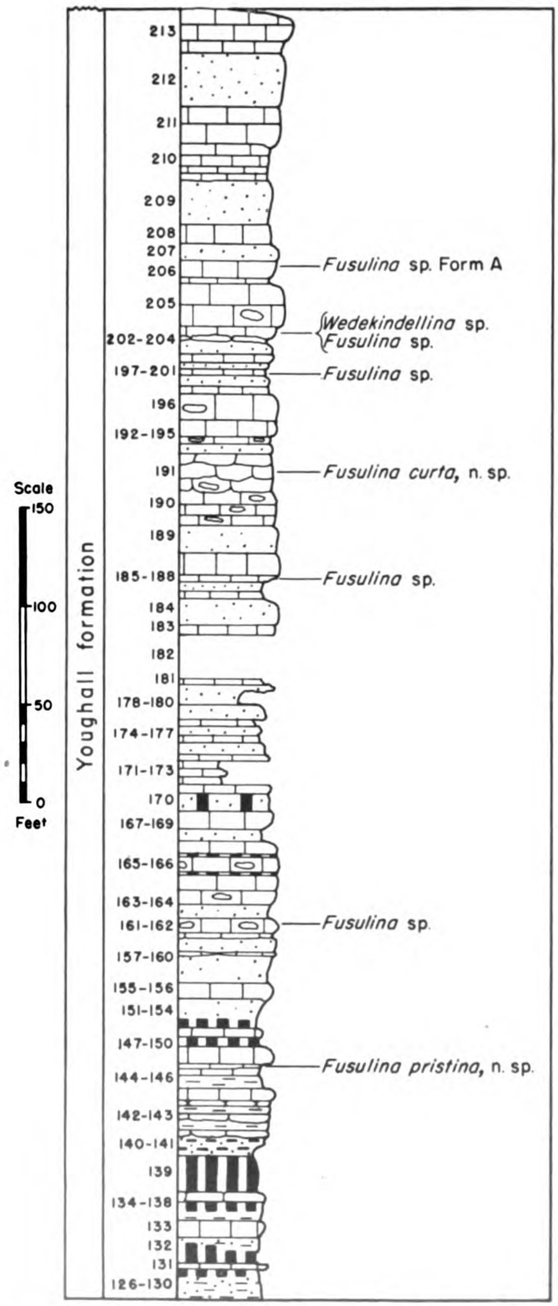

FIG. 9. Diagram and fusulinid faunas of the Youghall formation, Section P-13, Juniper Mountain Canyon.

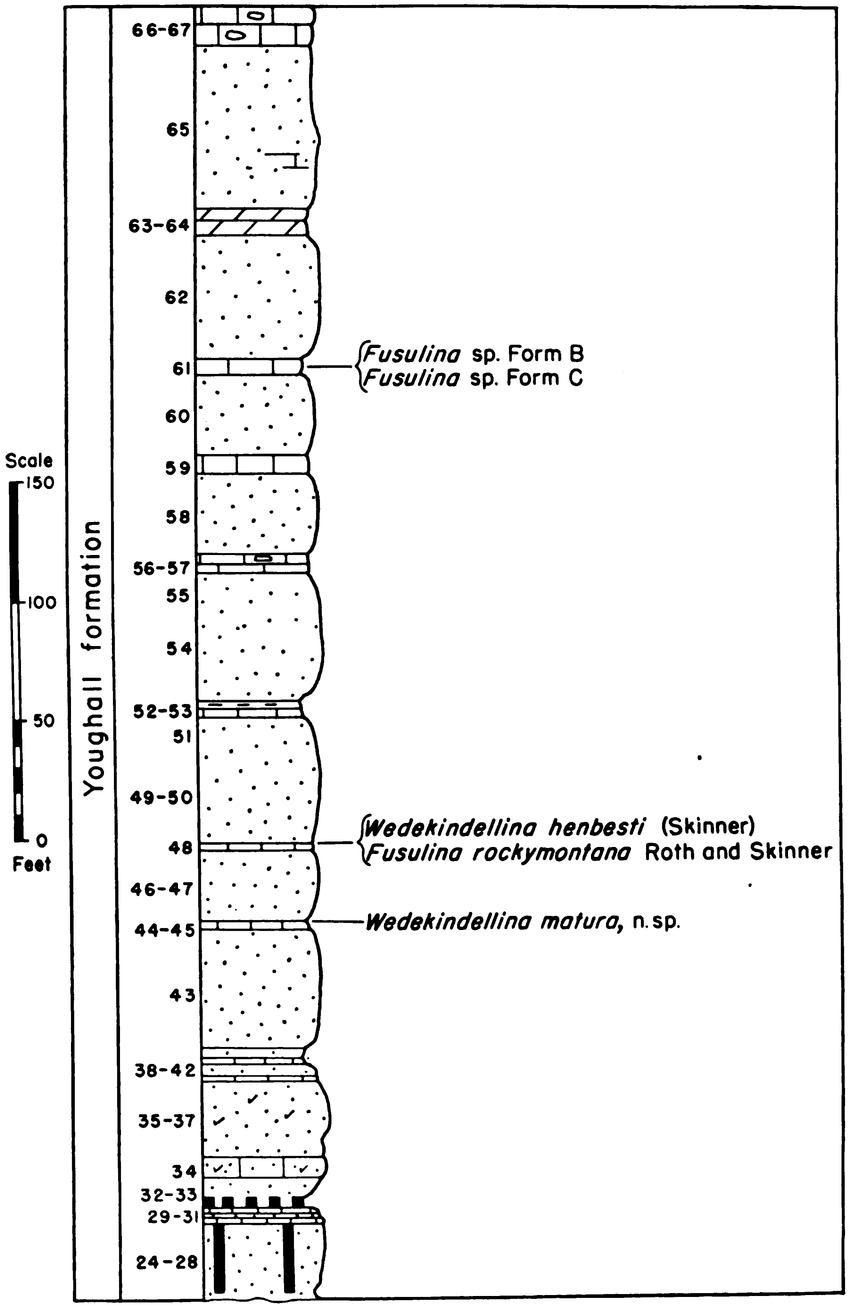

FIG. 10. Diagram and fusulinid faunas of the Youghall formation, Section P-9, Sheep Mountain Canyon.

occur in the upper fusulinid-bearing limestones. It is believed, therefore, that all the Youghall formation is equivalent in age to the Cherokee of the midcontinent region.

The strata of the Youghall formation are essentially parallel to those of the underlying Hell's Canyon formation, the Morgan formation, or the Belden formation, and to those of the overlying Weber sandstone. No physical evidence of an unconformity at the top or base of the formation was observed in the Uinta Mountains region, but absence of the Hell's Canyon formation on the north margin of the Uinta Mountains indicates that an unconformity separates the Belden formation and the Youghall formation in that area.

Weber sandstone.—The term Weber sandstone is applied to the buff, brownish, and light-gray highly cross-bedded to massive fine-grained sandstones in the Uinta Mountains between the Youghall formation below and the Park City formation above. Lenticular dolomites and dolomitic sandstones occur throughout the Weber. So far as could be determined, the contact between the Youghall formation and the Weber sandstone is conformable. The strata of the Weber sandstone and those of the overlying Park City formation are essentially parallel, at least in areas around the Uinta Mountains.

In the region north, northwest, and northeast of Vernal, Utah, the Weber sandstone is about 1,000 feet thick. Eastward from Split Mountain Canyon, the Weber decreases in thickness. On the north side of the Uinta Mountains, at Sheep Mountain Canyon, the Weber is about 850 feet thick.

No fossils were obtained from the rocks here referred to the Weber sandstone. Therefore, the age of the Weber was not determined.

FAUNAL SUMMARY AND STRATIGRAPHIC CORRELATION

Pennsylvanian Fusulinid Faunal Zones

General.—Fusulinid foraminifers occur throughout most of the Pennsylvanian system in central United States and have proved to be among the best index fossils for regional and interregional correlations of Pennsylvanian rocks. Land barriers between relatively narrow seaways seem to have dominated the paleogeography of the western midcontinent and Rocky Mountains areas during Pennsylvanian time. Many fusulinid species are restricted in their geographic distribution, perhaps due largely to land barriers and to marine tracts unsuited to them. Generic groups and their biologic stages of development have been found most useful for correlation of time-stratigraphic units over wide areas. Pennsylvanian rocks in most of North America can be referred to 5 major faunal zones based on the predominance of fusulinid genera, as indicated in following paragraphs. All 5 faunal zones are not represented completely in any single stratigraphic section. and it can not be demonstrated that the boundaries of all adjacent zones coincide.

Zone of Millerella.—The lowermost recognized Pennsylvanian fusulinid zone is designated as the Zone of *Millerella*. Species of *Millerella* Thompson occur throughout most of the marine Pennsylvanian section of America, but because the genus predominates in rocks of Morrowan age, almost to exclusion of other fusulinids, this part of the Pennsylvanian is conveniently defined as the Zone of *Millerella*. More highly developed fusulinids with which *Millerella* is commonly associated in post-Morrowan Pennsylvanian rocks distinguish these strata from the Zone of *Millerella*. Rocks referred to the Zone of *Millerella* are widespread in the midcontinent region; they include the Kearny formation of Kansas, the type Morrowan of Arkansas, the Wapanucka limestones and shales of Oklahoma, the lower part of the Dornick Hills formation of southern Oklahoma, the lower part of the Marble Falls limestone (type area) of central Texas, the Belden formation of Utah and Colorado, and at least the middle part of the "Amsden formation" of south-central Wyoming.

Zone of Profusulinella.—The genus *Profusulinella* Rauser-Cernoussova has a short stratigraphic range in America. In New Mexico the most primitive species occurs in the basal part of the Green Canyon group (Derryan) and the youngest form occurs in the upper part of the Green Canyon group. In other regions of America the genus seems to be as restricted stratigraphically as in New Mexico. Therefore, lower and middle Derryan and equivalent parts of the Pennsylvanian are referred to the Zone of *Profusulinella*.[3] This index genus occurs in the lower part of the Big

[3] Many American paleontologists prefer to use the term *Fusiella* Lee for the fusulinids here referred to *Profusulinella*.

Saline group of Texas and the lower part of the Atoka formation of Oklahoma. In New Mexico, Texas, and Oklahoma, *Profusulinella* is associated with *Millerella, Pseudostaffella,* and *Eoschubertella.*

Zone of Fusulinella.—Species of *Fusulinella* Möller are widespread in North America, appearing first in rocks of middle Derryan age (lower Mud Springs group) and ranging into the Desmoinesian. Stratigraphic and biologic studies indicate that *Fusulinella* was derived from *Profusulinella*. Species of *Millerella, "Nankinella," Pseudostaffella,* and *Eoschubertella* are associated with *Fusulinella* in the upper Derryan, and *Fusulina* is associated with it in much of its range in the Desmoinesian. Typical forms of *Fusulinella* predominate in the faunas of the upper Derryan and more highly developed forms of the genus predominate in the fusulinid faunas of rocks here considered to be early Desmoinesian. The early Desmoinesian *Fusulinella* forms occur in the lower part of the type Desmoinesian of Iowa, upper part of the "Pottsville series" of eastern Ohio (Mercer limestones), lower part of the Elephant Butte formation of southern New Mexico, Sandia formation of northern New Mexico, Hell's Canyon formation of Utah and Colorado, and lower part of the McCoy formation of north-central Colorado. At some of these localities, *Fusulinella* is associated with primitive forms of *Fusulina*. Many of the lowermost Desmoinesian fusulinids are so nearly intermediate in development that they are arbitrarily assigned to *Fusulina* or to *Fusulinella*. Most of them seem more closely related to the genotype of *Fusulinella* than to that of *Fusulina*, however, and accordingly they are referred by me to *Fusulinella*. Therefore, the upper Derryan and lowermost Desmoinesian rocks of central United States are referred to the Zone of *Fusulinella.*

Zone of Fusulina.—Species of *Fusulina* Fischer-de-Waldheim are abundant throughout most of the Desmoinesian of North America. Their lower limits are shortly above the base of the Desmoinesian and they have not been found in uppermost Desmoinesian rocks. Therefore, most of the Desmoinesian is referred to the Zone of *Fusulina*. Few large areas in America contain Pennsylvanian rocks that are not at least partly of Desmoinesian age.

Fusulina is believed to have been derived from *Fusulinella* and they overlap stratigraphically. In fact, forms occur near the top of the Desmoinesian (Thompson, 1945) that seem to be intermediate in nature between *Fusulinella* and *Fusulina*. *Millerella*, *Pseudostaffella*, *Eoschubertella*, "*Nankinella*," and *Wedekindellina* are associated with *Fusulina* in the Desmoinesian. However, *Wedekindellina* has not been found in lowermost or uppermost Desmoinesian rocks.

Zone of Triticites.—*Triticites* Girty occurs abundantly and widely in North America from near the base of the Missourian to above the base of the Permian Wolfcampian. Missourian and Virgilian rocks contain fusulinid faunas dominated by *Triticites* and are referred to as the Zone of *Triticites*. Faunas of *Millerella*, "*Nankinella*," *Schubertella*, *Waeringella*, and *Dunbarinella* make up only minor parts of the fusulinid faunas of the upper Pennsylvanian.

Belden Formation

The Belden formation is highly fossiliferous and contains abundant algae, brachiopods, corals, bryozoans, crinoid fragments, and foraminifers. Trilobites and pelecypods are less common. Fusulinid foraminifers are exceedingly abundant in many of the shales and limestones throughout most of the formation in the White River uplift and Uinta Mountains. In fact, some thin limestones are composed largely of fusulinids. All fusulinids so far discovered in the Belden formation are referable to the genus *Millerella*, which was originally described from the upper part of the Marble Falls limestone of Texas. Congeneric species are known to occur stratigraphically from near the base of the Morrowan series to near the top of the Pennsylvanian system. It is probable that further study will demonstrate the occurrence of *Millerella* in rocks older than the Morrowan.

Where species of *Millerella* have been found in rocks younger than Morrowan, they are closely associated with more highly developed fusulinids, such as *Pseudostaffella*, *Eoschubertella*, *Profusulinella*, *Fusulinella*, *Fusulina*, *Wedekindellina*, and *Triticites*. However, in the lower part of the Derryan in the southern Rocky Mountains region and in Texas, species of *Millerella* dominate the fusulinid faunas, and species of *Pseudostaffella*, *Eoschubertella*, and *Profusulinella* occur sparsely. It is evident that the mere presence of *Millerella* can not be considered diagnostic.

The fusulinid fauna of the Belden formation, part of which is described below, contains: *Millerella advena* Thompson, *M. in-*

flecta, n. sp., *M. circuli,* n. sp., *M.* cf. *M. pressa* Thompson, *M.* aff. *M. marblensis* Thompson, and *M.* sp. A. Numerous undescribed forms of *Millerella* are also known from the Belden formation. However, the above fauna will suffice to demonstrate the general nature of the Belden fusulinids.

Millerella has not been studied sufficiently to determine the nature of biological development within the genus. It is not possible in all cases to determine the stratigraphic position from any one species of the genus. Species from the Belden formation are closely similar to forms from the Kearny formation of Kansas, the Bloyd shale of the type Morrowan of Arkansas, and the Wapanucka limestone of Oklahoma. It is believed that the Belden is closely similar in age to these rock units. The Belden probably is closely similar in age to the Morrowan limestone of extreme western Texas.

Hell's Canyon Formation

Many of the calcareous shales and limestones of the Hell's Canyon formation are highly fossiliferous and contain abundant brachiopods, algae, crinoid fragments, corals, and foraminifers. Fusulinids dominate the foraminiferal faunas and include species of *Millerella, Pseudostaffella, Eoschubertella,* and *Fusulinella.* The following species, discussed and illustrated below, include some of the fusulinids from the Hell's Canyon formation of the Uinta Mountains: *Pseudostaffella* cf. *P. keytei* var. *maccoyensis* Thompson, *Fusulinella iowensis* var. *leyi,* n. var., *F. lounsberyi,* n. sp., *F. uintaensis,* n. sp., and *F. haywardi,* n. sp.

The species of *Fusulinella* in the Hell's Canyon formation are highly developed forms of the genus. They have well-defined diaphanotheca, and in most of them the septa are highly fluted in the extreme polar regions. In some forms the septal fluting extends across the central part of the shell and they may be more closely related to the genotype of *Fusulina* than to *Fusulinella.* Species from the Hell's Canyon formation are closely similar to undescribed species from the basal part of the Desmoinesian of New Mexico and Oklahoma. The form from the lower part of the Hell's Canyon formation, *F. iowensis* var. *leyi,* is similar biologically to *F. iowensis* Thompson from the basal Desmoinesian of Iowa and *F. iowensis* var. *stouti* Thompson from the Mercer limestone of Ohio. It is therefore believed that the Hell's Canyon formation should be referred to the upper part of the Zone of *Fusulinella.*

The species of *Fusulinella* from the lower part of the Hell's Canyon formation at Juniper Mountain are believed to be younger than the fusulinids from the lower part of the Pennsylvanian (Reclamation group) exposed at Hartville, Wyo. The fusulinid from the latter locality, *F. velmae*, is a primitive species of *Fusulinella*. In fact, that form seemingly is transitional in nature between *Profusulinella* and *Fusulinella*.

Youghall Formation

The Youghall formation is highly fossiliferous and contains abundant brachiopods, corals, algae, crinoidal remains, and fusulinid foraminifers. Some strata of the formation are composed largely of fusulinid tests and others of brachiopod shells. The following fusulinid fauna is described from the Youghall formation: *Wedekindellina matura*, n. sp., *W. henbesti* (Skinner), *Fusulina prima*, n. sp., *F. pristina*, n. sp., *F. rockymontana* Roth and Skinner, *F. curta*, n. sp., *F.* spp., Forms A, B, C, and D. *Fusulina* predominates in the fusulinid fauna of this formation and it is referred to the Zone of *Fusulina*. However, *Wedekindellina* is abundant in some strata.

Wedekindellina and *Fusulina* occur in many limestones in the middle and upper parts of the Youghall formation at Sheep Mountain Canyon. The lower fusulinid faunas of the formation at Juniper Mountain are composed of primitive species of *Fusulina*. Some of the upper limestones at Juniper Mountain Canyon contain *Wedekindellina* and *Fusulina*. *Wedekindellina* and *Fusulina* occur throughout much of the type section. It is concluded that the Youghall corresponds in age to a part of the Cherokee of the type section of the Desmoinesian series in Iowa and to a part of the Cherokee of Kansas.

SYSTEMATIC DESCRIPTIONS

Genus Millerella Thompson, 1942

Millerella inflecta, n. sp.

Plate 1, figures 1-7; plate 5, figures 2, 3; text figure 11

Shell minute, biscuit-shaped, umbilicate; with short axis of coiling, rounded periphery, strongly convex lateral slopes. Mature specimens of 4½ to 6 volutions 0.20-0.25 mm long and 0.36-0.58 mm wide. Form ratio 1:0.51-1:0.48, averaging 1:0.51 for 4 specimens. Average form ratios of first to sixth volution of 3 specimens 1:0.58, 1:0.55, 1:0.56, 1:0.53, 1:0.52, and 1:0.49, respectively. First volution strongly evolute, second to fourth volution almost completely involute, last part of fourth volution to maturity gradually becomes more highly evolute. Last part of sixth volution embraces only about one-third of radius of earlier part of shell (Fig. 11).

Proloculum minute, outside diameter 24-40 microns, averaging 32 microns for 5 specimens. Shell tightly coiled in inner 5 volutions, becomes more expanded immediately over tunnel in sixth volution. Average heights of first to sixth volution immediately over tunnel of 7 specimens 20, 24, 36, 56, 73, and 181 microns, respectively.

Spirotheca thin, composed of tectum and thin upper and lower layers. Becomes only slightly thinner poleward from center of shell.

Septal structure similar to that of spirotheca. Septa slightly arcuate immediately over tunnel, strongly arcuate anteriorly in polar regions. Average septal counts of first to fifth volution of 2 specimens 8, 11, 15, 18, and 23, respectively. Septa unfluted throughout length of shell.

Tunnel about one-third as high as chambers. Tunnel angles measure about 14, 18, and 22 degrees in fourth to sixth volution, respectively. Chomata developed in all parts of shell, except in first volution and outer part of last volution. Chomata about half as high as chambers, tunnel sides essentially vertical, poleward slopes low and extend about half distance from tunnel to polar regions.

Remarks.—This form resembles somewhat closely *Millerella pinguis* Thompson from the Bloyd shale of Arkansas and the Kearny formation of Kansas. However, its shell is smaller for corresponding volutions and is more highly evolute, and its chomata are more massive. *M. inflecta* can be distinguished from *M.? advena* Thompson from the Bloyd shale by its larger form ratio for corresponding volutions, more highly umbilicate axial regions, more broadly rounded periphery, and more highly evolute shell.

Measurements of Millerella inflecta, n. sp., Specimens A-G, in millimeters

Volution	Height of volution						
	A	B	C	D	E	F	G
0	.028	——	.024	.040	——	.036	.032
1	.028	——	.020	.014	——	.020	.016
2	.024	.024	.024	.024	——	.024	.024
3	.036	.040	.032	.044	.036	.028	.036
4	.061	.053	.065	.048	.048	.040	.077
5	.069	——	.081	.065	.061	.069	.093
6	——	——	——	——	.181	——	——

Volution	Form ratio of volution			Septal count		Tunnel angle (degrees)		
	A	D	E	F	G	A	D	E
1	1:0.58	1:0.59	——	9	7	—	—	—
2	1:0.52	1:0.59	——	12	11	—	—	—
3	1:0.60	1:0.59	1:0.48	16	14	—	—	—
4	1:0.52	1:0.54	1:0.52	20	16	14	—	—
5	1:0.55	1:0.50	1:0.51	23	24	18	17	19
6	——	——	1:0.49	—	—	—	—	22

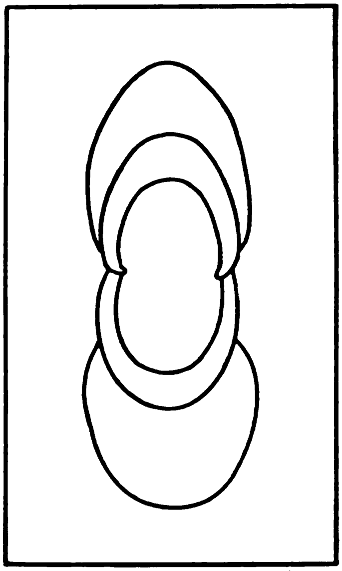

Fig. 11. Profile outline of *Millerella inflecta*, n. sp., x 100.

Occurrence.—The described syntypes were obtained from Bed 15, Section P-15, Sweetwater Creek, Belden formation. This form is also abundant in the Belden formation, Bed 34 and Bed 40, Section P-13, at Juniper Mountain Canyon, and in Bed 1, Section P-9, Sheep Mountain Canyon.

MILLERELLA CIRCULI*, n. sp.
Plate 1, figures 15-18

Shell minute, ellipsoidal; with short axis of coiling, rounded periphery, convex lateral slopes, depressed axial regions. Mature specimens of 5 volutions 0.295-0.303 mm long, 0.586-0.626 mm wide. Form ratio 1:0.50-1:0.52. Form ratio gradually decreases with growth of shell. Form ratios of first to fifth volution of holotype 1:0.62, 1:0.70, 1:0.64, 1:0.57, and 1:0.52, respectively. First volution evolute, fourth volution slightly evolute, and fifth volution more highly evolute. Second and third volutions essentially involute. Shell umbilicate throughout growth. Periphery rounded throughout shell, becoming more broadly rounded in outermost volution.

Proloculum minute, outside diameter 40-48 microns, averaging 42 microns in 4 specimens. Shell expands slowly and uniformly. Average heights of first to fifth volution of 4 specimens 22, 33, 56, 83, and 110 microns, respectively.

Spirotheca composed of tectum and thin upper and lower layers. Total thickness of spirotheca about 16 microns in third volution, 20 microns in fourth volution.

* Name refers to circles (nominative plural).

Septa thin, extend forward at angle of about 10 degrees in center of shell, arcuate anteriorly in polar regions. Septa unfluted throughout length of shell. Septal counts of first to fifth volution of 2 specimens average 8, 11, 15, 18, and 24, respectively.

Tunnel low and relatively wide. Tunnel angles in third to fifth volution about 17, 22, and 18 degrees, respectively. Chomata developed throughout shell, except in outer few chambers. In third to fifth volution chomata more than half as high as chambers, asymmetrical, with vertical tunnel sides and low poleward slopes. Poleward side extends more than half distance from tunnel to poles.

Remarks.—This is one of the largest species of *Millerella* know from America. In general shape *M. circuli* resembles *M. pinguis* Thompson from the Kearny formation of Kansas and the Bloyd shale of Arkansas. However, the polar regions are more deeply umbilicate, its form ratio for corresponding volutions is larger, its chomata are more massive, and its proloculum is larger.

Measurements of Millerella circuli, n. sp., Specimens A-D, in millimeters

Volution	—Height of volution— A	B	C	D	Form ratio of volution A	B	Septal count C	D	Tunnel angle (degrees) A	B
0	.048	.040	.040	.040	——	——	—	—	—	—
1	.024	.020	.020	.024	1:0.62	1:0.63	7	8	—	—
2	.028	.028	.036	.040	1:0.70	1:0.70	10	11	—	—
3	.057	.053	.057	.057	1:0.64	1:0.69	14	15	17	—
4	.085	.081	.081	.085	1:0.57	1:0.61	18	18	22	—
5	.101	.121	.113	.105	1:0.52	1:0.50	23	24	18	18

Occurrence.—This form is abundant in Bed 52, Section P-10, Split Mountain Canyon, Belden formation, from which the holotype and described and illustrated paratypes were obtained. It is also common in the Belden formation, Bed 15, Section P-15, Sweetwater Creek, and in the lower half of the upper part of Bed 5, Section P-9, Sheep Mountain Canyon. Specimens referred with question to this species occur in Bed 40, Section P-13, Juniper Mountain Canyon, Belden formation.

MILLERELLA cf. M. PRESSA Thompson
Plate 5, figures 1, 4

Millerella pressa THOMPSON, *1944*, Kansas Geol. Survey, Bull. 52, pp. 423-425, pl. 2, figs. 16-23.

The specimens from the Belden formation resemble the holotype and paratypes from the Kearny formation of Kansas somewhat closely in general shape. However, they differ from them especially in that they are narrower for corresponding volutions, have a slightly larger form ratio for corresponding volutions, a smaller proloculum, and more tightly coiled shell. Although they probably represent an undescribed species, a sufficient number of well-oriented sections have not been obtained to feel reasonably sure that internal features are thoroughly understood. The accompanying statistical data were obtained from specimens from the lower 10 feet of Bed 1, Section P-9, Sheep Mountain Canyon, Belden formation.

Measurements of Millerella cf. M. pressa Thompson, Specimens A-C, in millimeters

Volution	Height of volution			Form ratio of volution		Septal count	Tunnel angle (degrees)	
	A	B	C	A	B	C	A	B
0	.024	.024	.020	——	——	—	—	—
1	.016	.014	.010	1:0.53	1:0.70	—	—	—
2	.016	.022	.021	1:0.50	1:0.62	—	—	—
3	.016	.040	.032	1:0.55	1:0.50	14	—	—
4	.040	.050	.040	1:0.48	1:0.49	17	—	—
5	.061	.066	.077	1:0.46	1:0.44	22	20	22
6	.089	——	——	——	——	—	22	—

Occurrence.—In addition to the Sheep Mountain Canyon locality, specimens almost certainly conspecific with the illustrated thin sections are present in Bed 40, Section P-13, Juniper Mountain Canyon, and Bed 15, Section P-15, Sweetwater Creek, Belden formation.

MILLERELLA sp. A

Plate 1, figures 12-14

Shell minute, discoidal; with short axis of coiling, slightly umbilicate polar regions, essentially straight lateral slopes, sharply angular periphery. Inner volutions essentially involute, fifth volution slightly evolute. Specimens of 5 volutions 0.15-0.16 mm long and 0.40-0.44 mm wide. Form ratio 1:0.37-1:0.40. Proloculum minute, outside diameter about 24 microns. Shell tightly coiled. Heights of first to fifth volution about 10, 20, 30, 50, and 77 microns.

Septa slightly arcuate in center of shell, anterior side convex. Septa

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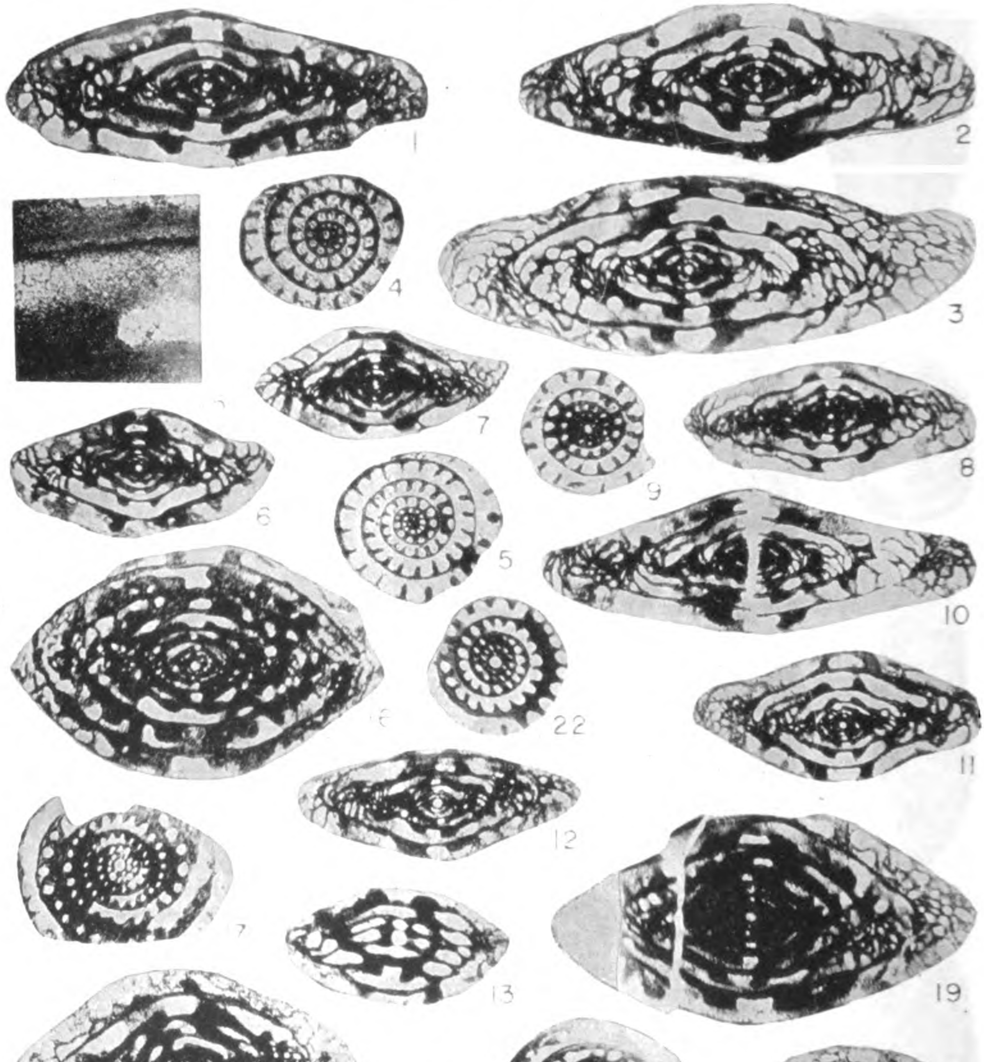
EXPLANATION OF PLATE 1

FIGURE	PAGE
1-7—*Millerella inflecta*, n. sp.	44
1-4, 6, 7, Axial sections; *5*, sagittal section; all x100. *1-6*, From Bed 15, Section P-15, Sweetwater Creek; *7*, from Bed 1, Section P-9, Sheep Mountain Canyon; Belden formation. (*See also* Pl. 5, figs. 2, 3; text fig. 11).	
8-11—*Pseudostaffella* cf. *P. keytei maccoyensis* (Thompson)	49
8, 9, Axial sections; *10*, oblique tangential section; *11*, sagittal section; all x50. *8, 9, 11*, From Bed 34, Section P-17; *10*, from Bed 26, Section P-17; Hell's Canyon, Hell's Canyon formation.	
12-14—*Millerella* sp. A	48
12, Parallel sagittal section; *13*, tangential section; *14*, axial section; all x 100. Bed 37, Section P-15, Sweetwater Creek, Belden formation.	
15-18—*Millerella circuli*, n. sp.	46
15, Tangential section of a paratype; *16*, axial section of a paratype; *17*, axial section of the holotype; *18*, sagittal section of a paratype; all x100. Bed 52, Section P-10, Split Mountain Canyon, Belden formation.	

Thompson, Pennsylvanian Fusulinids



Thompson, Pennsylvanian Fusulinids

highly arcuate anteriorly in polar regions. Over tunnel, septa extend anteriorly at angle of about 20 degrees. Septal count of fourth and fifth volutions about 23.

Remarks.—The sharply angular periphery, flat lateral slopes, and highly arcuate septa distinguish this form from other American species. It is not possible to draw up a detailed description of this form from the small number of well-preserved thin sections so far obtained. It will be described in more detail after more thorough sectioning and study.

Occurrence.—This form is exceedingly abundant in Bed 28 and Bed 37, Section P-15, Belden formation, Sweetwater Creek. The illustrated specimens were obtained from Bed 37.

Genus PSEUDOSTAFFELLA Thompson, 1942

PSEUDOSTAFFELLA cf. P. KEYTEI var. MACCOYENSIS (Thompson)

Plate 1, figures 8-11

Staffella keytei var. *maccoyensis* THOMPSON, *1935,* Jour. Paleontology, vol. 9, pp. 118, 119, pl. 13, figs. 11-15.

Pseudostaffella keytei var. *maccoyensis* THOMPSON, *1942,* Am. Jour. Sci., vol. 240, pp. 408, 410, pl. 1, fig. 24.

Specimens of *Pseudostaffella* are abundant in much of the Hell's Canyon formation. Beds 26 and 34, Section P-17, Hell's Canyon, contain common specimens that resemble somewhat closely *P. keytei* var. *maccoyensis,* originally described from the McCoy formation, near McCoy, Colo. None of my sections is perfectly oriented, but I am illustrating 4 of them and have drawn up the following brief description based on 10 specimens.

Shell minute, subspherical, umbilicate. Orientation of axis changes markedly with development of shell. Axis of first volution normal to that of outer volutions in some specimens. Specimens of 4 to 4½ volutions 0.32-0.34 mm long, 0.36-0.45 mm wide. Form ratio 1:0.7-1:0.9. Form ratios of first to fourth volution about 1:0.8, 1:1.1, 1:1.0, and 1:0.9, respectively.

EXPLANATION OF PLATE 2

FIGURE PAGE

1-5—*Fusulinella haywardi*, n. sp. 54

1, 3, Axial sections of paratypes; *2,* axial section of the holotype; *4, 5,* sagittal sections of paratypes; all x20. Bed 87, Section P-13, Juniper Mountain Canyon, Hell's Canyon formation. Bed 87, Section P-13 is same as Bed 123, Section P-13, due to repetition by thrust faulting. (*See also* Pl. 3, figs 1-5)

6-14—*Fusulinella lounsberyi*, n. sp. 53

6-8, 12, Axial sections of paratypes; *10,* axial section of an unusually long specimen; *11,* axial section of the holotype; *9, 14,* sagittal sections of paratypes; *13,* tangential section of a paratype; all x20. *6-9,* From Bed 112, Section P-13; *10-14,* from Bed 77, Section P-13; Juniper Mountain Canyon, Hell's Canyon formation. Bed 77 is same as Bed 112 due to repetition by thrust faulting.

15-25—*Fusulinella iowensis* var. *leyi*, n. var. 50

15, Enlarged portion of axial section of a paratype; *16, 18, 23-25,* axial sections of paratypes; *17, 20, 22,* sagittal sections of paratypes; *19,* axial section of the holotype; *21,* tangential section of a paratype; all x20, except *15* which is x100. *15-21,* From Bed 71; *22-25,* from Bed 70, Section P-13; Juniper Mountain Canyon, Hell's Canyon formation. (*See also* Pl. 3, figs. 16-21; Pl. 5, fig. 6).

Proloculum minute, outside diameter 44-65 microns, averaging 56 microns for 4 specimens. Average heights of first to fourth volution of 4 specimens 24, 31, 44, and 65 microns, respectively.

Spirotheca thin, composed of tectum and upper and lower tectoria. Septa of essentially same structure as spirotheca. Septa unfluted throughout length of shell. Septal counts of first to third volution about 6, 8, and 11, respectively.

Tunnel narrow and high. Tunnel angles of third and fourth volutions about 19 and 20 degrees, respectively. Chomata massive, with steep tunnel sides and low poleward slopes.

Remarks.—The type specimens of this variety are more tightly coiled for corresponding volutions, and have a larger number of volutions at maturity than any specimens so far discovered at Hell's Canyon.

Occurrence.—This form is abundant in parts of the type section of the Hell's Canyon formation and at about the same horizons at Juniper Mountain Canyon. The above description is based entirely on specimens from Hell's Canyon.

Genus FUSULINELLA Möller, 1877

FUSULINELLA IOWENSIS var. LEYI, n. var.

Plate 2, figures 15-25; plate 3, figures 16-21; plate 5, figure 6

Shell small, highly inflated fusiform, straight axis of coiling, steep lateral slopes, sharply pointed poles. Mature specimens of 7 to 8 volutions 2.5-3.4 mm long and 1.5-1.9 mm wide; form ratio 1:1.5-1:1.8, averaging 1:1.6 for 4 specimens. Inner one or two volutions essentially spherical and axis of coiling in some specimens at angles up to 90 degrees to axes of outer volutions. Average form ratios of first to eighth volution of 4 specimens 1:1.0, 1:1.2, 1:1.4, 1:1.5, 1:1.5, 1:1.6, 1:1.6, and 1:1.6, respectively. Thus mature shape of shell attained in fourth to sixth volution.

Proloculum spherical in shape, minute in size in specimens with asymmetrical first volution, small in other specimens. Outside diameter 69-121 microns, averaging 92 microns for 9 specimens. Average heights of first to eighth volution of 6 specimens 33, 44, 59, 79, 108, 138, 169, and 198 microns, respectively. Thus shell expands gradually.

Spirotheca composed of tectum, diaphanotheca, and upper and lower tectoria. Total thicknesses of spirotheca of third to eighth volution of 4 specimens averages about 5, 11, 13, 18, 20, and 24 microns, respectively. Diaphanotheca of essentially uniform thickness in central half of shell but decreases in thickness rapidly in end zones. Tectoria of essentially same thickness throughout length of shell.

Septa composed of tectum and diaphanotheca deflected downward from spirotheca. However, diaphanotheca thins rapidly below top of septa. Average septal counts of first to eighth volution of 2 specimens 12, 15, 19, 22, 26, 27, 32, and 34, respectively. Septal count of innermost asymmetrical volution about 8. Septa straight to broadly wavy in central fourth of shell, fluting forms closed chamberlets in end fourths of shell, septa broadly fluted in remainder of shell.

Tunnel relatively narrow, slightly more than half as high as chambers, path highly irregular. Average tunnel angles of fourth to eighth volution of 4 specimens 15, 16, 16, 18, and 24 degrees, respectively. Chomata massive and broad, about two-thirds as high as chambers. Slope on tunnel side steep, poleward slope low. Chomata reach from tunnel to poles in inner 5 volutions but more nearly symmetrical in outer volutions.

Remarks.—This variety may be distinguished from the typical variety, ***Fusulinella iowensis*** **var.** ***iowensis*** Thompson, from the lower part of the type Desmoinesian of Iowa by its more elongate shell, more highly fluted septa, more massive chomata in the inner volutions, and more highly inflated and higher chambers in the outer volutions. From *F. iowensis* var. *stouti* Thompson from the Mercer limestone of Ohio it can be distinguished by its slightly larger form ratio, more massive chomata, slightly larger size, and more highly fluted septa.

This form is named in honor of Mr. Henry Ley.

Measurements of Fusulinella iowensis var. leyi, n. var., Specimens A-K, in millimeters

Volution	Height of volution A	B	C	D	E	F	G	H	I	J	K
0	.081	.097	.097	.069	—	.081	—	.121	.113	.085	.089
1	.026	.036	.036	.032	—	.036	.040	.040	.040	.040	.040
2	.045	.045	.048	.036	.048	.045	.042	.072	.052	.062	.054
3	.054	.072	.073	.045	.054	.054	.077	.081	.085	.081	.090
4	.081	.090	.105	.062	.072	.063	.108	.108	.109	.108	.126
5	.108	.108	.137	.099	.108	.090	.108	.144	.101	.135	.135
6	.117	.144	.173	.126	.144	.126	.180	.198	.161	.180	.189
7	.171	.180	.181	.180	.162	.144	—	—	—	.153	—
8	.234	—	—	.198	.162	.198	—	—	—	—	—

Volution	Form ratio of volution A	B	D	F	H	J	K	Wall thickness A	B	D	E
1	1:1.1	1:1.3	1:1.0	1:1.2	1:1.2	1:1.5	1:1.3	—	—	—	—
2	1:1.2	1:1.4	1:1.1	1:1.4	1:1.4	1:1.6	1:1.5	—	—	—	—
3	1:1.4	1:1.4	1:1.2	1:1.5	1:1.5	1:1.6	1:1.7	.005	—	—	—
4	1:1.4	1:1.5	1:1.4	1:1.5	1:1.8	1:1.6	1:1.8	.008	—	.014	.012
5	1:1.4	1:1.5	1:1.5	1:1.5	1:1.9	1:1.8	1:1.7	.012	.014	.016	.012
6	1:1.4	1:1.6	1:1.6	1:1.6	1:1.9	1:1.6	1:1.7	.016	.020	.020	.016
7	1:1.4	1:1.7	1:1.7	1:1.6	—	1:1.6	—	.020	.016	.024	.020
8	1:1.5	—	1:1.8	1:1.5	—	—	—	.024	—	.024	.024

Volution	Septal count C	D	E	G	I	Tunnel angle (degrees) A	B	D	F	H	J
1	11	8	13	9	11	—	—	—	—	—	—
2	15	—	15	13	19	—	—	—		—	—
3	20	—	18	18	19	—	—	—	—	18	—
4	21	—	22	24	24	16	12	17	—	18	18
5	27	—	24	24	26	17	16	15	14	22	18
6	30	—	23	30	30	16	15	21	14	23	16
7	34	—	30	—	—	20	16	21	15	—	19
8	36	—	30	—	—	25	—	30	17	—	—

Specimens A-F are from Bed 26, Section P-17, Hell's Canyon, and G-K are from Bed 71, Section P-13, Juniper Mountain Canyon.

Occurrence.—This variety is abundant in Bed 26, Section P-17, Hell's Canyon, and Beds 70 and 71, Section P-13, Juniper Mountain Canyon, lower Hell's Canyon formation. At Hell's Canyon it is associated with *Pseudostaffella* sp. and *Millerella* sp.

FUSULINELLA UINTAENSIS, n. sp.

Plate 3, figures 6-15

Shell small, inflated fusiform; with straight axis of coiling, bluntly to sharply pointed poles, convex lateral slopes. Mature specimens of 6 to 7½ volutions 0.9-1.8 mm long, 0.6-0.9 mm wide. Form ratio 1:1.5-1:2.0, averaging 1:1.8 for 4 specimens. Form ratio of holotype 1:2.0. In some mature specimens, including holotype, first volution tightly coiled with form ratio 1:0.6-1.0.8. Form ratios of first to seventh volution of holotype 1:0.6, 1:0.9, 1:1.2, 1:1.5, 1:2.0, 1:2.0, respectively Thus mature shape of shell reached in about fifth volution.

Proloculum minute in specimens with tightly coiled first volution, small in others. Outside diameter 32-61 microns, averaging 45 microns in 8 specimens. Average heights of first to seventh volution of 6 specimens 20, 30, 38, 59, 74, 98, and 121 microns, respectively. However, corresponding volutions of holotype slightly lower than above figures.

Spirotheca composed of tectum, diaphanotheca, and upper and lower tectoria. Diaphanotheca first recognizable in second and third volutions. Average combined thicknesses of tectum and diaphanotheca in fourth to eighth volution in 4 specimens 8, 10, 12, 15, and 20 microns, respectively. Tectoria of essentially uniform thickness throughout length of shell.

Septa thin, composed of downward deflection of spirotheca. Diaphanotheca thins rapidly below top of septa. Average septal counts of first to seventh volution of 4 specimens 7, 11, 13, 15, 19, 22, and 24, respectively. Septa narrowly fluted in end thirds of shell so as to form closed chamberlets at base of chambers. Lower margins of septa broadly fluted across central part of shell.

Tunnel about two-thirds as high as chambers, relatively narrow. Average tunnel angles of third to seventh volution of 4 specimens 14, 15, 15, 17, and 20 degrees, respectively. Chomata well developed throughout all parts of shell, except outermost chambers. Tunnel sides of chomata vertical to overhanging. Chomata broad in inner volutions, with low slopes on poleward sides; asymmetrical and relatively narrow in outer volution.

Remarks.—This species is intermediate in development between *Fusulinella* and *Fusulina* and I refer it somewhat arbitrarily to *Fusulinella*. It can be distinguished from *F. haywardi*, n. sp., especially in that it is smaller at maturity, has a more inflated shell, smaller tunnel angle, and slightly more highly fluted septa. From *F. lounsberyi*, n sp., it can be distinguished by its more highly inflated shell, more massive and wider chomata, and more highly fluted septa.

Occurrence.—*Fusulinella uintaensis* is abundant in Bed 34, Section P-17, Hell's Canyon, Hell's Canyon formation. It is associated with common specimens of *Pseudostaffella* sp. and *Eoschubertella* sp. and abundant specimens of *Millerella* sp.

Measurements of Fusulinella uintaensis, n. sp., Specimens A-H, in millimeters

Volution	Height of volution C	D	E	F	G	H	Form ratio of volution E	F	G	H
0	.061	.044	.032	.048	.032	.048	—	—	—	—
1	.024	—	.012	.024	—	.020	1:0.6	1:0.6	—	1:0.8
2	.028	.032	.026	.032	.032	.028	1:0.9	1:1.0	—	1:1.4
3	.044	.032	.032	.040	.044	.036	1:1.2	1:1.2	1:1.4	1:1.7
4	.061	.081	.040	.053	.061	.057	1:1.5	1:1.5	1:1.7	1:1.6
5	.073	.093	.053	.069	.073	.081	1:2.0	1:1.5	1:1.6	1:1.9
6	.093	.121	.085	.081	.093	.113	1:2.0	1:1.5	1:1.6	—
7	.129	.127	.093	—	—	.133	1:2.0	—	—	—
8	—	—	.109	—	—	—	—	—	—	—

Volution	Wall thickness (Tectum + diaphanotheca) A	B	C	D	E	G	H	Septal count A	B	C	D	Tunnel angle (degrees) E	F	G	H
1	—	—	—	—	—	—	—	7	7	7	—	—	—	—	—
2	—	—	—	—	—	—	—	11	10	11	11	—	—	—	—
3	.007	.006	—	—	—	—	—	13	14	14	13	—	—	—	14
4	.010	.008	—	—	—	—	—	15	15	16	15	—	—	—	15
5	.012	.012	.012	.008	.012	.010	.010	20	20	20	17	17	14	12	15
6	.016	.016	.016	.010	.012	.012	.012	25	23	23	19	20	15	14	19
7	.016	—	—	.013	.016	—	.016	27	—	—	21	20	—	—	—
8	—	—	—	—	.020	—	—	—	—	—	—	—	—	—	—

Fusulinella lounsberyi, n. sp.

Plate 2, figures 6-14

Shell minute, inflated fusiform; with straight axis of coiling, pointed poles, slightly concave to convex lateral slopes. Mature specimens of 5 to 6½ volutions about 1.6-2.1 mm long and 0.8-0.9 mm wide, form ratio 1:2.0-1:2.3. First volution essentially spherical. Mature shape of shell first reached in about fourth volution. Average form ratios of first to sixth volution of 5 specimens 1:1.1, 1:1.4, 1:1.8, 1:2.1, 1:2.2, and 1:2.3, respectively.

Proloculum small, outside diameter 48-84 microns, averaging 70 microns for 6 specimens. Shell expands uniformly to fifth volution and more slowly in outer 2 volutions. Average heights of first to seventh volution of 6 specimens 27, 34, 52, 79, 116, 126, and 117 microns, respectively.

Septa thin, numerous. Average septal counts of first to sixth volution of 3 specimens 10, 12, 14, 17, 18, and 19, respectively. Septa straight across central part of shell, broadly wavy in lower margins of extreme polar regions.

Spirotheca thin, composed of tectum, thin diaphanotheca, upper and lower tectoria. Average thicknesses of spirotheca in first to sixth volution of 6 specimens 8, 10, 17, 20, 26, and 30 microns, respectively. However, measurements not consistent for same volution of different specimens or in different parts of chamber in same specimen, due largely to variations of thickness of tectoria across top of chamber. Therefore, above measurements indicate only that spirotheca are thin and increase in thickness with growth of individual.

Tunnel about half as high as chambers, path straight from second volution to maturity. Average tunnel angles of third to sixth volution in 5 specimens 20, 23, 28, and 32 degrees, respectively. Chomata narrow, more than half as high as chambers; tunnel side vertical to overhanging in outer 3 or 4 volutions. Chomata broad, asymmetrical, with low slopes on poleward sides in inner volutions.

Measurements of Fusulinella lounsberyi, n. sp., Specimens A-H, in millimeters

Volution	Height of volution						Form ratio of volution				
	A	B	C	D	E	F	B	C	D	E	F
0	.084	.084	.048	.064	.057	.081	——	——	——	——	——
1	.028	.032	.024	.024	.024	.028	1:1.7	1:0.8	1:1.0	1:1.0	1:1.9
2	.044	.036	.030	.032	.032	.032	1:2.0	1:1.3	1:1.3	1:1.3	1:1.2
3	.064	.065	.034	.061	.048	.040	1:2.4	1:1.8	1:1.8	1:1.4	1:1.5
4	.081	.101	.060	.085	.065	.081	1:2.5	1:2.3	1:2.1	1:1.9	1:1.7
5	.133	.125	.089	.125	.109	.113	——	1:2.6	1:2.3	1:2.3	1:1.7
6	——	——	.110	——	.141	——	——	1:2.6	——	1:2.2	1:2.1
7	——	——	.117	——	——	——	——	——	——	——	——

Volution	Wall thickness					Septal count			Tunnel angle (degrees)				
	A	B	C	E	F	A	G	H	B	C	D	E	F
1	.008	——	——	——	——	8	11	11	—	—	—	—	—
2	.012	——	——	——	.008	12	12	13	—	—	—	—	—
3	.020	.024	——	.008	.016	12	14	15	20	—	30	17	13
4	.024	.028	.012	.016	.020	16	18	16	24	20	32	21	13
5	.024	.032	.024	.020	.028	16	18	18	30	21	34	25	29
6	——	——	.036	.024	——	—	—	19	—	34	—	34	31

Remarks.—The unfluted septa and nature of the chomata of this form suggest a relationship to the primitive species of *Wedekindellina*, *W. matura*, n. sp., from the lower part of the Youghall formation. A species closely similar to *Fusulinella lounsberyi* may be ancestral to *Wedekindellina*.

This form is not closely similar to any previously described American species. Superficially it resembles *F. llanoensis* (Thomas) from the "Marble Falls" limestone of Texas. However, it is smaller in size, its septa are not as closely fluted, and the development of its tectoria are different. The resemblance of these two forms is believed to be one of general outline and does not necessarily indicate close biological affinities.

This species is named in honor of Mr. D. E. Lounsbery.

Occurrence.—This form is exceedingly abundant in Bed 112, Section P-13, Juniper Mountain Canyon, and in Bed 77 of same section (Bed 77 is same as Bed 112, due to repetition by thrust faulting).

FUSULINELLA HAYWARDI, n. sp.

Plate 2, figures 1-5; plate 3, figures 1-5

Shell small, elongate fusiform, straight axis of coiling, straight to slightly convex lateral slopes. Mature specimens of 5 to 6 volutions 2.6-3.1 mm long, 0.9-1.3 mm wide. Form ratio 1:2.8-1:3.2, averaging 1:3.0 for 3 specimens. Shell elongate throughout growth of most specimens. Average form ratios of first to fifth volution of 5 specimens 1:1.8, 1:2.1, 1:2.5, 1:2.8, and 1:2.8, respectively. In most specimens all volutions symmetrical. In some specimens first volution coiled at large angle to outer volutions and has form ratio of about 1:1. However, mature size of shell about same in both types.

Proloculum small, outside diameter 80-97 microns, averaging 85 microns in 7 specimens. Shell expands uniformly with growth. Average heights of first to sixth volution for 8 specimens 37, 55, 84, 124, 161, and 212 microns, respectively.

Spirotheca thin, composed of thin upper and lower tectoria, tectum, and relatively thick diaphanotheca. Diaphanotheca first observed plainly at end of second volution, well developed and thick from near end of fourth volution to maturity. Average thicknesses of spirotheca in first to sixth volution of 7 specimens 8, 14, 18, 22, 24, and 28 microns, respectively.

Septa thin. Diaphanotheca thins rapidly downward from top of septa. Average of septal counts of first to sixth volution of 3 specimens 8, 12, 14, 17, 20, and 22, respectively. Septa straight across central third of shell, broadly but highly fluted in end quarters. Fluting extends to tops of chambers in polar regions.

Tunnel high, elliptical in cross-section. Chomata well developed throughout all except outer few chambers. Tunnel sides of chomata vertical to overhanging, poleward slopes low in inner volutions and steeper in outer volutions. Average tunnel angles of second to sixth volution of 4 specimens 21, 28, 33, 40, and 62 degrees, respectively.

Measurements of Fusulinella haywardi, n. sp., Specimens A-H, in millimeters

Volution	Height of volution A	B	C	D	E	F	G	H	Form ratio of volution D	E	F	G	H
0	.085	——	.081	.085	.085	.081	.080	.097	——	——	——	——	——
1	.040	.036	.036	.040	.040	.036	.032	.036	1:2.4	1:1.6	1:1.4	1:2.0	1:1.6
2	.065	.053	.057	.061	.048	.053	.048	.053	1:2.5	1:1.9	1:1.8	1:2.0	1:2.1
3	.093	.081	.080	.093	.080	.080	.080	.084	1:3.0	1:2.3	1:2.0	1:2.3	1:2.8
4	.141	.121	.117	.137	.113	.121	.121	.121	1:3.1	1:3.1	1:2.5	1:2.5	1:2.8
5	.166	.161	.161	.170	.174	.150	.161	.145	——	1:2.9	1:2.8	1:2.5	1:3.2
6	——	——	.222	——	——	——	——	——	——	——	——	——	——

Volution	Wall thickness A	B	C	D	E	F	G	Septal count A	B	C	Tunnel angle (degrees) D	E	F	H
1	.008	——	——	——	——	——	——	9	8	8	—	—	—	—
2	.012	.008	.016	——	——	.016	.016	12	11	12	23	20	20	19
3	.016	.018	.016	——	.020	.018	——	13	14	14	29	24	25	27
4	.020	.016	.024	.020	.032	.020	.024	18	17	16	35	31	33	33
5	.024	.016	.028	.032	.032	.016	.023	20	20	19	40	31	41	47
6	——	——	.028	——	——	——	——	—	—	—	—	—	—	62

Remarks.—This form is larger at maturity, has a larger tunnel angle, smaller form ratio, and more highly fluted septa than *Fusulinella lounsberyi*, n. sp. It is more highly elongate and therefore less highly inflated, has a larger tunnel angle, thicker diaphanotheca, and less well developed tectoria than *F. llanoensis* (Thomas).

This species is named in honor of Mr. O. T. Hayward who assisted me with the field work on which this report is largely based.

Occurrence.—This form is exceedingly abundant in Bed 87, Section P-13, Juniper Mountain Canyon, and in Bed 123 of the same section (Bed 123 is same as Bed 87 due to repetition by overthrusting).

Genus Wedekindellina Dunbar and Henbest, 1933

Wedekindellina matura, n. sp.

Plate 4, figures 1-12; plate 5, figure 5

Shell small, fusiform; with sharply pointed poles, straight axis of coiling, uniform lateral slopes. Mature specimens of 6 to 7½ volutions 2.2-3.0 mm long and 0.8-1.3 mm wide. Form ratio 1:2.2-1:2.4, averaging about 1:2.3 for 3 typical specimens. Form ratios of first to sixth volution of holotype 1:2.0, 1:2.5, 1:2.7, 1:2.7, 1:2.7, and 1:2.7, respectively. Thus shell of essentially uniform shape for outer 4 volutions. Form ratio of first volution essentially of unit value in many individuals.

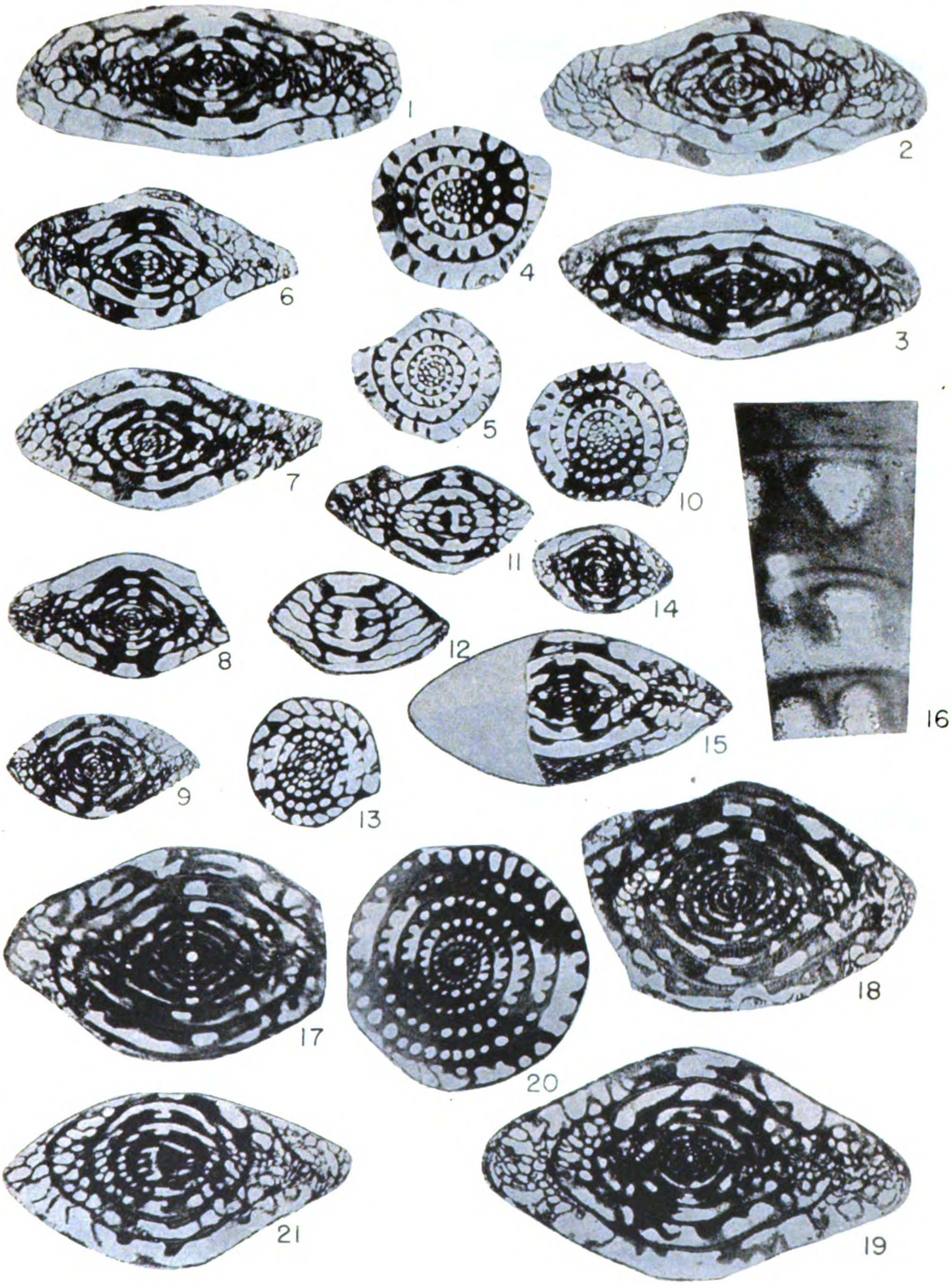
Proloculum small, outside diameter 65 to 101 microns, averaging 81 microns for 8 specimens. Shell expands uniformly, average heights of first to eighth volution of 8 specimens 29, 44, 56, 73, 92, 120, 146, and 181 microns, respectively.

Spirotheca composed of tectum, diaphanotheca, and upper and lower tectoria. Diaphanotheca relatively thick. Total thickness of spirotheca in second to sixth volution of 2 specimens averages about 10, 22, 30, 36, and 36 microns, respectively. Tectoria of essentially same thickness throughout length of shell but diaphanotheca thickest in central half of shell.

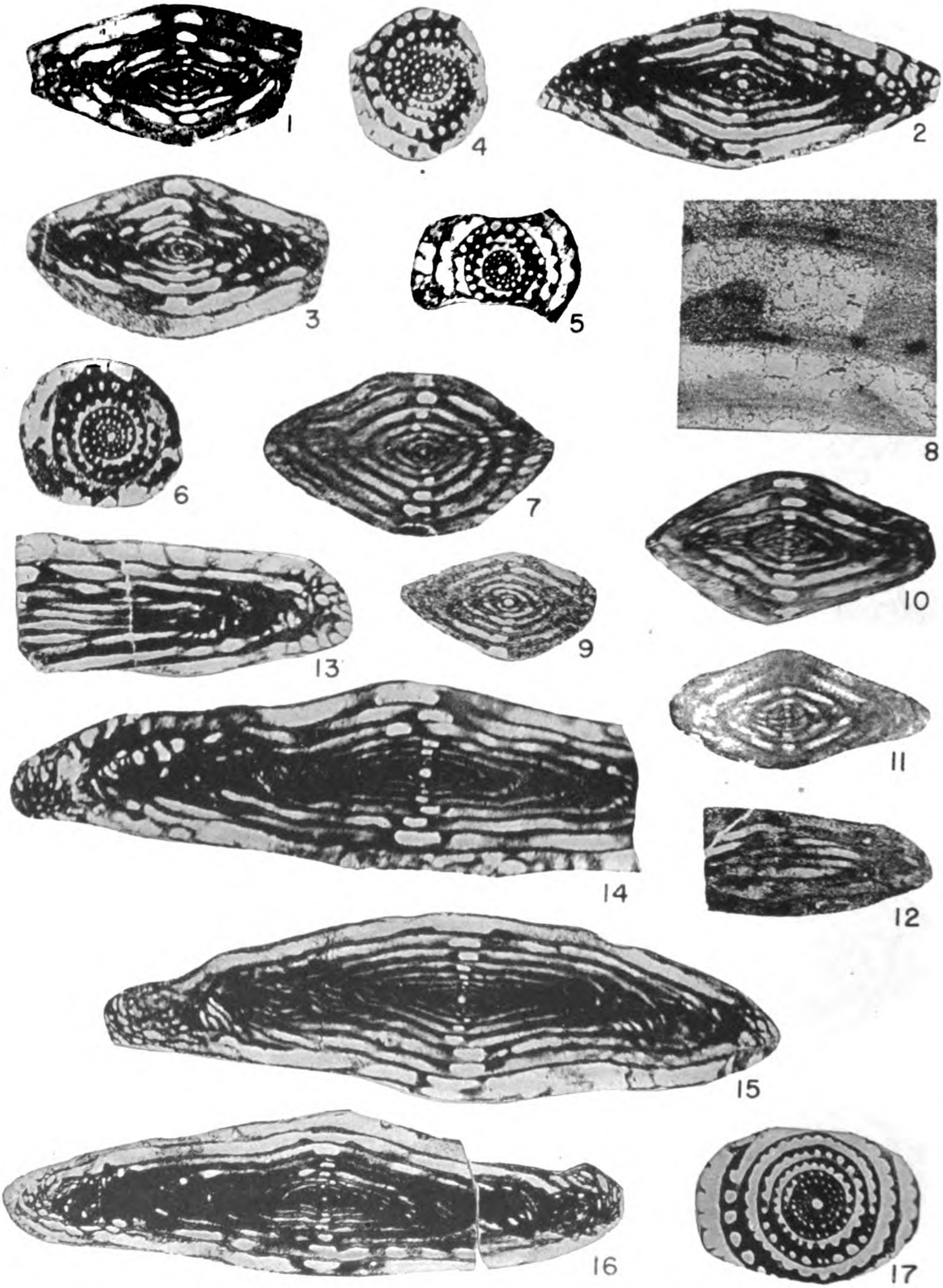
Septa thin, numerous, unfluted throughout length of shell. Average septal counts of first to seventh volution of 4 specimens 9, 13, 17, 20, 21, 26, and 30, respectively. Structure of septa essentially same as that of spirotheca, but diaphanotheca thins rapidly below top of septa.

EXPLANATION OF PLATE 3

FIGURE		PAGE
1-5—*Fusulinella haywardi*, n. sp.	*1-3*, Axial sections of paratypes; *4*, *5*, sagittal sections of paratypes; all x20. Bed 123, Section P-13, Juniper Mountain Canyon, Hell's Canyon formation. Bed 123 is same as Bed 87 due to repetition by thrust faulting. (*See also* Pl. 2, figs. 1-5)	54
6-15—*Fusulinella uintaensis*, n. sp.	*6*, *7*, *9*, *14*, Axial sections of paratypes; *8*, axial section of the holotype; *10*, sagittal section of a paratype; *11*, *12*, tangential sections of paratypes; *13*, sagittal section of a specimen referred with question to this species; *15*, axial section of a specimen referred with question to this species; all x20. From Bed 34, Section P-17, Hell's Canyon, Hell's Canyon formation.	52
16-21—*Fusulinella iowensis* var. *leyi*, n. var.	*16*, Enlarged portion of a sagittal section of a paratype; *17*, *18*, axial sections of paratypes; *19*, axial section of a paratype with asymmetrical first volution; *20*, sagittal section of a paratype; *21*, tangential section of a paratype; all x20, except *16*, which is x100. Bed 26, Section P-17, Hell's Canyon, Hell's Canyon formation. (*See also* Pl. 2, figs 15-25; Pl. 5, fig. 6)	50



Thompson, Pennsylvanian Fusulinids



Thompson, Pennsylvanian Fusulinids

Tunnel slightly more than half as high as chambers, elliptical in cross section, path irregular. Chomata high, asymmetrical; with vertical side adjacent to tunnel and low poleward slope. Axial fillings developed in extreme polar regions and extend toward tunnel with rapidly decreasing thickness. Tunnel angles of third to seventh volution of holotype 22, 22, 21, 25, and 27 degrees, respectively. Average tunnel angles of second to seventh volution for 3 specimens 22, 22, 21, 23, 25, and 26 degrees, respectively.

Remarks.—The small size, large form ratio, and light axial fillings suggest that this form is primitive biologically. Although it does not closely resemble any previously described American species, the unfluted septa,

Measurements of Wedekindellina matura, n. sp., Specimens A-H, in millimeters

Volution	Height of volution A	B	C	D	E	F	G	H
0	.101	.085	.093	.089	.085	.085	.065	.089
1	.036	.036	.028	.028	.024	.036	.024	.024
2	.057	.053	.040	.048	.036	.048	.032	.036
3	.073	.061	.061	.057	.044	.053	.048	.048
4	.101	.081	.061	.081	.065	.061	.061	.073
5	.121	.121	.081	.081	.065	.081	.101	.089
6	.141	.141	.133	.129	.081	.121	.121	.089
7	.161	——	.149	.160	.137	——	.149	.117
8	——	——	——	——	.181	——	——	——

Volution	Form ratio of volution A	G	Septal count C	D	E	H	Tunnel angle (degrees) A	B	G
1	1:2.0	1:1.2	10	9	8	9	—	—	—
2	1:2.5	1:2.1	13	13	13	13	24	20	—
3	1:2.7	1:2.5	17	16	15	17	20	24	22
4	1:2.7	1:2.4	24	20	16	20	23	19	22
5	1:2.7	1:2.4	24	20	17	23	27	23	21
6	1:2.7	1:2.3	22	23	22	28	28	23	25
7	——	——	—	—	—	30	—	24	27

Specimens A-D are from Bed 44, Section P-9, Sheep Mountain Canyon, and E-H are from Bed 90, Section P-17, Hell's Canyon.

EXPLANATION OF PLATE 4

FIGURE		PAGE
1-12—*Wedekindellina matura*, n. sp.		56
13-17—*Wedekindellina henbesti* (Skinner)		58

1-12: *1, 3, 9*, Axial sections of paratypes; *2*, axial section of the holotype; *4-6*, sagittal sections of paratypes; *7*, oblique section of a paratype; *8*, enlarged portion sagittal section illustrated as *3* that shows structure of spirotheca; *10-12*, tangential sections; all x20, except *8*, which is x100. *1, 5, 7, 9-12*, From Bed 90, Section P-17, Hell's Canyon; *2-4, 6, 8*, from Bed 44, Section P-9, Sheep Mountain Canyon; Youghall formation. (*See also* Pl. 5, fig. 5).

13-17: *13*, Tangential section; *14-16*, axial sections; *17*, sagittal section; all x20. Bed 48, Section P-9, Sheep Mountain Canyon, Youghall formation.

axial fillings, and fusulinellid-type spirothecal structure show clearly that it is referable to *Wedekindellina*. No other fusulinid was found associated with this form in the Uinta Mountains. However, a primitive species of *Fusulina, F. prima*, n. sp., occurs only a few feet below it in the Hell's Canyon section.

Occurrence.—This species is exceedingly abundant in Bed 90, Section P-17, Hell's Canyon, and in Bed 44, Section P-9, Sheep Mountain Canyon, lower Youghall formation.

WEDEKINDELLINA HENBESTI (Skinner)

Plate 4, figures 13-17

Wedekindia henbesti SKINNER, *1931*, Jour. Paleontology, vol. 5, p. 259, pl. 30, figs. 2, 3.

Wedekindellina henbesti THOMPSON, *1934*, Univ. Iowa, Studies Nat. History, vol. 16, p. 279.—DUNBAR AND HENBEST, *1942*, Illinois Geol. Survey, Bull. 67, pp. 99, 186, pl. 9, figs. 5-8.

Shell small, highly elongate fusiform, slightly irregular axis of coiling, concave to irregular lateral slopes. Mature specimens of 8½ to 9½ volutions 4.3-5.8 mm long and 1.0-1.8 mm wide, form ratio 1:3.8-1:4.1. Average form ratios of first to ninth volution for 3 specimens 1:2.0, 1:2.6, 1:3.5, 1:4.0, 1:4.3, 1:4.3, 1:4.3, 1:4.0, and 1:4.0, respectively. Thus form ratio decreases rapidly to fourth or fifth volution but remains essentially same value from there to maturity.

Proloculum small, spherical to ellipsoidal, outside diameter 65-121 microns, averaging 83 microns for 4 specimens. Shell expands slowly and uniformly. Heights of volutions about same throughout length of shell. Average heights of chambers of first to ninth volution of 3 specimens 24, 25, 33, 42, 61, 88, 94, 125, and 143 microns, respectively.

Spirotheca thin, contains 4 layers—tectum, diaphanotheca, and upper and lower tectoria. Average thicknesses of spirotheca of fifth to ninth volution in

Measurements of Wedekindellina henbesti (Skinner), Specimens A-D, in millimeters

Volution	Height of volution A	B	C	D	Form ratio of volution A	B	C	Septal count D	Tunnel angle (degrees) A	B	C
0	.081	.121	.065	.101	——	——	——	—	—	—	—
1	.028	.024	.020	.024	1:1.2	1:2.9	——	11	—	—	—
2	.024	.024	.020	.032	1:1.9	1:4.0	1:1.8	16	—	—	—
3	.028	.040	.028	.036	1:4.0	1:4.1	1:2.3	18	—	22	—
4	.040	.048	.032	.048	1:3.8	1:5.0	1:3.1	21	13	28	24
5	.060	.069	.053	.060	1:4.2	1:5.1	1:3.6	24	18	30	23
6	.081	.084	.065	.100	1:4.1	1:4.5	1:4.2	29	21	24	25
7	.093	.101	.081	.100	1:4.1	1:4.6	1:4.2	28	25	31	21
8	.121	.149	.109	.121	1:4.1	1:4.0	1:4.0	30	24	43	31
9	.141	.182	.109	.141	1:4.0	——	——	—	30	—	31
10	——	——	——	——	——	——	——	—	40	—	—

4 specimens 24, 28, 29, 32, and 28 microns, respectively. Diaphanotheca relatively thin but tectoria thick. Although shell of this form is larger than that of *Wedekindellina matura*, n. sp., diaphanotheca considerably thinner.

Septa thin and composed of same layers as spirotheca, unfluted throughout length of shell. Septal counts of first to ninth volution of one specimen 11, 16, 18, 21, 21, 24, 29, 28, and 30, respectively. Although septa are not fluted, broad undulations are developed in extreme polar regions of outer volutions.

Tunnel about three-fourths as high as chambers, path irregular, cross section elliptical. Averages of tunnel angles of third to tenth volution for 3 specimens 22, 22, 24, 23, 26, 33, 31, and 40 degrees, respectively. Chomata developed throughout shell except in outermost chambers, highly asymmetrical with steep slopes adjacent to tunnel and low slopes on poleward side. Axial fillings well developed throughout all of shell except in outermost volution.

Remarks.—The specimens of this species from the Uinta Mountains are closely similar in size for corresponding volutions, tunnel angles, size of proloculum, development of axial fillings, shape of shell, and other statistical data to the holotype and paratypes from Oklahoma. However, the Oklahoma types contain about one more volution at maturity than the largest specimens here described and illustrated.

Wedekindellina henbesti differs from *W. euthysepta* (Henbest) especially in that it is larger for corresponding volutions, has lighter axial fillings, more irregular axis of coiling, and more irregular lateral slopes. It is more highly elongate and narrower for corresponding volutions, has thinner axial fillings and wider tunnel angle than *W. excentrica* (Roth and Skinner). This form resembles *W. coloradoensis* (Roth and Skinner) closely, but the type specimens of the latter seem to be shorter, have a larger form ratio, and are slightly smaller for corresponding volutions.

Occurrence.—Specimens of this form are abundant in Bed 48, Section P-9, Sheep Mountain Canyon, lower Youghall formation, associated with abundant specimens of *Fusulina rockymontana* (Roth and Skinner).

Genus FUSULINA Fischer-de-Waldheim, 1829

FUSULINA PRIMA, n. sp.

Plate 6, figures 32-38

Shell minute, inflated fusiform; with irregular to curving axis of coiling, convex, concave to irregular lateral slopes, and bluntly pointed poles. Mature specimens of 5 to 6 volutions 2.1-3.2 mm long, 0.9-1.4 mm wide. Form ratio 1:2.2-1:2.6, averaging 1:2.4 for 4 specimens. First volution essentially spherical with large form ratio. Mature shape of shell first attained in third to fourth volution. Average form ratios of first to fifth volution of 4 specimens 1:1.2, 1:1.5, 1:1.9, 1:2.2, and 1:2.3, respectively.

Proloculum minute, outside diameter averages 88 microns in 6 specimens. Shell expands relatively rapidly and uniformly. Average heights of first to sixth volution of 6 specimens 35, 58, 91, 119, 162, and 185 microns, respectively. Chambers of outer volutions become noticeably higher poleward from center of shell.

Spirotheca thin, composed of tectum, thin diaphanotheca, and upper and lower tectoria. Lower part of upper tectorium much less dense than upper part, giving appearance of an upper diaphanotheca. Average combined thickness of tectum and diaphanotheca in fourth volution of 4 specimens 12 microns.

Septa thin, diaphanotheca thins rapidly below top of septa. Septal counts of first to fifth volution of a typical specimen 8, 12, 16, 20, and 26, respectively. Septa highly but broadly fluted in polar regions, broadly fluted in lower margins in central part of shell. Fluting forms closed chamberlets at base of septa from poles to margins of chomata.

Tunnel low, path irregular. Average tunnel angles of third to sixth volution of 4 specimens 22, 24, 28, and 32 degrees, respectively. Chomata third to half as high as chambers, asymmetrical in first 3 to 4 volutions, essentially symmetrical in outer volutions.

Remarks.—This is a primitive species of *Fusulina.* It is not greatly advanced biologically beyond the form from the Hell's Canyon formation described above as *Fusulinella uintaensis,* n. sp. In fact, the septal fluting of these two forms is developed to about the same degree, *Fusulina prima* being only slightly more highly fluted. The manner of development of the chomata, the spirothecal structure, and general development of the shell have largely influenced placing these two forms in different genera.

Occurrence.—This species is abundant in Bed 87, Section P-17, Hell's Canyon, lower Youghall formation.

Measurements of Fusulina prima, n. sp., Specimens A-F, in millimeters

Volution	Height of volution A	B	C	D	E	F	Form ratio of volution A	B	C	D
0	.085	.101	.073	.105	.085	.077	—	—	—	—
1	.032	.028	.032	.040	.040	.040	1:1.2	1:1.2	1:1.4	1:1.2
2	.053	.048	.061	.061	.061	.065	1:1.6	1:1.3	1:1.7	1:1.5
3	.101	.061	.093	.077	.101	.113	1:2.1	1:1.7	1:2.3	1:1.6
4	.121	.101	.125	.089	.141	.141	1:2.4	1:2.2	1:2.4	1:1.8
5	.182	.141	.162	.141	.185	—	1:2.2	1:2.6	1:2.4	1:2.1
6	—	.173	.202	.181	—	—	—	—	—	—

Volution	Wall thickness (Tectum + diaphanotheca) B	C	E	F	Septal count E	F	Tunnel angle (degrees) A	B	C	D
1	—	—	—	—	8	9	—	—	—	—
2	—	—	—	—	12	12	—	—	—	—
3	.008	—	—	—	16	13	22	—	28	17
4	.012	.012	.012	.012	20	18	24	23	26	21
5	.012	.016	—	—	26	—	—	32	28	26
6	—	—	—	—	—	—	—	38	26	33

FUSULINA PRISTINA, n. sp.

Plate 5, figures 7-18

Shell small, inflated fusiform; with straight axis of coiling, convex to straight lateral slopes, sharply pointed poles. Mature specimens of 6 to 7 volutions 2.3-3.2 mm long 1.4-1.9 mm wide. Form ratio 1:1.7-1:1.9. First volution subspherical, mature shape of shell first reached in third to fourth volution. Average form ratios of first to seventh volution of 3 specimens 1:1.3, 1:1.6, 1:1.6, 1:1.7, 1:1.8, 1:1.8, and 1:1.9, respectively.

Proloculum small, outside diameter 77-105 microns, averaging 86 microns in 5 specimens. Shell expands slowly. Average heights of first to seventh volution of 6 specimens 40, 54, 94, 128, 170, 201, and 216 microns, respectively. Heights of chambers essentially same throughout length of shell.

Spirotheca thin, composed of tectum, diaphanotheca, and thick upper and lower tectoria. Average thickness of combined tectum and diaphanotheca in fourth to seventh volution of 5 specimens 17, 20, 22, and 24 microns, respectively.

Septa thin, numerous. Septal counts of first to seventh volution of a typical specimen 11, 14, 15, 20, 23, 27, and 30, respectively. Septa fluted throughout length of shell, fluting forms closed chamberlets in lower part of chambers from poles to edge of tunnel. Septa more strongly fluted in polar regions.

Chomata developed throughout shell, except in outer few chambers, essentially symmetrical in outer volutions, highly asymmetrical in inner 4 to 5 volutions. Average tunnel angles in second to seventh volution of 4 specimens 19, 18, 19, 19, 22, and 20 degrees, respectively.

Measurements of Fusulina pristina, n. sp., Specimens A-F, in millimeters

Volution	Height of volution						Form ratio of volution		
	A	B	C	D	E	F	A	B	D
0	.081	.077	—	.085	.105	.081	—	—	—
1	.036	.044	.045	.040	.040	.032	1:1.1	1:1.3	1:1.5
2	.048	.061	.063	.053	.048	.048	1:1.6	1:1.6	1:1.5
3	.097	.101	.090	.121	.073	.081	1:1.6	1:1.6	1:1.6
4	.109	.129	.144	.161	.105	.121	1:1.7	1:1.7	1:1.7
5	149	.158	.162	.242	.129	.173	1:1.7	1:1.9	1:1.9
6	.190	.178	.180	.282	.173	.202	1:2.0	1:1.7	1:1.7
7	.230	—	—	—	.202	—	1:1.9	—	—

Volution	Wall thickness (Tectum + diaphanotheca)					Septal count		Tunnel angle (degrees)			
	A	B	C	D	E	E	F	A	B	C	D
1	—	—	—	—	—	11	9	—	—	—	—
2	—	—	—	—	—	14	13	—	19	—	—
3	—	—	—	—	—	15	16	26	15	16	15
4	.018	.020	—	.016	.014	20	16	20	17	20	17
5	.020	.020	.020	.020	.020	23	18	22	14	22	19
6	.028	.020	.024	.020	.020	27	26	24	13	22	28
7	—	—	—	—	.024	30	—	20	—	—	—

Remarks.—In size and general shape, this form resembles ***Fusulina pumila*** Thompson from the lower Cherokee of Iowa. However, its septa are not as narrowly and highly fluted and its chomata have different shapes and degree of development. This species also resembles in general shape ***Fusulinella uintaensis***, n. sp., but it is larger at maturity, has more highly fluted septa, and more nearly symmetrical and narrower chomata.

Occurrence.—This form is abundant is Bed 146, Section P-13, Juniper Mountain Canyon, lower Youghall formation.

FUSULINA ROCKYMONTANA Roth and Skinner

Plate 5, figures 19-25

Fusulina rockymontana ROTH AND SKINNER, *1930*, Jour. Paleontology, vol. 4, pp. 344, 345, pl. 31, figs. 4-6.—THOMPSON, *1936*, Jour. Paleontology, vol. 10, p. 109, pl. 16, figs. 10, 11.—DUNBAR AND SKINNER, *1937*, Univ. Texas, Bull. 3701, p. 746, pl. 43, figs. 3, 8.

Specimens here referred to *Fusulina rockymontana* are abundant in the lower part of the Youghall formation along the southeast and northeast margins of the Uinta Mountains. They have been compared directly with topotype specimens from the McCoy formation at McCoy, Colo., and are considered conspecific. Detailed specific descriptions are not deemed necessary but statistical data for the Uinta Mountain specimens are given.

The septal fluting, development of the chomata, and general shape of the shell of *Fusulina rockymontana* are closely similar to those of *F. euryteines*

Measurements of Fusulina rockymontana Roth and Skinner, Specimens A-E, in millimeters

Volution	Height of volution A	B	C	D	E	Form ratio of volution A	B	C
0	.162	.162	.141	.180	.141	——	——	——
1	.054	.057	.041	.057	.044	1:1.7	1:1.6	1:1.4
2	.063	.077	.057	.085	.061	1:2.1	1:1.8	1:2.0
3	.108	.097	.077	.105	.081	1:2.3	1:2.1	1:2.3
4	.126	.129	.097	.137	.125	1:2.6	1:2.2	1:2.6
5	.170	.141	.150	.181	.150	1:3.1	1:2.3	1:2.6
6	.180	.181	.178	.190	.202	——	1:2.3	1:2.8
7	——	.182	.194	.242	.185	——	——	——

Volution	Wall thickness A	B	D	E	Septal count D	E	Tunnel angle (degrees) A	B	C
1	——	——	——	——	14	12	—	—	—
2	——	——	——	——	21	20	—	—	—
3	——	——	——	——	26	23	17	17	20
4	.014	——	.012	.012	29	26	22	22	22
5	.020	——	.014	.016	36	28	37	24	32
6	——	.028	.020	.020	32	32	40	30	40
7	——	——	——	.028	32	35	52	33	54

Thompson from the Cherokee of Iowa. The detailed internal features of these forms differ in several respects. The inner volutions of *F. rockymontana* are slightly more loosely coiled and its chomata deposits do not spread laterally as heavy or wide as in *F. euryteines.* Also, the form ratios of corresponding volutions of *F. rockymontana* are smaller and the proloculum is larger.

Occurrence.—Specimens of this form are abundant in Bed 48, Section P-9, Sheep Mountain Canyon, from which the illustrated specimens were obtained. At this locality it is associated with abundant specimens of *Wedekindellina henbesti* (Skinner). This species was originally described from the McCoy formation at McCoy, Colo. Probably conspecific specimens are common in the Hartville area of eastern Wyoming.

FUSULINA CURTA, n. sp.

Plate 6, figures 10-16

Shell short, highly inflated fusiform; with straight axis of coiling, convex lateral slopes, bluntly pointed poles. Mature specimens of 7½ to 9 volutions 3.1-3.8 mm long, 2.0-3.9 mm wide. Form ratio 1:1.4-1:1.5. In many specimens shell retains essentially same shape throughout growth. In some, form ratio of first volution slightly smaller than that of mature shell. Average form

Measurements of Fusulina curta, n. sp., Specimens A-G, in millimeters

Volution	Height of volution							Form ratio of volution			
	A	B	C	D	E	F	G	A	B	C	D
0	.162	.108	.108	.234	.141	.145	.141	—	—	—	—
1	054	.054	.052	.072	.052	.052	.065	1:1.4	1:1.7	1:1.6	1:1.2
2	.061	.072	.073	.090	.077	.081	.085	1:1.5	1:1.6	1:1.8	1:1.3
3	.095	.090	.105	.099	.093	.121	.101	1:1.5	1:1.5	1:1.7	1:1.4
4	.144	.126	.141	.144	.145	.153	.121	1:1.5	1:1.6	1:1.7	1:1.4
5	.144	.144	.161	.162	.162	.173	.161	1:1.4	1:1.6	1:1.6	1:1.4
6	.180	.162	.181	.216	.186	.206	.165	1:1.4	1:1.5	1:1.6	1:1.4
7	.216	.180	.193	.270	.242	.226	.189	1:1.4	1:1.6	1:1.6	—
8	.216	.234	—	—	.222	.242	—	—	1:1.4	—	—
9	—	.216	—	—	—	—	—	—	—	—	—

Volution	Wall thickness (Tectum + diaphanotheca)			Septal count			Tunnel angle (degrees)			
	B	E	F	E	F	G	A	B	C	D
1	—	—	—	11	13	13	—	—	—	—
2	—	—	—	18	18	21	—	—	—	—
3	—	—	—	25	24	26	10	12	15	10
4	—	—	.010	30	27	31	11	13	17	11
5	—	.009	.012	33	34	36	10	11	11	13
6	.012	.012	.016	32	34	31	12	13	16	14
7	.016	020	.020	—	41	44	16	13	15	17
8	020	.020	—	44	52	—	—	15	—	—
9	—	—	—	—	—	—	—	28	—	—

ratios of all volutions in 4 specimens 1:1.5. A few specimens have form ratio of first volution 1:1.7 and that of mature specimen 1:1.4.

Proloculum minute, outside diameter 108-162 microns in 6 specimens, averaging 134 microns. In one specimen, outside diameter 234 microns. Shell expands slowly and uniformly. Average heights of first to ninth volution of 7 specimens 67, 90, 101, 140, 158, 185, 216, 228, and 216 microns, respectively.

Spirotheca thin. Diaphanotheca thin but well developed from near end of first volution to maturity. Average combined thicknesses of tectum and diaphanotheca in fourth to eighth volution of 3 specimens about 10, 11, 13, 19, and 20 microns, respectively.

Septa thin. Diaphanotheca extends almost to base of septa in center of shell. Septa fluted throughout shell, in outer volutions fluting forms closed chamberlets for more than half height of chambers immediately over tunnel. Average septal counts of first to eighth volution of 3 specimens 12, 19, 25, 34, 32, 42, and 48, respectively.

Tunnel narrow, path slightly irregular. Average tunnel angles in third to ninth volution of 4 specimens 12, 13, 11, 14, 15, and 28 degrees, respectively. Chomata half to four-fifths as high as chambers, both sides essentially vertical in center of chambers. Deposits extend laterally from chomata to form thick deposits on septa and floors of chambers.

Remarks.—In general shape, this form resembles *Fusulina girtyi* (Dunbar and Condra) more closely than any other American species. However, it is smaller at maturity, has less intensely fluted septa, lighter chomata deposits, and smaller septal counts for corresponding volutions.

Occurrence.—This species is abundant in Bed 191, Section P-13, Juniper Mountain Canyon, Youghall formation.

EXPLANATION OF PLATE 5

FIGURE — PAGE

1, 4—*Millerella* cf. *M. pressa* Thompson 47
Axial sections, x100. Bed 1, Section P-9, Sheep Mountain Canyon, Belden formation.

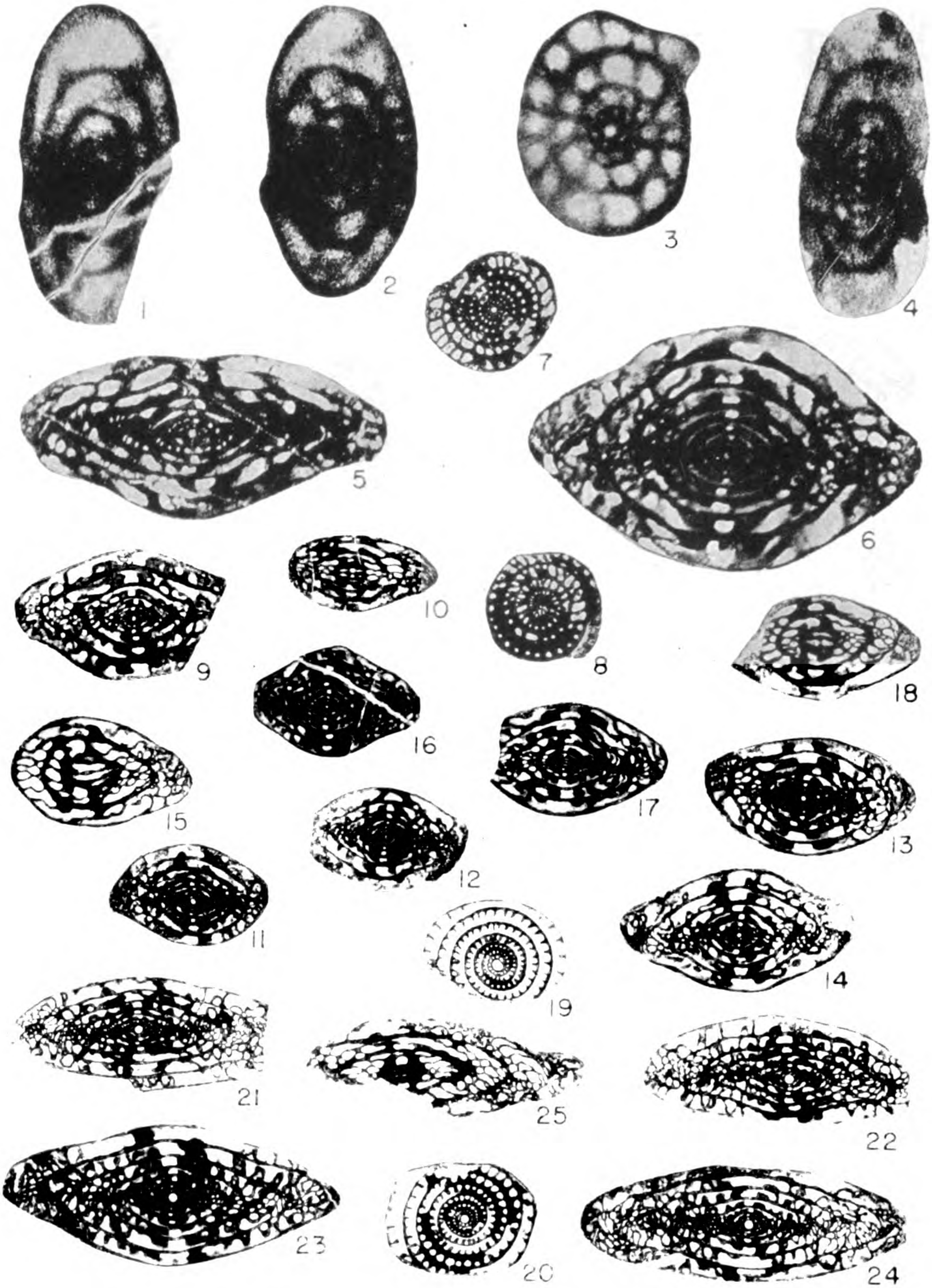
2, 3—*Millerella inflecta*, n. sp. 44
2, Oblique tangential section; *3*, oblique sagittal section; both x100. Bed 1, Section 9, Sheep Mountain Canyon, Belden formation. (*See also* Pl. 1, figs. 1-7; text fig. 11)

5—*Wedekindellina matura*, n. sp. 56
Axial section of a paratype, x20. Bed 44, Section P-9, Sheep Mountain Canyon, Youghall formation. (*See also* Pl. 4, figs. 1-12).

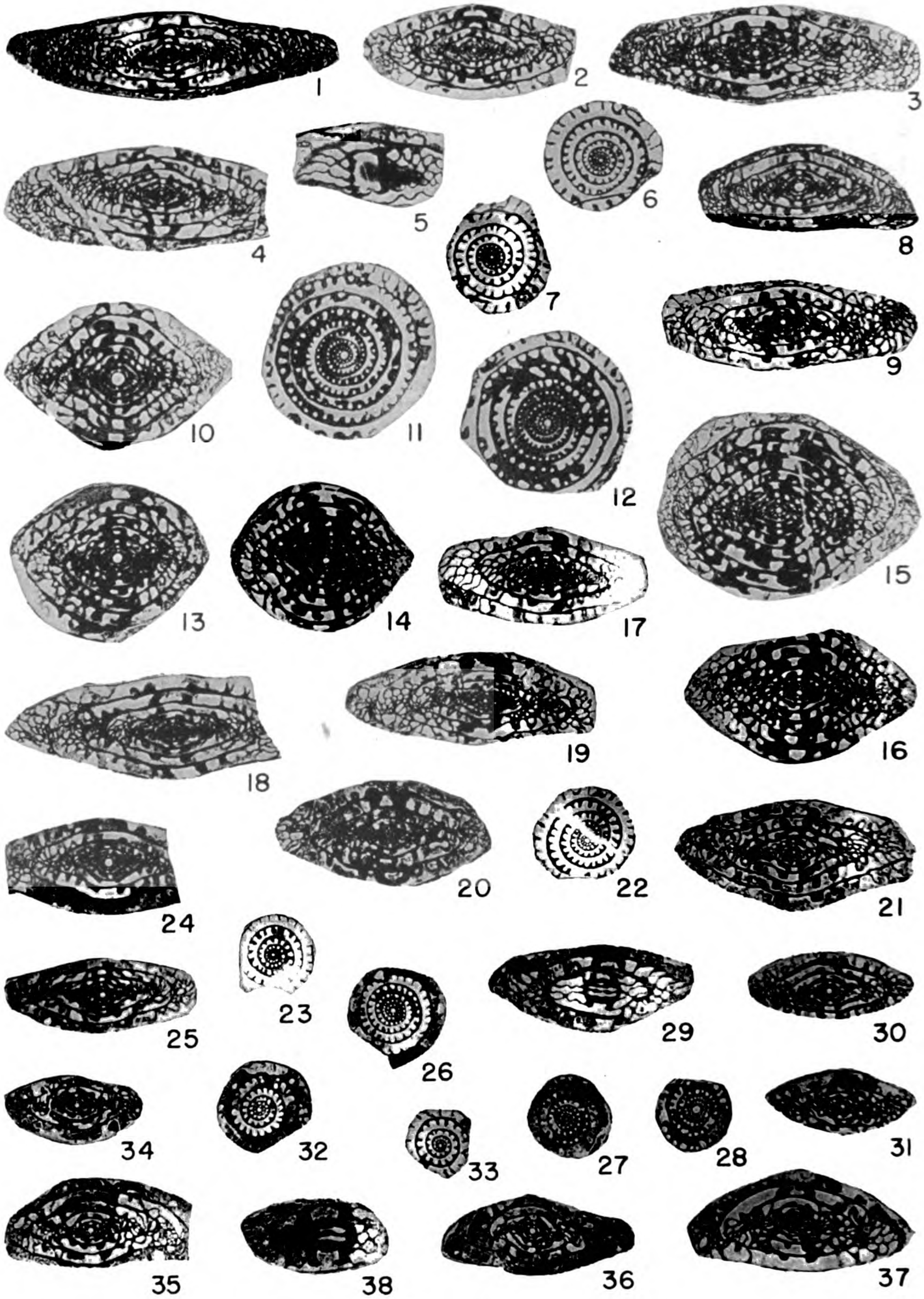
6—*Fusulinella iowensis* var. *leyi*, n. var. 50
Axial section of a paratype, x20. Bed 26, Section P-17, Hell's Canyon, Hell's Canyon formation. (*See also* Pl. 2, figs. 15-25; Pl. 3, figs. 16-21).

7-18—*Fusulina pristina*, n. sp. 61
7, Sagittal section of a paratype; *8*, parallel section of a paratype; *9, 11-13, 16*, axial sections of paratypes; *10, 15, 17, 18*, parallel sections of paratypes; *14*, axial section of the holotype; all x10. Bed 146, Section P-13, Juniper Mountain Canyon, Youghall formation.

19-25—*Fusulina rockymontana* Roth and Skinner 62
19, 20, Sagittal sections; *21-24*, axial sections; *25*, tangential section; all x10. Bed 48, Section P-9, Sheep Mountain Canyon, Youghall formation.



Thompson, Pennsylvanian Fusulinids



Thompson, Pennsylvanian Fusulinids

Fusulina spp.

Form A
Plate 6, figures 1-9

Form B
Plate 6, figures 17, 18, 22, 23

Form C
Plate 6, figures 19-21

Form D
Plate 6, figures 24-31

An abundant fauna of the genus *Fusulina* occurs throughout the Youghall formation in the Uinta Mountains, in addition to the forms described above. Additional sections must be prepared of some of them, however, before their nature can be understood with some degree of assurance and before their relationship to other species can be determined. However, it will suffice at this time to illustrate typical specimens of some of the more abundant forms and to give statistical data obtained from some of them.

Occurrence.—Specimens of Form A are abundant in Bed 206, Section P-13, Juniper Mountain Canyon; Forms B and C are abundant in Bed 61, Section P-9, Sheep Mountain Canyon; and Form D is abundant in Bed 101, Section P-17, Hell's Canyon. All are from the upper part of the Youghall formation.

EXPLANATION OF PLATE 6

FIGURE PAGE

1-9—*Fusulina* sp. Form A 65

1-4, 8, 9, Axial sections; *5*, tangential section; *6, 7*, sagittal sections; all x10. Bed 206, Section P-13, Juniper Mountain Canyon, Youghall formation.

10-16—*Fusulina curta*, n. sp. 63

10, Axial section of a specimen with an unusually large proloculum; *11, 12*, sagittal sections of syntypes; *13-15*, axial sections of syntypes; all x10. Bed 191, Section P-13, Juniper Mountain Canyon, Youghall formation.

17, 18, 22, 23—*Fusulina* sp. Form B 65

17, 18, Axial sections; *22, 23*, sagittal sections; all x10. Bed 61, Section P-9, Sheep Mountain Canyon, Youghall formation.

19-21—*Fusulina* sp. Form C 65

Axial sections, all x10. Bed 61, Section P-9, Sheep Mountain Canyon, Youghall formation.

24-31—*Fusulina* sp. Form D 65

24, 25, 30, 31, Axial sections; *26-28*, sagittal sections; *29*, tangential section; all x10. Bed 101, Section P-17, Hell's Canyon, Youghall formation.

32-38—*Fusulina prima*, n. sp. 59

32, 33, Sagittal sections of paratypes; *34-36*, axial sections of paratypes; *37*, axial section of the holotype; *38*, tangential section of a paratype; all x10. Bed 87, Section P-17, Hell's Canyon, Youghall formation.

Measurements of Fusulina sp., Form A, Specimens A-F, in millimeters

Volution	Height of volution A	B	C	D	E	F	Form ratio of volution A	B	C	D
0	.121	.113	.101	.101	.085	.089	—	—	—	—
1	.048	.040	.036	.032	.032	.032	1:1.8	1:1.3	1:1.6	1:1.5
2	.073	.048	.057	.057	.053	.040	1:1.8	1:1.7	1:2.0	1:2.1
3	.101	.089	.085	.081	.081	.081	1:2.2	1:1.7	1:2.4	1:2.3
4	.165	.105	.117	.121	.113	.093	1:2.3	1:2.4	1:2.6	1:2.8
5	.202	.174	.157	.161	.161	.125	1:2.8	1:2.7	1:2.9	1:3.0
6	—	.194	.210	—	202	.194	—	1:2.7	1:3.0	—
7	—	—	—	—	—	.202	—	—	—	—

Volution	Wall thickness B	E	F	Septal count E	F	Tunnel angle (degrees) A	B	C	D
1	—	—	—	8	9	—	—	—	—
2	—	—	—	13	15	24	—	—	—
3	—	—	—	15	15	23	18	20	25
4	—	—	—	17	20	27	20	23	33
5	.016	.016	.016	21	22	30	25	27	36
6	—	—	—	27	26	—	32	30	—
7	—	—	.020	—	28	—	—	—	—

Measurements of Fusulina sp., Form C, Specimen B, in millimeters

Volution	Height of volution B	Form ratio of volution B	Wall thickness B	Tunnel angle (degrees) B
0	.081	—	—	—
1	.040	1:1.2	—	—
2	.049	1:1.3	—	—
3	.085	1:1.9	—	16
4	.093	1:2.1	.012	24
5	.141	1:2.5	.012	24
6	.177	1:2.3	.016	23
7	.222	—	—	25

Measurements of Fusulina sp., Form D, Specimens A-F, in millimeters

Volution	Height of volution A	B	C	D	E	F	Form ratio of volution A	B	C	D
0	.109	.141	.109	.093	.109	.149	—	—	—	—
1	.040	.036	.032	.056	.052	.044	1:1.2	1:1.3	1:1.4	1:1.4
2	.065	.061	.061	.053	.069	.056	1:2.0	1:1.7	1:1.8	1:2.0
3	.093	.085	.065	.069	.085	.101	1:2.2	1:2.3	1:2.4	1:2.2
4	.129	.101	.093	.105	.125	.133	1:2.5	1:2.4	2:2.6	1:2.6
5	.162	.153	.101	.161	.162	.169	1:2.4	1:2.4	1:3.1	1:2.3
6	—	.202	.141	—	.180	—	—	—	1:2.5	—

Volution	Wall thickness (Tectum + diaphanotheca) A	B	D	E	Septal count E	F	Tunnel angle (degrees) A	B	C	D
1	—	—	—	—	10	11	—	—	—	—
2	—	—	—	—	17	19	25	—	—	—
3	—	—	.008	—	19	20	30	22	23	22
4	.016	—	.012	.012	21	22	27	36	30	30
5	.016	.020	—	—	27	26	28	36	35	37
6	—	—	—	—	28	—	—	40	38	—

DESCRIPTIONS OF MEASURED SECTIONS

Section P-9. Sheep Mountain Canyon, Utah

On Manila-Vernal road, 12 miles by highway from Manila, Utah. Base of section begins at base of north-dipping limestone, west side highway just north of small tributary canyon and about 100 yards north of vertical limestone. Section extending up cliff to north and along highway. Located mainly in sec. 9, T. 2 N., R. 19 E., Daggett County, Utah. (*See* Figs. 3, 10).

Thickness (feet) Bed

Weber sandstone

Youghall formation

8.5 (67) *Limestone*, blue, brittle and hard; abundant blue chert masses.

10.0 (66) *Limestone*, gray to bluish gray, highly fossiliferous; massively bedded with chert nodules; makes prominent band along cliff; weathers to slabby beds at base.

68.0 (65) *Sandstone*, fine-grained, cross-bedded, porous, calcareous, faces show thin lamination; weathers white in upper 40 feet; softer in upper part.

5.0 (64) *Siltstone*, highly arenaceous, dolomitic; weathers into thin fissile sheets; weathers bright yellow.

7.0 (63) *Dolomite*, yellow, arenaceous; weathers slabby.

51.0 (62) *Sandstone*, buff, cross-bedded; weathers to thin slabby beds.

6.0 (61) *Limestone*, bluish gray; thin bands and nodules of light-gray chert; abundant fusulinids.

32.4 (60) *Sandstone*, buff, fine-grained, glistening, porous, cross-bedded.

9.0 (59) *Limestone*, bluish gray, cherty; highly fossiliferous.

34.0 (58) *Sandstone*, buff, cross-bedded; forms cliff.

3.5 (57) *Limestone*, highly nodular; nodules imbedded in yellow to greenish shale; more massive and cherty in upper one foot.

4.5 (56) *Limestone*, sandy, yellowish gray where examined; contains prominent beds of light-gray chert; apparent irregular contact with sand below.

6.0 (55) *Sandstone*, shaly at base, buff, medium- to fine-grained; weathers yellow.

48.6	(54) *Sandstone*, buff, fine-grained, highly cross-bedded; upper 5 feet weathers more easily and is light gray.
0.5	(53) *Shale*, yellow at bottom, bluish gray at top.
3.0	(52) *Sandstone*, highly calcareous and fossiliferous; more highly calcareous in upper part.
15.5	(51) *Sandstone*, light gray, locally buff; weathers light buff to white; forms prominent light band on side of cliff.
32.0	(50) *Sandstone*, buff to light gray, cross-bedded, glistening, massively bedded.
5.0	(49) *Sandstone*, buff, highly cross-bedded, hard; weathers dark brown on surface; forms prominent bed along cliff.
3.0	(48) *Limestone*, light gray, fossiliferous; contains fusulinids; locally entirely replaced by light-gray chert.
24.8	(47) *Sandstone*, light gray to buff, fine-grained, cross-bedded, glistening.
3.0	(46) *Sandstone*, highly calcareous, cross-bedded, buff, glistening; contains nodular chert.
0.8	(45) *Limestone*, blue-gray to gray, hard; thinly laminated in appearance.
2.8	(44) *Limestone*, bluish gray to slightly brown, soft marly zones; highly fossiliferous; fusulinids abundant.
51.0	(43) *Sandstone*, light gray to buff, fine-grained, hard, cross-bedded, siliceous; contains soft light-gray streaks and abundant small limestone concretions in soft streaks; upper 5 to 8 feet weathers easily; forms bench.
0.5	(42) *Sandstone*, yellow, fine-grained.
2.5	(41) *Sandstone*, highly calcareous; contains lenses of lime, hard, sub-quartzitic.
1.4	(40) *Limestone*, finely nodular; interbedded with yellow shale.
3.6	(39) *Sandstone*, highly calcareous; stringers of chert.
0.8	(38) *Limestone*, bluish gray, highly sandy, fossiliferous, highly cherty; weathers bluish gray.
23.0	(37) *Sandstone*, light gray to tan, cross-bedded; sub-quartzitic on fresh breaks.
0.6	(36) *Sandstone*, soft; weathers yellowish.
7.5	(35) *Sandstone*, light gray, fine-grained, massive; weathers buff; thin shale break at base.
10.5	(34) *Sandstone*, calcareous, scattered chert bands, sub-quartzitic; chert up to 1 foot thick; appears as limestone on some fresh surfaces.
7.8	(33) *Sandstone*, yellow to buff, fine-grained; weathers bright yellow.
3.5	(32) *Shale*, dark purplish red, highly silty; scattered light-gray spherical concretionary masses; sharp contact with bed above.
0.5	(31) *Chert*, light gray to red.
0.5	(30) *Sandstone*, dark red, argillaceous, fine-grained.
1.0	(29) *Limestone*, light gray to tan, slightly sandy and cherty.
6.5	(28) *Sandstone*, purplish, calcareous; light-gray chert stringers; red in upper 2 feet.
10.0	(27) *Sandstone*, dark purplish red; soft and shaly in lower 5 to 6 feet;

slightly resistant in upper 3 feet; contains abundant small spherical yellow to light-gray concretionary stains.

5.0 (26) *Sandstone,* red; lower 2 feet soft; upper 3 feet resistant; contains limestone concretions.

6.5 (25) *Sandstone,* red; contains concretions up to 1.5 feet in diameter and small pebbles in lower part; lower 2 feet recemented and looks like limestone on fresh cut.

3.0 (24) *Sandstone,* fine-grained; green to yellow and red on weathered slope; grading upward into limestone concretionary zone.

BELDEN FORMATION

4.3 (23) *Limestone,* light gray, highly cherty (75 percent chert); fossiliferous in upper part.

3.8 (22) *Limestone,* light gray, crystalline, slabby; interbedded with hard yellow shale; fossiliferous.

4.0 (21) *Limestone* or *sandstone,* fossiliferous; fine-grained chert on weathered faces; abundant micro-cross-bedding.

0.8 (20) *Limestone,* light gray, coarsely crystalline, cherty; thin shale break at top and bottom.

1.5 (19) *Limestone,* light gray, light purple on fresh surface, coarsely crystalline, highly fossiliferous.

2.0 (18) *Quartzite,* light gray, glistening, cherty.

5.0 (17) *Shale,* yellow to light gray; weathers orange at top; contains nodules of yellow lime in upper part.

2.5 (16) *Limestone,* light gray to yellow, crystalline, slabby beds.

2.0 (15) *Shale,* purple; grading upward to yellow.

3.5 (14) *Limestone,* light gray, weathers lavender, brecciated in appearance, columnar fracture.

1.7 (13) *Limestone,* disseminated chert, yellow to white; weathers yellow; coarsely crystalline.

6.0 (12) *Limestone,* argillaceous, purple, prominent light-gray concretionary spherical stains; resistant in lower 1.5 feet; top 2 feet mainly purple shale; rubbly and nodular in upper part.

6.0 (11) *Limestone,* blue gray, conglomeratic in appearance, abundant chert masses (red to gray); lower 3 feet nodular with purple shale.

7.0 (10) *Limestone,* light yellowish gray to blue; about 50 percent banded chert.

5.0 (9) *Shale,* light yellow, fissile; alternating in upper part with thin bands of limestone.

3.5 (8) *Shale,* calcareous, purple, teeming with fossils; 0.5 feet chert at top; upper 2.5 feet resistant fossiliferous zone with chert band.

47.0 (7) *Limestone,* light bluish gray to light gray, massive to massively-bedded; granular and glistening in lower 5 feet; scattered bands of yellow chert; thin shale 10 feet from top; abundant chert in top 3 feet.

87.7 (6) *Limestone,* blue to bluish gray, massively bedded; interbedded with thin blue to yellowish-gray shale.

62.3 (5) *Limestone,* blue gray to pearl gray, slightly cherty, massive beds; interbedded with highly fossiliferous shale layers; shale blue gray to red, more abundant in upper part.

15.6 (4) *Limestone*, blue gray to purple, highly fossiliferous, fossils silicified; upper 5 feet purple shale; lower part abundant yellowish-gray shale.

4.5 (3) *Limestone*, blue to lavender; thinly laminated on weathering; chert abundant; masses of red chert in upper part; highly fossiliferous in upper 0.2 feet.

19.0 (2) *Limestone*, gray to blue, massively bedded, beds 1 to 2 feet thick; abundant masses and irregular beds of blue to red chert; interbedded with gray shale.

44.0 (1) *Limestone*, bluish gray to gray, highly fossiliferous; beds 0.5 to 2 feet thick; interbedded with thin shale streaks; contains some disseminated chert; large masses of blue chert 10 feet below top and in upper 3 feet.

Note: Talus covered slope below Bed 1.

Section P-13, Juniper Mountain Canyon, Colorado

On north wall of canyon of Yampa River. Base of section begins about one-third of a mile east diversion dam and extending eastward along wall of canyon, about 2 miles west by north Juniper Springs. Top of section at east mouth of canyon. N½ sec. 18, T. 6 N., R. 94 W., Moffat County, Colo. (*See* Figs. 5, 7, and 9.)

Thickness (feet) Bed

Youchall formation

22.5 (213) *Limestone*, bluish gray, fossiliferous; caps north bluff of east entrance of canyon; very irregular contact below.

37.5 (212) *Sandstone*, buff, fine-grained, cross-bedded.

20.0 (211) *Limestone*, bluish gray, massive, hard.

17.0 (210) *Limestone*, bluish gray, algal, thin even beds; becoming darker gray and brittle in upper part.

24.0 (209) *Sandstone*, buff, fine-grained, cross-bedded; weathers brown.

8.5 (208) *Limestone*, bluish gray, dense, hard; scattered brown chert at top

9.0 (207) *Sandstone*, buff, fine-grained; thin slabby beds.

12.0 (206) *Limestone*, bluish gray, highly algal, thin-bedded; lower 3.5 feet composed almost entirely of fusulinids.

21.0 (205) *Limestone*, bluish gray, dense and hard; common dark chert in lower 2 feet.

8.0 (204) *Limestone*, argillaceous, light gray; weathers very light gray; scattered fusulinids.

3.0 (203) *Limestone*, nodular, medium gray, argillaceous.

6.5 (202) *Sandstone*, buff; thin limestone lenses; limestone in lower part.

3.0 (201) *Limestone*, silty, light brownish gray.

2.6 (200) *Sandstone*, light gray, medium- to fine-grained.

2.9 (199) *Limestone*, light bluish gray, dense, hard; fusulinids abundant.

5.4 (198) *Sandstone*, medium buff to light gray.

2.9 (197) *Limestone*, bluish gray, dense, hard.

14.3 (196) *Limestone*, highly argillaceous and fossiliferous, light gray; abundant bryozoans and brachiopods; large masses and lenses of black chalcedonized chert; weathers light gray; forms slope.

2.5 (195) *Limestone*, bluish gray, hard; rough weathered surface.

6.5 (194) *Limestone;* alternating hard siliceous beds and easily weathered zones; light bluish gray.

2.0 (193) *Chert*, purplish; upper 1 foot contains large masses limestone.

4.0 (192) *Sandstone*, buff, fine-grained.

20.0 (191) *Limestone*, highly nodular; chert common in form of large round nodules; scattered fusulinids; abundant brachiopods; limestone, argillaceous; chert, black to dark gray; upper 1 to 2 feet principally chert.

17.5 (190) *Limestone*, bluish gray, extremely cherty; chert yellowish to brown.

13.0 (189) *Sandstone*, gray to buff, fine-grained, cross-bedded, hard.

14.9 (188) *Limestone*, bluish gray, massive, dense, hard.

3.5 (187) *Limestone*, medium to light gray, argillaceous; dark chert nodules common; scattered fusulinids.

1.5 (186) *Sandstone*, light gray to white, fine-grained; irregular contact with limestone below.

3.0 (185) *Limestone*, bluish gray, dense, hard.

14.0 (184) *Sandstone*, buff to light gray, fine-grained, cross-bedded; quartzitic in upper 3 feet.

5.0 (183) *Limestone*, light bluish gray.

22.5 (182) *Covered.*

3.0 (181) *Limestone*, bluish gray, hard.

1.0 (180) *Quartzite*, light gray.

9.8 (179) *Slope;* seemingly all argillaceous sand.

9.0 (178) *Sandstone*, gray to light brown, fine-grained; alternating soft and quartzite beds.

2.0 (177) *Limestone*, bluish gray, hard, massively bedded.

4.8 (176) *Sandstone*, light gray to buff; breaks into thin slabby sheets.

3.0 (175) *Limestone*, light bluish gray, hard.

6.0 (174) *Sandstone*, buff, thin-bedded, laminated; locally stained purple; breaks into slabs.

5.0 (173) *Limestone*, medium gray, hard.

12.6 (172) *Covered;* entire slope seemingly nodular lime.

3.0 (171) *Limestone*, bluish gray, hard, massively bedded; highly sandy in lower part.

9.0 (170) *Siltstone*, dark brownish red; mainly slope; poorly exposed.

7.0 (169) *Limestone*, bluish gray, hard; silty in lower part.

1.6 (168) *Limestone*, bluish gray, highly crinoidal; abundant yellow chert toward top.

6.0 (167) *Sandstone*, light gray, fine-grained.

21.6 (166) *Limestone*, earthy; large masses of red chert in middle; light purple at bottom; dark purple toward upper part and highly silty.

3.0 (165) *Limestone*, light gray, highly crinoidal.

8.0 (164) *Limestone*, light gray to slightly purplish, highly cherty; large masses and lenses of brown chert; upper 4 feet extremely cherty.

7.0 (163) *Sandstone,* light gray to buff, fine-grained.

6.3 (162) *Limestone,* hard, sandy; lenses and masses of yellow chert abundant; upper 3 feet mainly chert; scattered fusulinids.

3.5 (161) *Limestone,* shaly and nodular in lower 1 foot, fossiliferous, gray, highly crinoidal.

7.0 (160) *Sandstone,* light gray, fine-grained, hard.

1.0 (159) *Limestone,* blue gray, highly sandy.

3.5 (158) *Sandstone,* silty, light gray to pink, fine-grained, sub-quartzitic.

9.6 (157) *Sandstone,* light gray, fine-grained, cross-bedded; highly mottled purple and yellow.

6.2 (156) *Limestone,* bluish gray, fossiliferous, soft; upper 1.2 feet hard, purplish.

4.6 (155) *Limestone,* light gray, silty; 1 foot purple zone 1 foot from base.

5.5 (154) *Sandstone,* calcareous, highly silty, light gray to bluish gray; alternating with thin white soft sandstone layers.

1.6 (153) *Sandstone,* soft, fine-grained.

2.5 (152) *Sandstone,* light gray to white, fine-grained, hard, sub-quartzitic.

4.3 (151) *Shale,* red, greenish yellow in upper 1 foot.

5.0 (150) *Limestone,* light purplish gray, nodular; upper 2 feet breaks down easily.

3.0 (149) *Shale,* bright red to purple; upper 0.5 foot contains nodular green limestone.

1.0 (148) *Limestone,* nodular, purplish to yellow; interbedded with purple shale.

7.5 (147) *Limestone,* massive to massively bedded; lenses and beds of red chert.

8.0 (146) *Limestone,* light purplish gray, contains scattered fusulinids, soft; breaks into slope; middle part shaly with light-gray mottling.

7.0 (145) Partly covered; gray shale showing in middle 3 feet; may have limestone at bottom and top.

4.5 (144) *Limestone,* medium gray, slightly purplish; massive in lower 2 feet, thinner bedded above.

20.0 (143) *Limestone,* thin wavy beds; interbedded with yellow to gray shale; stained purplish in upper part.

2.0 (142) *Limestone,* bluish gray; massive in lower part; thin-bedded above; fusulinids and horn corals common.

1.0 (141) *Shale,* bright purple.

1.0 (140) *Sandstone,* highly calcareous, fine-grained, gray.

19.0 (139) *Shale,* salmon to bright purple; upper 5 to 6 feet poorly exposed.

7.5 (138) Partly covered; apparently all soft highly crinoidal purple limestone.

1.5 (137) *Limestone,* medium gray; nodular in lower part.

2.4 (136) *Shale,* red.

1.0 (135) *Sandstone,* fine-grained, brown to red.

1.0 (134) *Shale,* greenish gray, thin-bedded.

8.0 (133) *Limestone,* bluish gray; interbedded with purplish shaly limestone; extremely fossiliferous, fossils mainly in red chert.

14.0 (132) *Shale*, silty and sandy, gray to purple and red; more silty in upper 3 to 4 feet.
2.8 (131) *Limestone*, medium gray, silty, evenly bedded; algal.
1.6 (130) *Shale*, purple, thin-bedded, silty; yellowish gray in upper part.
0.4 (129) *Sandstone*, greenish gray, highly silty.
1.5 (128) *Shale*, medium gray, silty, hard and blocky.
2.0 (127) *Sandstone*, buff, mottled purple, fine-grained, silty.
3.6 (126) *Shale*, gray, soft.

HELL'S CANYON FORMATION

3.5 (125) *Limestone*, medium brownish gray, irregular bedding; scattered lenses of red chert; fossiliferous, fossils red and silicified.
1.0 (124) *Limestone*, medium gray; massive.
2.5 (123) *Shale*, calcareous; nodular limestone in top; scattered thin beds limestone throughout; abundant fusulinids.
3.6 (122) *Limestone*, alternating irregular limestone ledges and nodular limestone; upper 1 foot composed almost entirely of fusulinids.
5.7 (121) *Shale*, light bluish gray.
4.0 (120) *Limestone*, medium gray, irregularly bedded, hard; contains fusulinids.
6.3 (119) *Limestone*, highly nodular, medium gray; interbedded with gray shale; forms slope.
2.6 (118) *Limestone*, medium gray, nodular beds, highly fossiliferous.
8.4 (117) *Shale*, alternating green and purple in lower 4 feet, bluish gray in middle part; upper part calcareous.
4.0 (116) *Limestone*, nodular, medium gray; shale break in middle.
4.5 (115) *Limestone*, nodular, medium gray, silty; nodules 1 to 2 inches in diameter.
3.6 (114) *Limestone*, medium gray, algal, nodular in appearance; shale break in middle.
14.8 (113) *Limestone*, nodular, interbedded with silty shale.
2.0 (112) *Limestone*, nodular; interbedded with shale; abundant fusulinids; upper 1 foot more resistant.
2.3 (111) *Shale*, thin-bedded; alternating gray and purple.
0.5 (110) *Limestone*, silty, algal; brownish gray.
5.3 (109) *Sandstone;* fine-grained; mottled buff and red; middle 1 foot soft.
5.4 (108) *Shale*, purplish gray, thin-bedded; weathers light lavender; becomes silty in upper part.
2.3 (107) *Limestone*, light gray; composed mostly of crinoid stems.
3.5 (106) *Shale*, purplish gray.
1.0 (105) *Limestone*, medium gray, nodular.
3.4 (104) *Shale*, salmon colored in lower part, dark purple above.
5.0 (103) *Limestone*, bluish gray to medium gray, nodular bedded; beds up to 2.5 feet thick; *Chaetetes* abundant.
5.2 (102) *Shale*, gray, highly calcareous; abundant limestone nodules.

NOTE: Beds 72-101 duplicated by thrust faulting. Total thickness of Hell's Canyon formation probably greater than measured because of elimination of beds by flowage.

6.8 (71) *Limestone,* bluish gray, nodular, argillaceous; lower 1.5 feet and upper 2 feet more massively bedded; fusulinids abundant in lower 2 feet; red chert in upper part.

3.8 (70) *Shale,* greenish yellow in lower 0.5 feet, purplish gray in middle part; upper 1.5 feet contains abundant nodular limestone.

6.5 (69) *Limestone,* bluish gray, massive, irregular beds, ledge forming; *Chaetetes* abundant in upper part.

7.1 (68) *Limestone,* bluish gray, irregularly bedded; upper 4 feet nodular; massive nodular beds; *Chaetetes* abundant in upper 2 feet.

39.6 (67) *Slope;* outcrops of nodular limestone and shale throughout interval; shale, purplish in lower part and uppermost part; limestone, bluish gray; argillaceous.

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19.2 (66) *Limestone,* bluish gray; large masses of white to yellow chert throughout; 2.5 feet mainly chert 7.5 feet from top.

13.3 (65) *Limestone,* bluish gray; lower 4 feet nodular; upper part massively bedded; yellow chert common on upper surface.

6.5 (64) *Limestone,* brownish gray, massive, scattered small chert masses; weathers to rough surface; upper 1.5 feet forms reëntrant on cliff.

7.5 (63) *Limestone,* bluish gray, brittle, evenly bedded.

1.2 (62) *Limestone,* light bluish gray, slightly porous.

3.2 (61) *Limestone,* light bluish gray; weathers yellow.

7.0 (60) *Limestone,* bluish gray, algal; alternating soft and hard beds; upper 1 foot thin-bedded.

1.8 (59) *Limestone,* powder blue; weathers yellow; one massive bed.

6.0 (58) *Limestone,* bluish gray; alternating with gray shale; lower 3 feet mainly lime.

9.0 (57) *Limestone,* massive; pink in lower 6 feet; yellowish gray in upper part.

0.8 (56) *Limestone,* pink, thin wavy beds, hard and dense.

5.0 (55) *Limestone and shale interbedded;* limestone irregular beds, bluish gray; shale brownish gray; upper 2 inches yellowish-green shale.

0.2 (54) *Shale,* greenish yellow.

4.3 (53) *Limestone,* bluish gray, massive; abundant calcite geodes.

2.4 (52) *Limestone,* dove gray; lead-gray 2 inch chert laminae in middle part.

2.5 (51) *Shale,* greenish yellow; thin limestone near middle part.

4.3 (50) *Limestone;* as below but more massively bedded.

14.5 (49) *Limestone,* nodular; upper 1.5 feet soft, bluish gray, weathers brownish; lower 6.5 feet more bluish gray.

7.0 (48) *Limestone,* light gray, nodular; upper 1 foot weathers brown, algal.

0.4 (47) *Limestone,* bluish gray, dense, hard.

6.5 (46) *Limestone,* bluish gray, nodular, highly algal; alternating hard and soft zones.

2.5 (45) *Limestone,* argillaceous; interbedded with calcareous and fossiliferous shale.

4.0 (44) *Limestone,* light gray, algal; weathers light bluish.

5.0 (43) *Limestone,* pink, coarsely crystalline, becoming light gray in upper part.

7.0 (42) *Limestone,* bluish gray, irregular beds, highly algal; appears conglomeratic.

3.3 (41) *Limestone,* bluish gray, dense and hard; alternating nodular and irregular beds.

2.0 (40) *Limestone,* bluish gray, highly nodular.

5.0 (39) *Limestone,* bluish gray, massively to irregularly bedded, dense and hard.

1.6 (38) *Limestone,* medium gray, dense, hard.

2.5 (37) *Limestone,* highly algal; appears conglomeratic with limestone pebbles; weathering easily in upper part.

2.0 (36) *Limestone,* medium to light gray; one massive bed.

3.2 (35) *Limestone,* pink, brittle, one massive bed.

2.7 (34) *Limestone,* medium to light gray, dense, hard.

6.0 (33) *Covered.*

3.0 (32) *Shale,* dark red.

0.5 (31) *Shale,* yellowish green, soft.

2.5 (30) *Shale,* brown in lower 1 foot, bright red in upper part.

1.0 (29) *Shale,* greenish yellow; scattered yellowish-gray limestone nodules.

4.5 (28) *Shale,* red; upper 2 feet contains abundant green limestone nodules.

1.2 (27) *Limestone,* greenish gray; small pellets of chert common; conglomeratic.

2.0 (26) *Shale,* red; calcareous shale in middle part.

2.3 (25) *Limestone,* medium gray, irregularly bedded.

4.6 (24) *Sandstone,* light gray, fine-grained, hard, cross-bedded; upper part highly calcareous.

0.8 (23) *Limestone,* argillaceous, light gray.

4.0 (22) *Shale,* purplish red, hard; contains nodules of claystone in lower 1 foot; upper 0.7 foot more resistant.

3.6 (21) *Claystone,* silty, local calcareous masses, hard, medium gray to red.

2.4 (20) *Shale,* red; contains dark-brown limestone nodules.

3.0 (19) *Limestone,* light bluish gray, slightly yellowish; sand in lower 1 foot; medium gray and nodular in upper part; upper 1 foot contains masses of bedded chert.

4.0 (18) *Limestone,* medium gray; weathers nodular.

0.8 (17) *Limestone,* light gray.

1.0 (16) *Shale,* green, silty, soft.

6.5 (15) *Limestone,* light medium gray, hard, dense; badly fractured where measured.

12.0 (14) *Sandstone,* medium- to fine-grained; conglomerate in lower part; coarse-grained in lower 1 foot; contains pebbles of limestone.

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2.0 (13) *Limestone,* medium gray, hard, highly fractured.

3.5 (12) *Sandstone*, buff, silty, medium- to fine-grained; becoming coarse-grained in upper part.

3.0 (11) *Shale*, yellow, hard; highly silty in upper part.

2.0 (10) *Sandstone*, light gray, fine-grained, silty; scattered coarse grains in upper part.

2.5 (9) *Shale*, highly silty, alternating hard greenish brown and soft green beds, thin-bedded; slightly sandy in top.

7.6 (8) *Sandstone*, light gray, poorly assorted, coarse- to fine-grained; soft and porous where observed.

3.4 (7) *Sandstone*, light brown, medium- to fine-grained.

5.5 (6) *Sandstone*, hard; brownish to yellow in lower 1 foot; upper 1.5 feet hard; middle part breaks down.

3.5 (5) *Shale*, yellow, silty; becoming more sandy in upper part.

0.8 (4) *Sandstone*, light gray, medium- to coarse-grained, hard.

3.0 (3) *Sandstone*, yellowish to greenish, fine-grained, argillaceous, soft.

2.0 (2) *Covered;* apparently as in bed 3.

MISSISSIPPIAN LIMESTONE

89.0 (1) *Limestone*, hard, fine-grained; glistening on fresh surface; alternating medium to light-gray and dark-gray beds; scattered chert throughout; 3 foot bed of gray sandstone occurs about 15 feet from top. This bed was measured in crest of drag fold and limestone is badly shattered.

SECTION P-15, SWEETWATER CREEK, EAGLE COUNTY, COLORADO

Measured on north bluff of Sweetwater Creek, about one quarter of a mile west of mouth of creek. Base of section begins in creek bed and section extends northwestward up valley wall. Section located mainly in sec. 3, T. 4 S., R. 86 W., Eagle County, Colo. (*See* Fig. 2).

Thickness (feet) Bed

BELDEN FORMATION

Note: Top of section overlain by 30 feet of cross-bedded conglomeratic, micaceous, red to brown sandstone.

9.0 (38) *Limestone*, dark gray to black; even thick beds below, thin-bedded at top; highly fossiliferous.

15.0 (37) *Shale*, dark gray, thin-bedded to fissile; interbedded with nodular limestone; limestone more abundant in upper part, highly fossiliferous; upper 4 feet extremely fossiliferous.

4.0 (36) *Limestone*, gray, alternating hard and soft beds; contains thin-bedded streaks of micaceous sand.

1.0 (35) *Shale*, slightly silty, yellowish to bluish gray.

0.8 (34) *Limestone*, brownish gray, argillaceous.

7.0 (33) *Sandstone*, gray to greenish-gray, cross-bedded, highly micaceous.

4.8 (32) *Shale*, dark gray to black; interbedded with nodular dark-gray limestone.

0.4	(31) *Sandstone*, grayish green, highly micaceous, medium-grained.
12.2	(30) *Shale*, bluish gray to dark gray; interbedded with abundant nodular limestone; limestone nodules highly algal.
2.5	(29) *Sandstone*, medium- to coarse-grained, sub-quartzitic, micaceous; alternating soft and hard beds, greenish brown.
11.0	(28) *Shale*, calcareous, highly fossiliferous, soft, yellowish gray.
5.0	(27) *Limestone*, argillaceous, dark gray; soft in lower 1.5 feet; becoming shaly in upper 1 foot.
1.0	(26) *Conglomerate*, fine pebbles of limestone and hard shale; very irregular contact with bed below, probably due to compression.
8.5	(25) *Limestone*, dark gray to black; interbedded with dark-gray to black gypsiferous shale; fossils abundant 2 to 4 feet from top.
2.0	(24) *Limestone*, gray, argillaceous, hard, fossiliferous.
4.9	(23) *Limestone*, dark gray; interbedded with dark-gray to black shale and nodular limestone.
19.5	(22) *Shale*, dark gray to black; interbedded with even to nodular dark-gray to black limestone.
9.0	(21) *Sandstone*, medium- to coarse-grained; alternating soft and hard layers, greenish gray, highly micaceous.
5.0	(20) *Limestone*, gray to dark gray, highly fossiliferous, abundant brachiopods and crinoids; lower 2 feet shaly and soft; middle 2 feet hard; upper 1 foot mainly shale.
4.0	(19) *Limestone*, argillaceous, black, brittle, evenly bedded.
6.3	(18) *Limestone*, dark gray to black; interbedded with black fissile shale; limestone alternating silty and argillaceous beds; shale contains abundant gypsum veins.
1.7	(17) Limestone, dark gray, highly fossiliferous, highly argillaceous.
19.0	(16) *Limestone*, dark gray to black; interbedded with dark-gray to black shale; predominantly shale in middle part, containing numerous veins of selenite.
2.3	(15) *Limestone*, gray to pearl gray, argillaceous, alternating hard and soft beds, highly fossiliferous.
3.5	(14) *Limestone*, dark gray to black; interbedded with dark-gray to black thin-bedded shale.
0.5	(13) *Conglomerate*, as below.
3.5	(12) *Limestone* and *shale*, black, brecciated.
1.6	(11) *Conglomerate;* poorly rounded pebbles and boulders of limestone, sandstone, and shale; highly gypsiferous.
10.0	(10) *Limestone*, dark gray to black; interbedded with hard black shale.
2.4	(9) *Sandstone*, gray, argillaceous, fine-grained, silty, porous cones; weathers brown.
2.0	(8) *Limestone*, gray, argillaceous, fossiliferous; interbedded with thin-bedded gray fossiliferous shale.
14.0	(7) *Limestone*, dark gray to black, argillaceous; interbedded with dark-gray highly gypsiferous shale; limestone laminated to wavy bedded; thin bed in about middle part; weathers brown.

2.0 (6) *Conglomerate:* angular fragments of dark-gray to black limestone up to 2 inches diameter imbedded in fine sand.

148.0 (5) *Limestone*, dark gray to black; interbedded with dark-gray to black fissile shale: lower 5 feet mainly limestone containing abundant bryozoans and small brachiopods: bed of highly algal and fossiliferous limestone 1 foot thick 93 feet above base; limestone porous, brownish gray; slope intermittently exposed at this place.

8.0 (4) *Sandstone*, gray to dark brown, micaceous, lenticular, medium-grained; overlain by 2.5 feet highly arenaceous and silty gray to yellow shale. Within short distance Bed 5 seems to bevel most of Bed 4.

6.0 (3) *Shale*, gray to yellow and purple, silty, becoming more sandy toward top, lens of granular conglomerate up to 2 feet thick about 2 feet above base; granules of quartz.

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15.0 (2) *Limestone* and *shale:* shale, brownish red, hard, abundant hematite shows on surface of lower 7 feet; limestone in upper 6 feet medium to dark gray, interbedded with greenish-gray shale, exposed in road cuts; limestone highly fossiliferous; lower 5 feet red shale with hematite concretions.

MISSISSIPPIAN LIMESTONE

40.0 (1) *Limestone*, massive, gray, hard, highly fossiliferous. Upper surface irregular and cavernous, filled with shale of Bed 2 or of Belden formation.

Note: Bed 2 is missing from the top of the Mississippian limestone only a short distance from this section, probably owing to pre-Belden erosion.

SECTION P-17, HELL'S CANYON, MOFFAT COUNTY, COLORADO

Lower part of section measured up west cliff of Hell's Canyon (beds 1-101) on east face of rounded cliff in sec. 31, T. 6 N., R. 102 W., and upper part (beds 102-106) measured on east and west walls of Hell's Canyon in W½ sec. 7, T. 5 N., R. 102 W., Moffat County, Colo. Top of section at head of Hell's Canyon 11.5 miles west junction Wolf Creek and Youghall truck trails and 2 miles by ranch road north of graded county road. (*See* Figs. 6, 8.)

Thickness (feet) Bed

WEBER SANDSTONE

509.7 (106) *Sandstone*, buff, fine-grained, highly cross-bedded; weathers buff to light gray, relatively soft where weathered.

Note: Top of Bed 106 obviously not at top of Weber; seemingly 150 to 200 feet of Weber occur above this point. Beds dip at an angle of 63° where last measured, become vertical higher in section. Continuous exposure not observed in upper Weber.

37.0 (105) *Dolomite*, slightly sandy, porous, light brown, hard; forms prominent brown hogback on north side of canyon.

247.7 (104) *Sandstone*, dark brown in lower part, buff above, light gray in top, cross-bedded, fine- to medium-grained, glistening; alternating resistant and softer layers; upper part breaks into thin slabby beds.

YOUGHALL FORMATION

23.6 (103) *Limestone*, bluish gray; massively bedded at top and bottom, brittle in middle part; abundant yellow chert masses in upper massive part, fossiliferous.

53.5 (102) *Sandstone*, buff, highly cross-bedded, fine- to medium-grained.

8.0 (101) *Limestone*, light gray, dense and hard; contains abundant fusulinids; forms cap on top of hill in section 31.

45.0 (100) *Sandstone*, brown, cross-bedded, fine-grained; upper 5 feet light gray.

5.0 (99) *Limestone*, sandy, light gray, breaks into thin sheets, cross-bedded.

22.0 (98) *Limestone*, light gray, crystalline, highly fossiliferous; lenses of chert abundant 10 feet from base; contains fusulinids.

20.0 (97) *Sandstone;* buff, medium- to fine-grained; cross-bedded.

6.0 (96) *Limestone*, gray to bluish gray, highly crinoidal; fusulinids common.

54.0 (95) *Sandstone*, brown, cross-bedded, fine-grained.

7.0 (94) *Limestone*, light gray, highly fossiliferous; abundant fusulinids; grading upward to a 1 foot bed of purple calcareous sand; abundant thin dark-gray chert layers.

95.0 (93) *Sandstone*, brown, fine-grained, highly cross-bedded.

7.5 (92) *Limestone*, light gray, highly crinoidal (composed largely of crinoid stems).

65.0 (91) *Sandstone*, brownish red, fine- to medium-grained, cross-bedded to massively bedded.

5.8 (90) *Limestone*, gray, hard, slightly sandy, finely oölitic; teeming with fusulinids in upper part.

3.6 (89) *Sandstone*, light gray, fine-grained, calcareous, cross-bedded; cliff faces covered with chert.

3.5 (88) *Limestone*, gray to purplish gray, sandy, broadly cross-bedded; weathers bluish gray.

4.0 (87) *Limestone*, light gray, highly fossiliferous, fusulinids.

4.3 (86) *Sandstone*, light pink, fine-grained, one massive bed, hard.

3.8 (85) *Sandstone*, reddish brown, fine-grained, cross-bedded.

6.5 (84) *Limestone*, light gray, stained purple, fossiliferous; upper 3.5 feet sandy, slightly fossiliferous.

95.0 (83) *Sandstone*, light red, cross-bedded, fine-grained.

7.0 (82) *Sandstone*, light gray, fine-grained, hard, dense; forms one continuous massive ledge.

5.0 (81) *Sandstone*, reddish brown, fine-grained, mottled with gray; bright red and soft in lower 1.5 feet.

1.4 (80) *Sandstone*, bluish gray to brown, highly calcareous, nodular in appearance.

1.3 (79) *Sandstone*, light purplish brown, hard, calcareous; mottled with gray spherical masses.

4.5 (78) *Sandstone*, reddish brown, cross-bedded, laminated with gray; abundant concentric red and gray rings in upper part.

1.5 (77) *Sandstone*, fine-grained, thin-bedded, alternating reddish brown and gray streaks; breaks into thin streaks.

6.0 (76) *Sandstone*, bright red, highly silty, fine-grained; upper 1 foot highly mottled with gray.

11.0 (75) *Limestone*, bluish gray, highly crinoidal; alternating thick and thin beds; weathers to rough surface.

15.0 (74) *Sandstone*, brownish red, fine-grained, cross-bedded.

10.5 (73) *Limestone*, gray, dense, hard; lenses and masses of red chert 3.5 feet above base; highly crinoidal at top.

6.5 (72) *Sandstone*, gray, fine-grained, soft.

1.0 (71) *Siltstone*, gray; interbedded with thin layers of red and gray siltstone.

2.2 (70) *Sandstone*, red, fine-grained, silty, laminated.

5.0 (69) *Siltstone*, brownish red, thin- to nodular-bedded; contains abundant light-gray concretionary mottling.

8.0 (68) *Limestone*, gray to slightly purplish; has abundant spherical light-gray mottling; more mottled in upper part; upper part mainly shale.

3.0 (67) *Limestone*, gray; weathers light bluish gray; disseminated chert.

HELL'S CANYON FORMATION

8.0 (66) *Shale*, bluish gray, thin-bedded, fissile.

2.0 (65) *Limestone*, gray, hard, teeming with fossils.

4.5 (64) *Shale*, red in lower 2.5 feet, bluish gray in upper part.

2.0 (63) *Sandstone*, gray, weathers brown, highly cross-bedded, fine-grained, hard.

0.5 (62) *Shale*, yellow, soft.

3.5 (61) *Limestone*, gray, argillaceous, teeming with fossils; interbedded with thin fissile shale.

1.0 (60) *Shale*, gray, highly calcareous, highly fossiliferous; mottled with small spherical concretionary structures.

3.3 (59) *Limestone*, gray; composed largely of fossils; two hard beds.

2.0 (58) *Shale*, purplish gray, thin-bedded, silty.

2.0 (57) *Limestone*, gray, highly fossiliferous; abundant thin lenses of chert.

13.0 (56) *Shale*, gray; composed largely of fossils in lower part, especially bryozoans, horn corals, and crinoids.

2.5 (55) *Limestone*, gray, coquinoid, partly silicified; red stringers of chert.

10.0 (54) *Sandstone*, purple, thin-bedded, fine-grained; alternating buff and purple layers.

1.8 (53) *Limestone*, gray to bluish gray, wavily bedded, highly fossiliferous.

8.5 (52) *Sandstone*, light gray to buff, medium- to fine-grained, cross-bedded; weathers to spalling surface.

10.0 (51) *Shale*, gray, slightly bluish; nodular limestone abundant in lower 5 feet; upper 3 to 4 feet not exposed.

1.5 (50) *Sandstone*, purple, highly calcareous, fine-grained, wavily bedded.

1.8 (49) *Limestone*, gray, dense, hard.

1.0 (48) *Shale*, gray to brownish gray; brown and sandy in lower part.

1.0 (47) *Sandstone*, dark reddish brown, fine-grained.

2.0 (46) *Shale*, alternating greenish gray, purple, and light gray.

2.0 (45) *Limestone*, gray, dense and hard; yellow chert in top; silicified fossils in upper part.

1.5 (44) *Limestone*, bluish gray, dense and hard; upper 0.6 foot weathers easily.

0.3 (43) *Shale*, purple, sandy.

4.0 (42) *Sandstone*, light gray, fine-grained, hard; upper 2 feet soft; upper part contains masses of calcareous sandstone.

0.5 (41) *Shale*, bluish gray to gray.

3.0 (40) *Limestone*, bluish gray, hard, highly fossiliferous; most fossils silicified (red chert); abundant masses of red chert; algal in upper part.

2.5 (39) *Shale*, gray, highly calcareous and thin beds of limestone; highly fossiliferous; brachiopods abundant.

2.3 (38) *Limestone*, greenish gray to gray; red chert masses abundant; highly fossiliferous; crinoidal; abundant fusulinids, granular appearance.

15.0 (37) *Limestone*, highly silty, nodular; interbedded with silty shale; gray to bluish gray, purplish tinge; streaks of purple shale 10 feet above base; abundant red chert lenses and nodules in upper 4 feet.

5.5 (36) *Limestone*, gray to purplish gray, wavily bedded to laminated, silty, hard.

6.0 (35) *Limestone*, thin-bedded, highly argillaceous in lower 2 to 3 feet, gray to purplish gray, mottled gray and purple; interbedded with thin shales toward top.

2.8 (34) *Limestone*, gray to bluish gray, dense and hard; teeming with fusulinids in upper 1.3 feet.

0.6 (33) *Shale*, light greenish gray, thin-bedded, highly calcareous; with thin nodules of limestone.

3.0 (32) *Sandstone*, purplish gray, fine-grained, thin-bedded; weathers yellowish, becomes dark purple and argillaceous in upper part.

4.0 (31) *Shale*, bluish to greenish gray, hard; gradational with bed above.

8.5 (30) *Limestone*, light bluish gray, dense, hard; upper 3 to 4 feet almost entirely light gray to blue chert.

3.5 (29) *Limestone*, light gray, earthy, brittle.

1.5 (28) *Shale*, bluish gray, highly silty; interbedded with thin limestones in upper part.

3.0 (27) *Covered.*

3.0 (26) *Limestone*, light bluish gray, dense and hard; large dentritic to spherical masses of gray chert; abundant fusulinids.

1.0 (25) *Shale*, thin-bedded to fissile; highly calcareous and fossiliferous, abundant fusulinids.

1.3 (24) *Limestone*, light bluish gray, dense and hard; contains abundant colonies of *Chaetetes* and scattered fusulinids.

2.0 (23) *Shale*, gray, sandy.

40.0 (22) *Shale*, red to purple; contains scattered zones of nodular limestone in lower part; upper 5 to 6 feet dark brown; sandy and silty.

2.0 (21) *Siltstone*, highly argillaceous, purplish red, highly mottled with spherical light gray masses, calcareous; red chert in lower part.

21.0 (20) *Shale*, purplish gray; contains nodules and thin beds of purplish-gray to yellow limestone; becoming harder in upper 3 to 4 feet; highly mottled with spherical gray concretionary spots; highly silty in upper part; highly fossiliferous calcareous zone 5 feet from base.

5.0 (19) Shale, red to dark brown.

1.0 (18) *Limestone or sandstone*, light gray, hard, purple mottling; thin stringers of bright-red chert in middle part.

3.0 (17) *Siltstone to fine sandstone*, purple to red; highly stained with light-gray concretionary mottling.

2.2 (16) *Sandstone*, light gray to white, fine-grained; in two hard beds; upper bed highly stained with purple mottling.

1.5 (15) *Siltstone*, purplish gray, alternating hard and soft beds, laminated on weathered edges; abundant light-gray concretionary areas.

1.5 (14) *Siltstone*, purplish gray, highly calcareous, hard; abundant light-gray concretionary areas.

11.0 (13) *Shale*, purple to purplish gray, thin-bedded to fissile; slightly nodular in upper part; abundant spherical concretionary light-gray mottling.

2.5 (12) *Limestone*, gray to slightly brownish gray, dense, hard; upper part greenish gray; in two massive beds.

6.5 (11) *Shale*, purplish gray; nodules of limestone common; abundant light-gray concretionary mottling.

3.0 (10) *Limestone*, bluish gray to greenish gray, nodular; stringers and masses of red chert abundant.

4.5 (9) *Limestone and shale;* shale purplish gray, limestone purplish gray and nodular; abundant concretionary spots.

15.0 (8) *Shale*, purplish gray, gray to purplish-gray limestone nodules abundant 3 to 7 feet below top.

5.0 (7) *Limestone*, light purplish gray, highly argillaceous; soft crinkly beds; small masses of red chert common.

10.0 (6) *Conglomerate*, limestone and chert pebbles up to 2 inches in diameter; interstices filled with yellow to red sandstone.

BELDEN FORMATION

10.5 (5) *Limestone*, light bluish gray; massive in lower part; nodular and jointed in upper part; upper 2 to 3 feet composed largely of light-gray to white chert.

3.5 (4) *Limestone*, bluish gray, wavily bedded, laminated; 1 foot bed of purple to brown shale at base; middle part cherty; gray shale and nodular limestone at top.

2.0 (3) *Limestone*, bluish gray, dense, hard; algal at top.

2.3 (2) *Limestone*, gray, highly argillaceous; interbedded with calcareous shale; highly fossiliferous.

108.0 (1) ***Limestone,*** gray to bluish gray; alternating massive to nodular beds interbedded with thin purple shales and nodular limestone zones; yellow to light-gray beds and masses of chert abundant throughout; gray to purple chert becomes more abundant in upper 30 feet; uppermost bed contains lenses up to 1.5 feet thick of gray to purple chert; algae abundant in upper part of major limestone beds; highly fossiliferous.

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