

Carboniferous Foraminifera and Algae of the Amsden Formation (Mississippian and Pennsylvanian) of Wyoming

GEOLOGICAL SURVEY PROFESSIONAL PAPER 848-B



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By BERNARD L. MAMET

THE AMSDEN FORMATION (MISSISSIPPIAN AND PENNSYLVANIAN)
OF WYOMING

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UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1975

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress Cataloging in Publication Data

Mamet, Bernard L.

Carboniferous foraminifera and algae of the Amsden Formation (Mississippian and Pennsylvanian) of Wyoming. (The Amsden Formation (Mississippian and Pennsylvanian) of Wyoming) (Geological Survey professional paper; 848-B)

Bibliography: p.

Includes index.

1. Foraminifera, Fossil. 2. Algae, Fossil. 3. Paleontology--Carboniferous. 4. Paleontology--Wyoming. I. Title. II. Series. III. Series: United States. Geological Survey. Professional paper; 848-B.

QE772.M294 557.3'08s [563'.1] 75-619056

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THE AMSDEN FORMATION (MISSISSIPPIAN AND PENNSYLVANIAN) OF WYOMING

CARBONIFEROUS FORAMINIFERA AND ALGAE
OF THE AMSDEN FORMATION
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ABSTRACT

Calcareous microfossil assemblages from the Amsden Formation of Wyoming consist of at least 100 taxa, predominantly foraminifers but including some algae and forms of uncertain biologic affinity. Approximately 70 taxa are reported herein. No microfossils were found in the Darwin Sandstone Member, but significant microfossil assemblages were recovered from the Horseshoe Shale, Moffat Trail Limestone, and Ranchester Limestone Members of the Amsden. The reported assemblages permit recognition of Zones 17-21, an age range of earliest Namurian (middle Chesterian) into early Westphalian (Atokan).

INTRODUCTION

The presence of endothyrid foraminifers and primitive fusulinids in the Upper Mississippian and Lower Pennsylvanian strata of Montana and Wyoming is well documented (Scott, 1945a, 1945b; Zeller *vide* Cooper, 1947; Zeller, 1950; Easton, 1962). Little attempt has been made, however, to use them as stratigraphic indices. This short contribution is aimed at underlining the usefulness of these microfossils for Carboniferous correlations. In particular, the fossils are of some interest for recognition of the controversial Mississippian-Pennsylvanian boundary.

Details of the stratigraphy and the occurrences of these fossils are given by Sando, Gordon, and Dutro (1974). Representative thin sections of the Amsden microfossils are shown in plates 1 and 2. Lists of microfossils are given in terms of the stratigraphic units and localities described in Sando, Gordon, and Dutro (1974), and the localities are documented in table 1.

Calcareous secreted Foraminifera are unevenly distributed in the Amsden Formation. The Darwin Sandstone Member, for instance, yields no identifiable fauna. Calcareous beds of the Horseshoe Shale, Ranchester Limestone and Moffat Trail Limestone Members yield variable amounts of microfauna; the richest assemblages are found in the pelmatozoan-lump-bearing grainstones and packstones; in contrast, red silty mudstones and dolomites yield very poor assemblages. However, despite the uneven distribution, the variable preservation, and the fact that the collections studied here were not made specifically for foraminifers, sufficient material was found to establish a biostratigraphic zonation.

At least 100 different foraminiferal taxa have been observed in about 120 thin sections of samples collected from 40 localities. Most of these taxa are very scarce or could not be identified to the specific level. Moreover, apterrinellids, serpulopsids, and calcitornellids cannot be identified with confidence on random thin sections, and their role and value, if any, in stratigraphy remain obscure.

The most important forms for biostratigraphic correlations are reported here:

Archaediscus sp.

Archaediscus of the group *A. chernoussoviensis* Mamet

A. krestovnikovi Rauzer-Chernoussova

Archaediscus of the group *A. krestovnikovi* Rauzer-Chernoussova

Asteroarchaediscus sp.

A. baschkiricus (Krestovnikov and Teodorovitch)

Asteroarchaediscus of the group *A. baschkiricus* (Krestovnikov and Teodorovitch)

Biseriella sp.

B. moderata (Reitlinger)

B. parva (Chernysheva)
Biseriella of the group *B. parva* (Chernysheva)
Bradyina? sp.
Climacammina sp.
 "Cornuspira" sp.
Diplosphaerina sp.
Earlandia sp.
E. clavatula (Howchin)
E. elegans (Rauzer-Chernoussova)
E. vulgaris (Rauzer-Chernoussova and Reitlinger)
 cf. *Endostaffella*? sp.
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips emend.
 Brady
E. excellens (Zeller)
 "Endothyra" of the group "*E.*" *prisca* Rauzer-Chernoussova and Reitlinger
Endothyra of the group *E. similis* Rauzer-Chernoussova and Reitlinger
E. tantala (Zeller)
Endothyranella sp.
 cf. *Eolasiotrochus* sp.
Eoschubertella sp.
 "Eosigmoilina" sp.
Eostaffella sp.
Eostaffella of the group *E. acutissima* Kireeva
E. circuli (Thompson)
Eostaffella of the group *E. pseudostruvei* (Rauzer-Chernoussova)
E. pinguis (Thompson)
Eostaffellina sp.
E. paraprotvae (Rauzer-Chernoussova)
Eotuberitina sp.
Globivalvulina sp.
Globivalvulina of the group *G. bulloides* (Brady)
Globoendothyra sp.
Glomospira sp.
Lipinella sp. (nom. nud.)
Millerella sp.
M. pressa Thompson
M. aff. M. pura Malakhova
Monotaxinoides sp.
Neoarchaediscus sp.
N. incertus (Grozilova and Lebedeva)
Neoarchaediscus of the group *N. incertus* (Grozilova and Lebedeva)
Neoarchaediscus of the group *N. parvus* (Rauzer-Chernoussova)
N. parvus (Rauzer-Chernoussova)
 cf. *Palaeonubecularia*? sp.
Palaeotextularia sp.
Palaeotextularia of the group *P. consobrina* Lipina
Palaeotextularia of the group *P. longiseptata* Lipina
Planoendothyra sp.
Planospirodiscus sp.
P. minimus (Grozilova and Lebedeva)
Pseudoendothyra sp.
Pseudoendothyra of the group *P. kremenskensis* Rozovskaia
Pseudoendothyra of the group *P. ovata* (Reitlinger)
Pseudoendothyra of the group *P. struvei* (von Möller)
Pseudoglomospira sp.
Tetrataxis sp.

"Tetrataxis" of the group "*T.*" *eominima* Rauzer-Chernoussova
Trepeilopsis sp.
Tuberitina sp.
Volvo-textularia sp.
Zellerina sp.
Z. discoidea (Girty)

In addition to foraminifers, algae and incertae sedis are also present. Among the algae, Spongiostromata are the most widespread. Also noticeable are the Rhodophycophyta (*Stacheia*, *Stacheoides*, etc.). Calcspheres are mostly represented by *Calcsphaera laevis* Williamson. *Asphaltina* is present. None of these forms has precise stratigraphic value.

TAXONOMIC COMPOSITION OF THE AMSDEN FAUNAS

ARCHAEDISCIDAE

The most useful index for stratigraphic zonation of the latest Viséan-early Namurian is the *Archaeodiscus* - *Neoarchaediscus* - *Planospirodiscus* - *Asterarchaediscus* - *Quasiarchaediscus* - "*Eosigmoilina*" phylogeny. These genera have been found in abundance in most of the fossiliferous Amsden Formation thin sections. As is generally the case in rocks of Namurian age, *Archaeodiscus* is represented only by relict *Archaeodiscus* of the group *A. krestovnikovi*, all other groups (*A. moelleri*, *A. chernoussoviensis*) being rare or absent. The *Archaeodiscidae* with obstructed lumen dominate, and *Asterarchaediscus* and *Neoarchaediscus* are common in all clean wackestones and packstones.

The progressive elimination of the pseudofibrous wall structure and its replacement by a "porcellaneous" wall, concomitant with the disappearance of the inner tectum, lead to "*Eosigmoilina*" which is derived, for the first time, in Zone 19 from *Quasiarchaediscus*. This evolutionary change is well observed in the middle part of the Amsden Formation at the Berry Creek section.

BISERIAMMINIDAE

Biseriamminids are abundant in the Amsden Formation from Zone 18 upwards. Earliest forms are *Biseriella* of the group *B. parva* (Chernysheva), whose outburst underlies Zone 18 (upper Chester time equivalent in the Midcontinent and the Cordillera).

Globivalvulina sensu stricto, with its characteristic diaphanotheca, appears for the first time in the basal Pennsylvanian beds. It is an important faunal element of Zone 21 (*Globivalvulina* of the group *G. bulloides* (Brady)).

TABLE 1.—Checklist of Amsden foraminifer collections

Collection No.	Permanent USGS catalog No.	Name of locality	Mountain range	County	Location	Member
1	5441-PC	Cherokee Spring	Rawlins hills	Carbon	Probably SW $\frac{1}{4}$ sec. 11, T. 21 N., R. 88 W.	Horseshoe Shale.
2	8071-PC	do	do	do	do	Do.
3	3139-PC	do	do	do	NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 11, T. 21 N., R. 88 W	Do.
4	3140-PC	Cherokee Peak	do	do	NE $\frac{1}{4}$ sec. 10, T. 21 N., R. 88 W	Do.
5	3085-PC	do	do	do	SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 10, T. 21 N., R. 88 W	Do.
6	3843-PC	Rawlins US 287	do	do	Probably NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 32, T. 22 N., R. 87 W.	Ranchester Limestone.
13	21729-PC	Meadow Ranch	do	do	SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T. 22 N., R. 88 W	Do.
14	21725-PC	Buck Spring	do	do	NW $\frac{1}{4}$ sec. 33, T. 23 N., R. 88 W	Do.
45	21719-PC	Livingston Ranch	Washakie Range	Fremont	SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 29, T. 43 N., R. 106 W	Horseshoe Shale.
50	11112-PC and 19187-PC.	Trout Creek	Bighorn Mountains	Washakie	Sec. 19, T. 41 N., R. 88 W	Ranchester Limestone.
63	22206-PC	Amsden Creek	do	Sheridan	SW $\frac{1}{4}$ sec. 34, T. 57 N., R. 87 W	Do.
64	22207-PC	do	do	do	do	Do.
65	22208-PC	do	do	do	do	Do.
67	16215-PC	do	do	do	do	Do.
68	22204-PC	do	do	do	do	Do.
71	do	Tip Top Well	Green River Basin	Sublette	SE $\frac{1}{4}$ sec. 32, T. 57 N., R. 87 W	Do.
74	22985-PC	Moffat Trail	Salt River Range	Lincoln	NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 19, T. 28 N., R. 113 W	Do.
75	22986-PC	do	do	do	NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 3, T. 33 N., R. 117 W	Moffat Trail Limestone.
77	6960A-PC	do	do	do	do	Do.
78	6960B-PC	do	do	do	do	Do.
79	22981-PC	do	do	do	do	Do.
82	22984-PC	do	do	do	do	Ranchester Limestone.
90	22995-PC	Covey Cutoff Trail	do	do	NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 27, T. 34 N., R. 117 W	Moffat Trail Limestone.
92	3965-PC	do	do	do	do	Do.
93	6951-PC	do	do	do	do	Do.
100	6965D-PC	do	do	do	do	Ranchester Limestone.
103	17905-PC	Haystack Peak	do	do	Center sec. 19, T. 34 N., R. 117 W	Moffat Trail Limestone.
104	17906-PC	do	do	do	do	Do.
105	17907-PC	do	do	do	do	Do.
109	23002-PC	South Indian Creek	Snake River Range	do	NE $\frac{1}{4}$ sec. 14, T. 38 N., R. 118 W	Do.
121	16208-PC	Hoback Canyon	Hoback Range	Teton	Sec. 2, T. 38 N., R. 115 W	Do.
122	16209-PC	do	do	do	do	Do.
124	18790-PC	do	do	do	Sec. 3, T. 38 N., R. 115 W	Do.
125	18785-PC	do	do	do	Sec. 2, T. 38 N., R. 115 W	Do.
126	22998-PC	do	do	do	do	Do.
132	16211-PC	do	do	do	do	Ranchester Limestone.
145	23006-PC	Phillips Canyon	Teton Range	do	SW $\frac{1}{4}$ sec. 16, T. 41 N., R. 117 W	Moffat Trail Limestone.
153	24059-PC	Berry Creek	do	do	NW $\frac{1}{4}$ sec. 22, T. 47 N., R. 116 W	Horseshoe Shale.
154	24060-PC	do	do	do	do	Do.
160	24057-PC	Elk Ridge	do	do	SW $\frac{1}{4}$ sec. 26, T. 47 N., R. 116 W	Ranchester Limestone.

BRADYINIDAE

Bradyina? has only been observed once, at the Tip Top Well locality.

CORNUSPIRIDAE (sensu lato)

"*Cornuspira*" is present but scarce. The absence of *Brunsia* is puzzling.

EARLANDIIDAE

Common in most facies, the family is essentially represented by *Earlandia*. No zonation can be derived from this genus in Namurian time.

ENDOTHYRIDAE

Although this family is of great stratigraphic value in the Tournaisian-Viséan, its usefulness dwindles in the Late Viséan and disappears in the Namurian. Only *Endothyra* and *Planoendothyra* have been observed, the latter genus being scarce. Even at a specific level, little evolution can be detected, hence no zonation is feasible at the Mississippian-Pennsylvanian boundary.

EOSTAFFELLIDAE

Four genera of Eostaffellidae are known: *Eostaffella*, *Endostaffella*?, *Eostaffellina*, and *Zellerina*. *Zellerina* is abundant at all levels of the Chester and has often been confused for *Millerella*.

Eostaffellina, where it occurs in abundance (Amsden Creek section), is a good marker for the upper Chester and Morrow age equivalents.

FUSULINIDAE

Eoschubertella is restricted to the upper part of the Amsden Formation (Ranchester Limestone Member).

GLOBOENDOTHYRIDAE

The family is poorly represented by scarce *Globoendothyra*.

LASIODISCIDAE

The most primitive member of this family, *Eolasiodiscus*, is abundant at the Covey Cutoff section.

OZAWAINELLIDAE

The unique representative of this family is *Milnerella* sensu stricto; its first appearance is basal Pennsylvanian (Zone 20).

PALAEOTEXTULARIIDAE

As in most of the American Midcontinent and in the Williston basin, the family is poorly developed in early Namurian with occasional *Climacammina* and *Palaeotextularia*. These genera become rather abundant in the Pennsylvanian.

PSEUDOENDOTHYRIDAE

Pseudoendothyra is the only known representative of the family in the Amsden Formation.

TETRATAXIDAE

The family is unusually poorly represented by *Tetrataxis* and *Monotaxinoides*.

This composition of the families is typical of any North American Namurian carbonate platform microfauna. The only difference observed between the Amsden fauna and that of comparable carbonate assemblages of the Midcontinent and the Cordillera is the very poor development of the Tetrataxidae and Bradyinidae and the absence of Endothyranopsidae.

ZONATION

Five Carboniferous foraminiferal zones can be identified in the Amsden Formation; they represent the time equivalents of the middle Chester to the Atoka classical sequence of the Midcontinent (fig. 1).

ZONE 17

Definition.—The base of the zone is defined at the outburst of *Asteroarchaediscus* and in particular at the first proliferation of *Asteroarchaediscus baschkiricus* (Krestovnikov and Teodorovitch). The zone contains many elements inherited from the underlying Viséan Zone 16, such as *Neoarchaediscus* and *Planospirodiscus*. The top of the zone yields the first biseriamminids referable to *Biseriella*. Examples of Zone 17 assemblages are illustrated on plate 1, figures 1–3.

Comparison.—In the Carboniferous Tethys, the base of Zone 17 is characterized by the disappearance of numerous Viséan elements such as *Valvulinerella*, *Howchinia*, and residual lituotubellids and

MISSISSIPPIAN				PENNSYLVANIAN		NORTH AMERICAN SYSTEMS	
CHESTERIAN		<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div>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FIGURE 1.—Stratigraphic ranges of Amsden foraminifers related to standard time-stratigraphic units.

forschiids. These taxa are unknown outside the Tethyan realm. Zone 17 also normally yields *Endothyranopsis sphaerica* (Rauzer-Chernousova and Reitlinger); no Endothyranopsidae has been encountered in the Amsden Formation.

Occurrence in Amsden Formation.—The Zone 17 assemblage of the Amsden Formation is known only from the Moffat Trail Limestone Member of extreme western Wyoming, where it has been positively identified in collections 103, 104, and 109 from the Haystack Peak and South Indian Creek localities. These faunules contain the oldest foraminifers known from the Amsden. Other collections (75, 79, 90, 92, 93, 126) from the Moffat Trail Limestone Member at Moffat Trail, Covey Cutoff Trail, and Hoback Canyon contain assemblages that represent Zone 17 or 18 but lack critical elements that permit differentiation of the two zones.

Correlation.—Zone 17 is of middle Chesterian age; it includes a foraminiferal assemblage that occurs in the Glen Dean and Menard Limestones of the Midcontinent region. The base of the Glen Dean is characterized by the first outburst of *Asteroarchaediscus baschkiricus* (Krestovnikov and Teodorovitch), while the underlying Golconda Formation yields only *Neoarchaediscus* and *Planospiriodiscus*. Zone 17 is also known from the base of the Surret Canyon Formation and from the upper part of the White Knob Limestone of central Idaho (Mamet and others, 1971; Skipp and Mamet, 1970). It has been observed in the Monroe Canyon Limestone of southeastern Idaho (Sando and others, 1969). In Nevada, the upper part of the Battleship Wash Formation is early Namurian (Mamet and Skipp, 1970).

In Alaska, Zone 17 is observed in the Calico Bluff Formation and in the middle part of the Alapah Limestone of the Lisburne Group in the Sadlerochit Mountains, the Romanzoff Mountains, and the central part of the Brooks Range (Armstrong and others, 1970). It is poorly developed in the Kogruk Formation at Cape Lewis (Armstrong and others, 1971).

Zone 17 is also widespread in Canada, where it occurs in the upper part of the Windsor Group of Nova Scotia (Mamet, 1970), in the middle part of the Etherington Formation in Alberta and British Columbia (Mamet, 1968), in the middle part of the Nizi Formation in British Columbia (Mamet and Gabrielse, 1969), in the middle part of the Alapah Limestone and at the top of the Hart River Formation in the Yukon Territory (Mamet and Mason, 1970; Mamet and Ross in Bamber and Waterhouse, 1971).

ZONE 18

Definition.—This zone is characterized by the outburst of *Biseriella* of the group *B. parva* (Chernysheva). *Eostaffellina* is also present. The top of the zone is marked by the first appearance of *Quasiarchaediscus*.

Comparison.—In the Carboniferous Tethys, these characteristic elements are present, but *Eostaffellina* is more abundant. Spherical "*Pseudoendothyra*" are also encountered in the Tethys; in comparison, they are unknown in North America. *Loeblichia* is also restricted to the Tethyan realm.

Occurrence in Amsden Formation.—The principal occurrences of the Zone 18 assemblage are in the Moffat Trail Limestone Member, where the assemblage has been identified in collections 74, 77, 78, 105, 122, 124, and 145 from the Moffat Trail, Haystack Peak, Hoback Canyon, and Phillips Canyon localities of western Wyoming. The zone may be represented in collection 125 from the Moffat Trail Limestone Member at Hoback Canyon.

The Zone 18 assemblage also has been found in the Horseshoe Shale Member at Livingston Ranch in the Washakie Range (colln. 45), where it indicates partial time equivalence of the Horseshoe Shale and Moffat Trail Limestone Members. Possible representation of Zone 18 in the Horseshoe Shale Member at Berry Creek (colln. 154) and in the Ranchester Limestone Member at Elk Ridge (colln. 160), localities in the Teton Range, is doubtful because these occurrences are more in keeping with the distribution of the Zone 19 assemblage.

Correlation.—Zone 18 is of late Chesterian age; it includes a foraminiferal assemblage that occurs in the Clore and Kinkaid Limestones of the Midcontinent region. In Idaho, Zone 18 is known from the middle part of the Surret Canyon Formation, the top of the White Knob Limestone (Mamet and others, 1971) and the upper part of the Monroe Canyon Limestone (Sando and others, 1969). It is also observed in the Indian Spring Formation of Nevada (Mamet and Skipp, 1970).

In Alaska, the zone is well displayed in the upper part of the Alapah Limestone in the Sadlerochit Mountains, Romanzoff Mountains, and the central part of the Brooks Range (Armstrong and others, 1970). It is also known from the upper part of the Kogruk Formation at Cape Lewis (Armstrong and others, 1971).

In Canada, Zone 18 is unknown in the Maritime Provinces, where nonmarine or brackish sediments overlie early Namurian carbonates. It is present in the upper part of the Etherington Formation of Alberta and British Columbia (Mamet, 1968) and

in the Nizi Formation of northern British Columbia (Mamet and Gabrielse, 1969). It is also observed in the upper part of the Alapah Limestone and in the Ettratin Formation of the Yukon Territory (Mamet and Mason, 1970; Mamet and Ross in Bamber and Waterhouse, 1971).

ZONE 19

Definition.—This zone is characterized by the acme of *Eosigmolites-Quasiarchaediscus*. In addition, it contains some elements inherited from early Namurian zones such as *Biseriella* and *Asteroarchaediscus*.

Comparison.—The same faunal characteristics are known in the Tethys, where the zone is equivalent to most of the *Homoceras* Zone.

Occurrence in Amsden Formation.—The Zone 19 assemblage is known definitely only from collection 153 in the Horseshoe Shale Member at Berry Creek in the Teton Range. It is probably also present in collection 154 at Berry Creek and may be represented in the Ranchester Limestone Member at Elk Ridge (colln. 160).

Correlation.—Zone 19 is considered to be of latest Chesterian age although it is absent from the Midcontinent region owing to post-Kinkaid, pre-Pennsylvanian hiatus. This zone is known from the uppermost part of the Surret Canyon Formation of central Idaho and is particularly well displayed in the upper part of the Indian Spring Formation in Nevada (Mamet and Skipp, 1970).

In Alaska, Zone 19 has been observed in the uppermost part of the Alapah Limestone in the West Sadlerochit Mountains. In Canada, the zone has been identified in the Trail River-Trout Lake region in the Yukon Territory (Mamet and Mason, 1970). It is also present in the uppermost Alapah Limestone of the British and Buckland Mountains (Mamet and Ross in Bamber and Waterhouse, 1971).

ZONE 20

Definition.—The zone is identified on the first occurrence of true fusulinids (*Millerella* sensu stricto). The first diaphanotheca-bearing *Globivalvulina* also occur for the first time, but they are scarce. Examples of Zone 20 assemblages are shown on plate 1, figures 6–8 and plate 2, figures 1–8.

Comparison.—The same faunal characteristics are known in the Tethys, where *Semistaffella* and primitive *Pseudostaffella*? occur in addition.

Occurrence in Amsden Formation.—The princi-

pal occurrences of the Zone 20 assemblage are in the Ranchester Limestone Member, where it has been found at two localities in western Wyoming (collns. 100, 132) and four localities in central Wyoming (collns. 13, 14, 50?, 63, 64, 65, 67, 68). It also occurs in the Horseshoe Shale Member of the Rawlins hills (collns. 1–5).

Correlation.—In the United States, the first true fusulinids occur in the basal Pennsylvanian and may therefore be used to underline the sequence. Zone 20 corresponds to the Morrowan Series of the standard North American sequence.

Zone 20 is well displayed at the base of the Pennsylvanian sequence of central Idaho (Mamet and others, 1971) and in the basal carbonates of the Bird Spring Formation in Nevada (Mamet and Skipp, 1970). In Alaska, Zone 20 is widespread at the base of the Wahoo Limestone in the Sadlerochit Mountains (Armstrong and others, 1971).

ZONE 21

Definition.—This zone is recognized on the outburst of *Eoschubertella* and *Pseudostaffella*. Diaphanotheca-bearing *Globivalvulina* also become abundant at the base of the zone.

Comparison.—Direct comparison with the Carboniferous Tethys is difficult. Further studies are necessary in order to relate Zone 21 with the standard Baschkirian-Moscovian succession. If the Donbass sequence established by Brazhnikova and others (1967) is correct, Zone 21 is still Baschkirian, a correlation which conflicts with the generally accepted view that the base of the Atokan Series is equivalent to the basal Moscovian (Thompson in Loeblich and Tappan, 1964).

Occurrence in Amsden Formation.—The Zone 21 assemblage is known only from the Ranchester Limestone Member in the Rawlins hills (colln. 6) and at the Tip Top Well in the Green River Basin (colln. 71).

Correlation.—In the United States, Zone 21 is well displayed in the Atoka age equivalent sequence of central Idaho (Mamet and others, 1971). It is poorly displayed in the Bird Spring Formation of Nevada.

In Alaska, the zone is omnipresent in the oolitic facies of the middle part of the Wahoo Limestone in the Sadlerochit Mountains. In Canada, it is present in the Lisburne Group of the Malcolm River section and in the Ettratin Formation in the Keele Range (Yukon Territory) (Mamet and Ross in Bamber and Waterhouse, 1971).

THE MISSISSIPPIAN-PENNSYLVANIAN BOUNDARY

As previously mentioned (Mamet and others, 1971), the formations exposed in the Midcontinent are unsuitable for definition of the Mississippian-Pennsylvanian boundary because the two sequences are separated by a hiatus. The exact biostratigraphic span of this hiatus is unknown, but the latest Mississippian (Kinkaid Limestone, Grove Church Member) yields a good Zone 18 assemblage, while the first Pennsylvanian fauna is Zone 20. Thus it is certain that Zone 19 is entirely missing and plausible that Zones 18 and 20 are incomplete.

Zone 19 has been considered here as latest Chesterian age equivalent, although it is missing in the type Chester region. This age assignment is biostratigraphically consistent with the observation that Zone 19 is the acme of the evolution of the Archæodiscidae and is phylogenically linked with the underlying Zone 18. Moreover, Zone 20 marks the appearance of the first true fusulinids, which become the dominant assemblage of the Pennsylvanian microfossils. This placement of the boundary respects both lithostratigraphic and biostratigraphic conventions.

A somewhat similar position was adopted by Lane, Sanderson, and Verville (1972), who considered the Zone 19 Indian Springs Formation of Nevada to be entirely Chesterian. They defined the base of the Pennsylvanian on the first occurrence of the conodonts *Adetognathus lautus* and *A. gigantus*, which occur for the first time slightly above the top of the Indian Springs Formation. According to Brenckle, Zone 19 is still present in the lowermost part of the Bird Spring Formation in the Arrow Canyon composite section of Nevada (1973).

One must underline, however, the confusion observed in the literature concerning the status of *Millerella*. When Thompson (1942) originally defined the genus, he correctly assumed that it was diagnostic of the Pennsylvanian. However, the Thompson concept of the genus subsequently varied greatly, and he incorporated in *Millerella* species which would now be referred to *Eostaffella* or *Zellerina* (Thompson, 1944, 1945). Scott (1945a, 1945b) correctly identified *Millerella*, but references to *Millerella* in the upper Chester (Henbest, 1946, 1947; Cooper, 1946, 1947; Mellen, 1947; Thompson, 1948; E. J. Zeller, 1950; D. E. N. Zeller, 1953; Sage, 1954) have to be re-evaluated. All published material of such low *Millerella* occurrences (Cooper, 1947; E. J. Zeller, 1950; Sage, 1954) show taxa which should be referred to the Eostaffellidae, not to the Ozawainel-

lidae. Pennsylvanian *Millerella* of Easton (1952) and of Moore (1964) correctly fit the Thompson (1942) diagnosis.

LIST OF MICROFOSSILS

Collection 1.—Horseshoe Shale Member, Cherokee Spring locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).

Foraminifers present.

Apterrinellidae

Archæodiscus sp.

Asphaltina sp.

Asteroarchæodiscus sp.

Asteroarchæodiscus of the group *A. baschkiricus* (Krestovnikov and Teodorovitch)

Calcisphaera sp.

Earlandia sp.

Endothyra sp.

Endothyranella sp.

Lipinella sp. (nom. nud.)

Millerella sp.

Neoarchæodiscus of the group *N. incertus* (Grozdilov and Lebedeva)

Planospirodiscus sp.

Pseudoglomospira sp.

Zellerina sp.

Collection 2.—Horseshoe Shale Member, Cherokee Spring locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).

Foraminifers present.

Apterrinellidae

Archæodiscus sp.

Asteroarchæodiscus sp.

A. baschkiricus (Krestovnikov and Teodorovitch)

Biseriella sp.

B. moderata (Reitlinger)

Calcisphaera sp.

"*Cornuspira*" sp.

Diplosphaerina sp.

Earlandia sp.

"*Endothyra*" sp.

Eostaffella sp.

Eotuberitina sp.

Girvanella sp.

Globivalvulina sp.

Lipinella sp. (nom. nud.)

Millerella sp.

Neoarchæodiscus of the group *N. incertus* (Grozdilov and Lebedeva)

N. parvus (Rauzer-Chernousova)

Planospirodiscus sp.

Pseudoendothyra sp.

Collection 3.—Horseshoe Shale Member, Cherokee Spring locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).

Foraminifers abundant.

Apterrinellidae

Asphaltina sp.

Asteroarchaediscus sp.
Asteroarchaediscus of the group *A. baschkiricus*
 (Krestovnikov and Teodorovitch)

Biseriella sp.
Calcisphaera sp.
C. laevis Williamson

Earlandia sp.
Endothyra sp.

"*Endothyra*" of the group "*E.*" *prisca* Rauzer-
 Chernousova and Reitlinger

Millerella sp.
M. pressa Thompson
Neoarchaediscus incertus (Grozdilova and Lebedeva)
N. parvus (Rauzer-Chernousova)
Planoendothyra sp.
Planospirodiscus sp.
Pseudoglomospira sp.
Zellerina sp.

Collection 4.—Horseshoe Shale Member, Cherokee Peak locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).

Foraminifers present to abundant.

Apterrinellidae

Archaediscus sp.

Archaediscus of the group *A. krestovnikovi* Rauzer-
 Chernousova

Asphaltina sp.

Asteroarchaediscus sp.

Asteroarchaediscus of the group *A. baschkiricus*
 (Krestovnikov and Teodorovitch)

Calcisphaera sp.

Earlandia sp.

Endothyra sp.

"*Endothyra*" of the group "*E.*" *prisca* Rauzer-
 Chernousova and Reitlinger

Lipinella sp. (nom. nud.)

Millerella sp.

M. pressa Thompson

Neoarchaediscus incertus (Grozdilova and Lebedeva)

N. parvus (Rauzer-Chernousova)

Planospirodiscus sp.

Pseudoendothyra sp.

Pseudoglomospira sp.

Collection 5.—Horseshoe Shale Member, Cherokee Peak locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).

Foraminifers abundant.

Apterrinellidae

Archaediscus sp.

Archaediscus of the group *A. krestovnikovi* Rauzer-
 Chernousova

Asphaltina sp.

Asteroarchaediscus sp.

A. baschkiricus (Krestovnikov and Teodorovitch)

Calcisphaera sp.

C. laevis Williamson

"*Cornuspira*" sp.

Diplosphaerina sp.

Earlandia sp.

Endothyra sp.

Eotuberitina sp.

Neoarchaediscus sp.
N. incertus (Grozdilova and Lebedeva)
N. parvus (Rauzer-Chernousova)
Planospirodiscus sp.
Pseudoglomospira sp.
Pseudoendothyra sp.
 Rhodophycophyta
Zellerina sp.

Collection 6.—Ranchester Limestone Member, Rawlins US
 287 locality.

Age.—Zone 21, early Westphalian, Pennsylvanian
 (Atokan).

Foraminifers present.

Archaediscus sp.

Asteroarchaediscus sp.

Calcisphaera sp.

C. laevis Williamson

Eoschubertella sp.

Eostaffella sp.

Millerella sp.

Pseudoglomospira sp.

Tetrataxis sp.

Collection 13.—Ranchester Limestone Member, Meadow
 Ranch locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone),
 Pennsylvanian (Morrowan).

Foraminifers scarce.

Asteroarchaediscus sp.

Asteroarchaediscus of the group *A. baschkiricus*
 (Krestovnikov and Teodorovitch)

Calcisphaera sp.

C. laevis Williamson

Earlandia sp.

Endothyra of the group *E. bowmani* Phillips emend.

Brady

Eostaffella sp.

Eostaffellina sp.

Globivalvulina sp.

Lipinella sp. (nom. nud.)

Millerella sp.

M. pressa Thompson

M. aff. M. pura Malakhova

Neoarchaediscus sp.

Planoendothyra sp.

Pseudoendothyra sp.

Tetrataxis sp.

Zellerina sp.

Collection 14.—Ranchester Limestone Member, Buck Spring
 locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).

Foraminifers abundant.

Asteroarchaediscus sp.

A. baschkiricus (Krestovnikov and Teodorovitch)

Biseriella sp.

B. moderata (Reitlinger)

Calcisphaera sp.

Endothyra sp.

Earlandia sp.

Eostaffella sp.

"*Eotuberitina*" sp.

Globivalvulina of the group *G. bulloides* (Brady)

Lipinella sp. (nom. nud.)
 cf. *Palaeonubecularia*? sp.
Pseudoglomospira sp.
Tuberitina sp.

Collection 45.—Horseshoe Shale Member, Livingston Ranch locality.

Age.—Zone 18, early Namurian (*Eumorphoceras* Zone), Late Mississippian (late Chesterian).
 Foraminifers present.
Asteroarchaediscus sp.
Biseriella sp.
Biseriella of the group *B. parva* (Chernysheva)
Calcisphaera sp.
Earlandia sp.
Endothyra sp.
Eostaffella sp.
Eostaffellina sp.
Neoarchaediscus sp.
Palaeotextularia sp.
Planospirodiscus sp.
Pseudoendothyra sp.
Zellerina discoidea (Girty)

Collection 50.—Ranchester Limestone Member, Trout Creek locality.

Age.—Zone 20?, late Namurian (*Reticuloceras* Zone)?, Pennsylvanian (Morrowan)?
 Foraminifers scarce and poorly preserved.
 Apterrinellidae
Calcisphaera sp.
 Cornuspiridae
Earlandia sp.
 cf. *Lipinella* sp. (nom. nud.)
Pseudoglomospira sp.

Collection 63.—Ranchester Limestone Member, Amsden Creek locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).
 Foraminifers abundant.
 Apterrinellidae
Archaediscus sp.
Archaediscus of the group *A. krestovnikovi* Rauzer-Chernoussova
Asteroarchaediscus sp.
A. baschkiricus (Krestovnikov and Teodorovitch)
Biseriella sp.
Biseriella of the group *B. parva* (Chernysheva)
B. moderata (Reitlinger)
Calcisphaera sp.
Climacammina sp.
 Cornuspiridae
Diplosphaerina sp.
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips emend. Brady
Eostaffella sp.
Eostaffellina sp.
Eotuberitina sp.
Globivalvulina sp.
Millerella sp.
Neoarchaediscus of the group *N. incertus* (Grozdilova and Lebedeva)
Palaeotextularia sp.

Planoendothyra sp.
Pseudoendothyra sp.
 Stacheiinae
Tetrataxis sp.

Collection 64.—Ranchester Limestone Member, Amsden Creek locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).
 Foraminifers abundant.
 Apterrinellidae
Asteroarchaediscus sp.
Biseriella moderata (Reitlinger)
Calcisphaera sp.
 Cornuspiridae
Endothyra sp.
Eostaffella sp.
E. circuli (Thompson)
Eostaffellina sp.
Globivalvulina sp.
Lipinella sp. (nom. nud.)
 cf. *Palaeonubecularia*? sp.
Pseudoendothyra sp.
Zellerina discoidea (Girty)

Collection 65.—Ranchester Limestone Member, Amsden Creek locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).
 Foraminifers abundant.
 Apterrinellidae
Archaediscus sp.
Archaediscus of the group *A. krestovnikovi* Rauzer-Chernoussova
Asteroarchaediscus sp.
A. baschkiricus (Krestovnikov and Teodorovitch)
Biseriella sp.
B. moderata (Reitlinger)
Calcisphaera sp.
 Cornuspiridae
Endothyra sp.
Eostaffella sp.
E. circuli (Thompson)
Eostaffella of the group *E. pseudostruvei* (Rauzer-Chernoussova)
Eostaffellina sp.
E. paraprotvae (Rauzer-Chernoussova)
Globivalvulina sp.
Lipinella sp. (nom. nud.)
Millerella sp.
Neoarchaediscus sp.
 cf. *Palaeonubecularia*? sp.
Pseudoendothyra sp.
Pseudoglomospira sp.
Volvotextularia sp.

Collection 67.—Ranchester Limestone Member, Amsden Creek locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).
 Foraminifers present.
Asteroarchaediscus sp.
A. baschkiricus (Krestovnikov and Teodorovitch)
Biseriella moderata (Reitlinger)
B. parva (Chernysheva)

Diplosphaerina sp.
Earlandia sp.
Endothyra sp.
Eostaffella sp.
Eotuberitina sp.
Globivalvulina sp.
Globoendothyra sp.
Lipinella sp. (nom. nud.)
Neoarchaediscus sp.
 cf. *Palaeonubecularia*? sp.
Palaeotextularia of the group *P. consobrina* Lipina
Palaeotextularia of the group *P. longiseptata* Lipina
Tuberitina sp.

Collection 68.—Ranchester Limestone Member, Amsden Creek locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).
 Foraminifers abundant.
 Apterrinellidae
Archaediscus sp.
Asteroarchaediscus baschkiricus (Krestovnikov and Teodorovitch)
Biseriella sp.
Biseriella of the group *B. parva* (Chernysheva)
B. moderata (Reitlinger)
Calcisphaera sp.
Climacammina sp.
 Cornuspiridae
Endothyra sp.
Eostaffella sp.
Eostaffella paraprotae (Rauzer-Chernousova)
Eotuberitina sp.
Globivalvulina sp.
Lipinella sp. (nom. nud.)
 cf. *Millerella*? sp.
Neoarchaediscus of the group *N. incertus* (Grozdilova and Lebedeva)
Neoarchaediscus of the group *N. parvus* (Rauzer-Chernousova)
Palaeotextularia of the group *P. consobrina* Lipina
Palaeotextularia of the group *P. longiseptata* Lipina
Planospirodiscus sp.
Pseudoglomospira sp.
 Stacheiinae
Tetrataxis sp.
Zellerina sp.

Collection 71.—Ranchester Limestone Member, Tip Top Well locality.

Age.—Zone 21, early Westphalian, Pennsylvanian (Atokan).
 Foraminifers present.

The following list was compiled by Betty Skipp (written commun., 1969).

Asteroarchaediscus sp.
Bradyina? sp.
Climacammina sp.
Endothyra sp.
Eostaffella sp.
Eostaffella of the group *E. acutissima* Kireeva
Eostaffella? sp.
Globoendothyra sp.
Lipinella sp. (nom. nud.)
Millerella sp.

Palaeotextularia of the group *P. consobrina* Lipina
Palaeotextularia of the group *P. longiseptata* Lipina
Pseudoglomospira? sp.
Stacheia sp.
Stacheoides sp.
 "Trepeilopsis" sp.
Tuberitina sp.

Collection 74.—Moffat Trail Limestone Member, Moffat Trail locality.

Age.—Zone 18, late early Namurian (upper *Eumorphoceras* Zone), Late Mississippian (Chesterian).

Foraminifers present.

Archaediscus sp.

Archaediscus of the group *A. krestovnikovi* Rauzer-Chernousova

Asteroarchaediscus sp.

A. baschkiricus (Krestovnikov and Teodorovitch)

Biseriella parva (Chernysheva)

B. moderata (Reitlinger)

Calcisphaera sp.

C. laevis Williamson

Earlandia clavatula (Howchin)

E. elegans (Rauzer-Chernousova)

Endothyra sp.

Endothyra of the group *E. bowmani* Phillips emend.

Brady

Endothyra of the group *E. similis* Rauzer-Chernousova and Reitlinger

E. excellens (Zeller)

Eostaffella sp.

E. circuli (Thompson)

Endothyranella sp.

Eotuberitina sp.

Neoarchaediscus incertus (Grozdilova and Lebedeva)

N. parvus (Rauzer-Chernousova)

Palaeotextularia sp.

Planospirodiscus sp.

Pseudoendothyra sp.

Pseudoendothyra of the group *P. kremenskensis* Rozovskaia

Zellerina discoidea (Girty)

Collection 75.—Moffat Trail Limestone Member Moffat Trail locality.

Age.—Zone 17 or 18, early Namurian (*Eumorphoceras* Zone), Late Mississippian (Chesterian).

Foraminifers present.

Archaediscus sp.

Archaediscus of the group *A. krestovnikovi* Rauzer-Chernousova

Asteroarchaediscus sp.

Calcisphaera sp.

Endothyra sp.

Endothyra of the group *E. bowmani* Phillips emend.

Brady

Eostaffella circuli (Thompson)

Neoarchaediscus sp.

Pseudoendothyra sp.

Pseudoendothyra of the group *P. kremenskensis* Rozovskaia

Collection 77.—Moffat Trail Limestone Member, Moffat Trail locality.

Age.—Zone 18, early Namurian, Late Mississippian (late Chesterian).

- Foraminifers scarce.
Archaeodiscus sp.
Asteroarchaeodiscus sp.
Earlandia sp.
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips emend.
 Brady
Pseudoendothyra sp.
Zellerina sp.
- Collection 78.—Moffat Trail Limestone Member, Moffat Trail locality.
 Age.—Zone 18, early Namurian, Late Mississippian (late Chesterian).
 Foraminifers scarce.
Archaeodiscus sp.
Asteroarchaeodiscus sp.
Calcisphaera sp.
 "Cornuspira" sp.
Endothyra of the group *E. bowmani* Phillips emend.
 Brady
Eostaffellina sp.
Pseudoendothyra sp.
Zellerina sp.
- Collection 79.—Moffat Trail Limestone Member, Moffat Trail locality.
 Age.—Zone 17 or younger, early Namurian (*Eumorphoceras* Zone) ?, Late Mississippian (Chesterian) ?
 Foraminifers present.
Archaeodiscus of the group *A. krestovnikovi* Rauzer-Chernoussova
Asteroarchaeodiscus sp.
Calcisphaera sp.
Endothyra sp.
Eostaffella sp.
E. circuli (Thompson)
Neoarchaeodiscus sp.
Pseudoendothyra sp.
Pseudoendothyra of the group *P. kremenskensis*
 Rozovskaia
Pseudoendothyra of the group *P. ovata* (Reitlinger)
Pseudoendothyra of the group *P. struvei* (von Möller)
- Collection 82.—Ranchester Limestone Member, Moffat Trail locality.
 Age.—Undetermined.
 Foraminifers very scarce.
Calcisphaera sp.
Endothyra sp.
- Collection 90.—Moffat Trail Limestone Member, Covey Cutoff locality.
 Age.—Zone 17 or 18, early Namurian (*Eumorphoceras* Zone), Late Mississippian (Chesterian).
 Foraminifers abundant.
Archaeodiscus sp.
A. krestovnikovi Rauzer-Chernoussova
Asteroarchaeodiscus sp.
A. baschkiricus (Krestovnikov and Teodorovitch)
Calcisphaera sp.
Climacammina sp.
 "Cornuspira" sp.
Diplosphaerina sp.
Earlandia clavatula (Howchin)
E. elegans (Rauzer-Chernoussova)
Endothyra sp.

- Endothyra* of the group *E. bowmani* Phillips emend.
 Brady
Endothyra of the group *E. similis* Rauzer-Chernoussova and Reitlinger
Eostaffella sp.
E. circuli (Thompson)
Eotuberitina sp.
Globoendothyra sp.
Neoarchaeodiscus incertus (Grozilova and Lebedeva)
N. parvus (Rauzer-Chernoussova)
Palaeotextularia of the group *P. consobrina* Lipina
Palaeotextularia of the group *P. longiseptata* Lipina
Pseudoendothyra sp.
Pseudoendothyra of the group *P. kremenskensis*
 Rozovskaia
Stacheoides sp.
Tuberitina sp.
Zellerina discoidea (Girty)
- Collection 92.—Moffat Trail Limestone Member, Covey Cutoff locality.
 Age.—Zone 17 or 18, early Namurian (*Eumorphoceras* Zone), Late Mississippian (Chesterian).
 Foraminifers abundant.
Archaeodiscus sp.
Asteroarchaeodiscus sp.
A. baschkiricus (Krestovnikov and Teodorovitch)
Calcisphaera sp.
C. laevis Williamson
Climacammina sp.
Diplosphaerina sp.
Earlandia sp.
E. clavatula (Howchin)
E. elegans (Rauzer-Chernoussova)
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips emend.
 Brady
E. excellens (Zeller)
Endothyra of the group *E. similis* Rauzer-Chernoussova and Reitlinger
E. tantala (Zeller)
Eostaffella sp.
E. circuli (Thompson)
Eotuberitina sp.
Neoarchaeodiscus sp.
N. incertus (Grozilova and Lebedeva)
N. parvus (Rauzer-Chernoussova)
Palaeotextularia of the group *P. consobrina* Lipina
Palaeotextularia of the group *P. longiseptata* Lipina
Planospirodiscus sp.
P. minimus (Grozilova and Lebedeva)
Pseudoendothyra sp.
Pseudoendothyra of the group *P. kremenskensis*
 Rozovskaia
Pseudoglomospira sp.
Tetrataxis sp.
Tuberitina sp.
Zellerina discoidea (Girty)
- Collection 93.—Moffat Trail Limestone Member, Covey Cutoff locality.
 Age.—Zone 17 or 18, early Namurian (*Eumorphoceras* Zone), Late Mississippian (Chesterian).
Archaeodiscus sp.
Asteroarchaeodiscus sp.

cf. *Biseriella*? sp.

Calcisphaera sp.

Earlandia sp.

Endothyra sp.

Eostaffella sp.

Neoarchaediscus sp.

Planospirodiscus sp.

Pseudoendothyra sp.

Tetrataxis sp.

Collection 100.—Ranchester Limestone Member Covey Cutoff locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zone), Pennsylvanian (Morrowan).

Foraminifers abundant.

Archaediscus sp.

Asteroarchaediscus sp.

Biseriella of the group *B. parva* (Chernysheva)

B. moderata (Reitlinger)

Calcisphaera sp.

Endothyra of the group *E. bowmani* Phillips emend.

Brady

E. excellens (Zeller)

"*Endothyra*" of the group "*E.*" *prisca* Rauzer-Chernousova and Reitlinger

Endothyra of the group *E. similis* Rauzer-Chernousova and Reitlinger

cf. *Eolasiiodiscus*? sp.

Eostaffella sp.

Globivalvulina sp.

Lipinella sp. (nom. nud.)

Millerella sp.

M. pressa Thompson

Monotaxinoides sp.

Neoarchaediscus sp.

Planoendothyra sp.

Planospirodiscus sp.

Pseudoendothyra sp.

Pseudoglomospira sp.

Zellerina sp.

Collection 103.—Moffat Trail Limestone Member, Haystack Peak locality.

Age.—Zone 17, earliest Namurian (lower *Eumorphoceras* Zone), Late Mississippian (middle Chesterian).

Foraminifers scarce.

Archaediscus sp.

Asteroarchaediscus sp.

Calcisphaera sp.

C. laevis Williamson

Earlandia sp.

Endothyra sp.

Neoarchaediscus sp.

Planospirodiscus sp.

Collection 104.—Moffat Trail Limestone Member, Haystack Peak locality.

Age.—Zone 17, earliest Namurian (lower *Eumorphoceras* Zone), Late Mississippian (middle Chesterian).

Foraminifers present.

Archaediscus sp.

Asteroarchaediscus sp.

Calcisphaera laevis Williamson

C. pachysphaerica (Pronina)

Earlandia sp.

Endothyra sp.

Endothyra of the group *E. bowmani* Phillips emend.

Brady

Endothyra of the group *E. similis* Rauzer-Chernousova and Reitlinger

Eostaffella sp.

E. circuli (Thompson)

Neoarchaediscus sp.

Palaeotextularia of the group *P. consobrina* Lipina

Palaeotextularia of the group *P. longiseptata* Lipina

Pseudoendothyra sp.

Pseudoendothyra of the group *P. kremenskensis*

Rozovskaia

Stacheia sp.

Stacheoides sp.

Collection 105.—Moffat Trail Limestone Member, Haystack Peak locality.

Age.—Zone 18, late early Namurian (upper *Eumorphoceras* Zone), Late Mississippian (Chesterian).

Foraminifers present.

Archaediscus sp.

Asteroarchaediscus sp.

Calcisphaera laevis Williamson

Climacammina sp.

Earlandia sp.

E. elegans (Rauzer-Chernousova)

Endothyra sp.

Endothyra of the group *E. bowmani* Phillips emend.

Brady

Endothyra of the group *E. similis* Rauzer-Chernousova and Reitlinger

Eostaffella sp.

E. pinguis (Thompson)

Eostaffellina sp.

Neoarchaediscus sp.

Palaeotextularia of the group *P. consobrina* Lipina

Palaeotextularia of the group *P. longiseptata* Lipina

Pseudoendothyra sp.

Pseudoendothyra of the group *P. kremenskensis*

Rozovskaia

Zellerina discoidea (Girty)

Collection 109.—Moffat Trail Limestone Member, South Indian Creek locality.

Age.—Zone 17, earliest Namurian (lower *Eumorphoceras* Zones), Late Mississippian (Chesterian).

Foraminifers abundant.

Archaediscus sp.

A. krestovnikovi Rauzer-Chernousova

Asteroarchaediscus sp.

A. baschkiricus (Krestovnikov and Teodorovitch)

Earlandia sp.

E. clavatula (Howchin)

E. vulgaris (Rauzer-Chernousova and Reitlinger)

Endothyra sp.

Endothyra of the group *E. bowmani* Phillips emend.

Brady

Endothyra of the group *E. similis* Rauzer-Chernousova and Reitlinger

Eostaffella sp.

Globoendothyra sp.

Neoarchaediscus sp.

N. incertus (Grozdilova and Lebedeva)

N. parvus (Rauzer-Chernousova)

Planospirodiscus sp.

P. minimus (Grozdilova and Lebedeva)

Pseudoendothyra sp.

Zellerina discoidea (Girty)

Collection 121.—Moffat Trail Limestone Member, Hoback Canyon locality.

Age.—Undetermined.

Foraminifers scarce, occur as ghosts.

Archaeodiscidae?

Endothyridae?

Eostaffellidae?

Collection 122.—Moffat Trail Limestone Member, Hoback Canyon locality.

Age.—Zone 18, late early Namurian (upper *Eumorphoceras* Zone), Late Mississippian (Chesterian).

Foraminifers scarce.

Archaeodiscus sp.

Archaeodiscus of the group *A. chernoussoviensis* Mamet

Archaeodiscus of the group *A. krestovnikovi* Rauzer-

Chernoussova

Asteroarchaediscus sp.

A. baschkiricus (Krestovnikov and Teodorovitch)

Biseriella sp.

B. parva (Chernysheva)

B. moderata (Reitlinger)

Calcisphaera sp.

"*Cornuspira*" sp.

Earlandia sp.

Endothyra sp.

Eostaffella sp.

Neoarchaediscus sp.

N. incertus (Grozdilova and Lebedeva)

N. parvus (Rauzer-Chernoussova)

Planospirodiscus sp.

Zellerina discoidea (Girty)

Collection 124.—Moffat Trail Limestone Member, Hoback Canyon locality.

Age.—Zone 18, early Namurian (*Eumorphoceras* Zone), Late Mississippian (late Chesterian).

Foraminifers present.

Archaeodiscus of the group *A. krestovnikovi* Rauzer-Chernoussova

Asteroarchaediscus sp.

Asteroarchaediscus of the group *A. baschkiricus* (Krestovnikov and Teodorovitch)

Biseriella of the group *B. parva* (Chernysheva)

B. moderata (Reitlinger)

Calcisphaera sp.

Cornuspiridae

Endothyra sp.

cf. *Endostaffella*? sp.

Neoarchaediscus sp.

Planospirodiscus sp.

"*Tetrataxis*" of the group "*T. eominima* Rauzer-Chernoussova

Trepeilopsis sp.

Zellerina discoidea (Girty)

Collection 125.—Moffat Trail Limestone Member, Hoback Canyon locality.

Age.—Zone 18 (or younger?), early Namurian (*Eumorphoceras* Zone), Late Mississippian (late Chesterian).

Foraminifers scarce.

Apterrinellidae

Asteroarchaediscus sp.

Biseriella sp.

B. moderata (Reitlinger)

Neoarchaediscus sp.

Pseudoglomospira sp.

Collection 126.—Moffat Trail Limestone Member, Hoback Canyon locality.

Age.—Zone 17 or 18, early Namurian (*Eumorphoceras* Zone), Late Mississippian (Chesterian).

Foraminifers present.

Archaeodiscus sp.

A. krestovnikovi Rauzer-Chernoussova

Asteroarchaediscus sp.

A. baschkiricus (Krestovnikov and Teodorovitch)

Earlandia sp.

Endothyra sp.

Endothyra of the group *E. bowmani* Phillips emend.

Brady

Eostaffella sp.

Glomospira sp.

Monotaxinoides sp.

Neoarchaediscus sp.

Planospirodiscus sp.

Pseudoglomospira sp.

"*Tetrataxis*" of the group "*T. eominima* Rauzer-Chernoussova

Zellerina discoidea (Girty)

Collection 132.—Ranchester Limestone Member, Hoback Canyon locality.

Age.—Zone 20, late Namurian (*Reticuloceras* Zones), Pennsylvanian (Morrowan).

Foraminifers scarce.

Biseriella sp.

Calcisphaera sp.

Earlandia sp.

Endothyra sp.

Globivalvulina of the group *G. bulloides* (Brady)

Pseudoglomospira sp.

Collection 145.—Moffat Trail Limestone Member, Phillips Canyon locality.

Age.—Zone 18, late early Namurian (upper *Eumorphoceras* Zone), Late Mississippian (Chesterian).

Foraminifers scarce.

Archaeodiscus sp.

Archaeodiscus of the group *A. krestovnikovi* Rauzer-Chernoussova.

Asteroarchaediscus sp.

Biseriella sp.

B. parva (Chernysheva)

B. moderata (Reitlinger)

Calcisphaera sp.

Earlandia sp.

Endothyra sp.

Neoarchaediscus sp.

Planospirodiscus sp.

Pseudoglomospira sp.

Tuberitina sp.

Collection 153.—Horseshoe Shale Member, Berry Creek locality.

Age.—Zone 19, middle Namurian (*Homoceras* Zone), Late Mississippian (latest Chesterian).

Foraminifers scarce.

Apterrinellidae

- Archaediscus* sp.
Asteroarchaediscus sp.
 Cornuspiridae
Eosigmoilina sp.
Eostaffella sp.
Neoarchaediscus sp.
- Collection 154.—Horseshoe Shale Member, Berry Creek locality.
 Age.—Zone 18 or younger, early Namurian (*Eumorphoceras* Zone) ?, Late Mississippian (Chesterian) ?
 Foraminifers scarce.
 Apterrinellidae
 Cornuspiridae
Biseriella of the group *B. parva* (Chernysheva)
- Collection 160.—Ranchester Limestone Member, Elk Ridge locality.
 Age.—Zone 18 or younger, early Namurian (*Eumorphoceras* Zone) ?, Late Mississippian (Chesterian) ?
 Foraminifers scarce.
 Apterrinellidae
Asteroarchaediscus sp.
Biseriella of the group *B. parva* (Chernysheva)
Climacammina sp.
 Cornuspiridae
Earlandia sp.
Endothyra sp.
E. excellens (Zeller)
Eostaffella sp.
Palaeotextularia sp.
Planospirodiscus sp.
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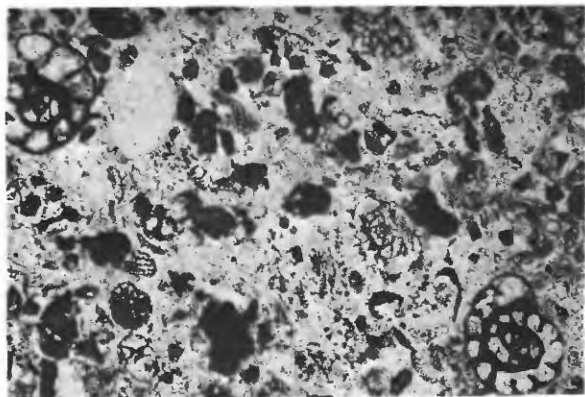
PLATES 1 and 2

[Contact photographs of the plates in this report are available, at
cost, from U.S. Geological Survey Library, Federal Center,
Denver, Colorado 80225]

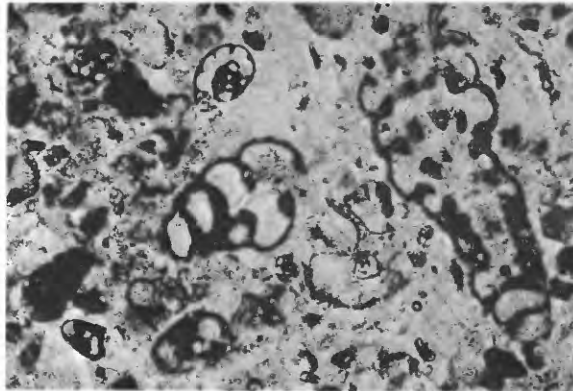
PLATE 1

[All figures $\times 25$, except fig. 8 $\times 17$]

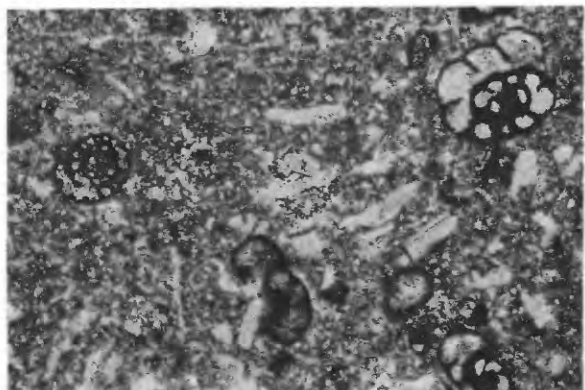
- FIGURES 1, 2. Collection 92, Covey Cutoff locality, Moffat Trail Limestone Member, Zone 17, earliest Namurian, middle Chester equivalent. Recrystallized foraminiferal-pelmatozoan-lump-bearing grainstone. Foraminiferal wall recrystallization is highly variable—in figure 1, the diaphanotheca of the *Pseudoendothyra* sp. is reduced to a ghost, whereas the tectum of the nearby *Endothyra* is perfectly preserved. Biota is composed of *Endothyra* of the group *E. bowmani* Phillips emend. Brady (*Endothyra excellens* of Zeller), *Endothyra* sp., *Climacammina* sp., *Calcisphaera laevis* Williamson and minute *Zellerina* sp.
3. Collection 109, South Indian Creek locality, Moffat Trail Limestone Member, Zone 17, earliest Namurian, middle Chester equivalent. Slightly recrystallized wackestone; diverse sections of *Endothyra* of the group *E. bowmani* Phillips emend. Brady, *Earlandia* sp., and *Pseudoendothyra* sp. are recognizable.
- 4, 5. Collection 79, Moffat Trail locality, Moffat Trail Limestone Member, Zone 17 or 18, early Namurian, upper Chester equivalent. Slightly dolomitized, recrystallized packstone and grainstone. Foraminifers are almost exclusively pseudoendothyrids; *Pseudoendothyra* of the group *P. ovata* Reitlinger, *Pseudoendothyra* of the group *P. struvei* (von Möller), etc.
- 6–8. Collection 10, Covey Cutoff locality, Ranchester Limestone Member, Zone 20, late Namurian, basal Pennsylvanian. Slightly recrystallized foraminiferal wackestone-packstone. Numerous equatorial sections of *Monotaxinoides* sp. are visible. Other taxa are *Endothyra* of the group *E. bowmani* Phillips emend. Brady (*Endothyra excellens* of Zeller), *Zellerina* sp., cf. *Millerella*? sp., *Earlandia* sp., *Turrispiroides* sp., and “*Endothyra*” of the group “*E. prisca*” Rauzer-Chernousova and Reitlinger.



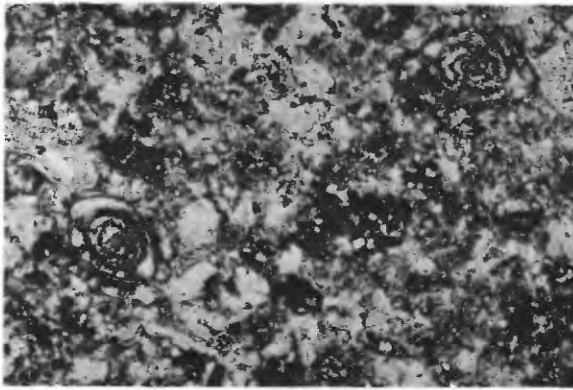
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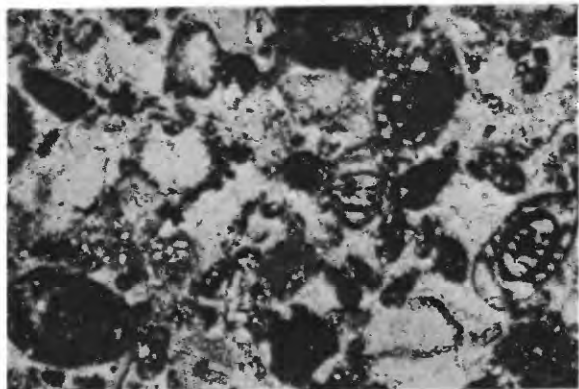
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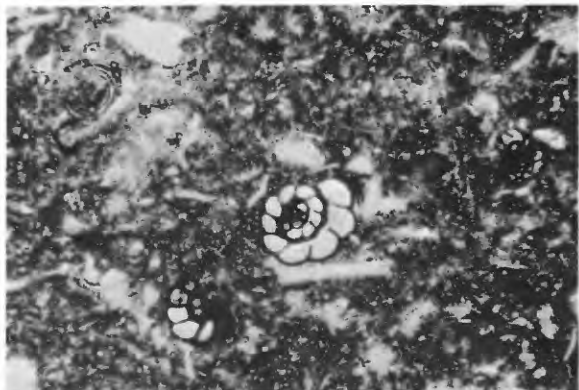
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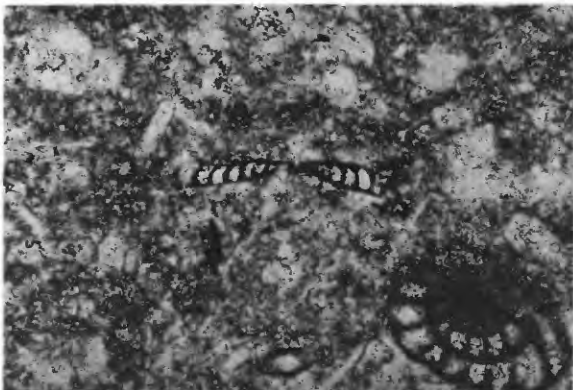
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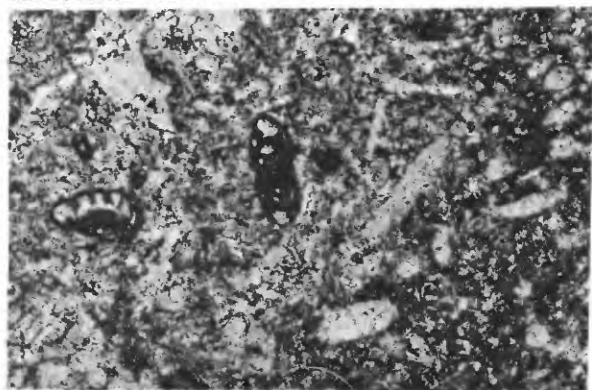
8

REPRESENTATIVE THIN SECTIONS OF FORAMINIFERS AND
ALGAE FROM THE AMSDEN FORMATION

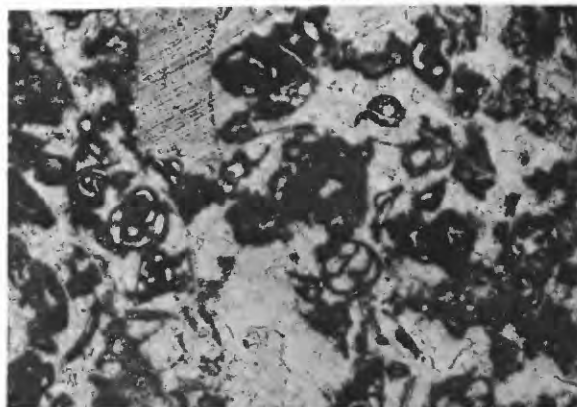
PLATE 2

[All sections from Ranchester Limestone Member, Zone 20, late Namurian, basal Pennsylvanian]

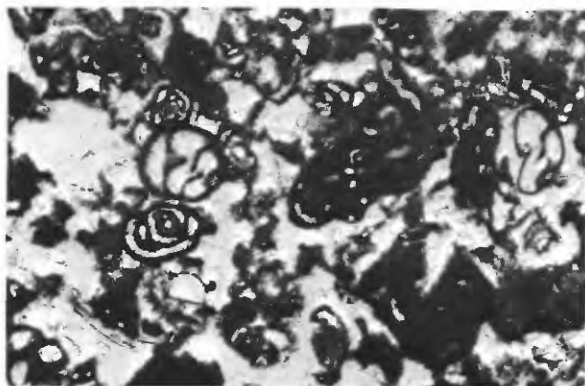
- FIGURE 1. Collection 13, Meadow Ranch locality, $\times 30$. Recrystallized wackestone. A small *Asteroarchaediscus* of the group *A. baschkiricus* (Krestovnikov and Teodorovitch) is barely visible, right of *Eostaffella* sp.
- 2, 3. Collection 14, Buck Spring locality $\times 30$. Foraminiferal-pelmatozoan-spongiostromid pelletoid grainstone. Note the abundance of serpulopsids, apterrinellids, and biseriamminids (*Globivalvulina* sp., *Biseriella* sp.). Small tuberitinids ("*Eotuberitina*" sp.) are also present.
- 4-6. Collection 65, Amsden Creek locality, figs. 4, 5, $\times 97$, fig. 6, $\times 25$. Foraminiferal packstone rich in apterrinellids, serpulopsids, and eostaffellids (*Eostaffellina paraprotvae* (Rauzer-Chernoussova), *Eostaffella circuli* (Thompson), deeply umbilicated *Eostaffella* of the group *E. pseudostruvei* (Rauzer-Chernoussova), *Eostaffella* sp.). Some *Endothyra* sp., *Pseudoendothyra* sp., *Biseriella moderata* (Reitlinger), *Biseriella* sp., and *Calcisphaera* sp. are also present. The high magnification photographs show the wall structure of *Biseriella* sp. (a dark, dense tectum) and of *Eostaffellina paraprotvae* (Rauzer-Chernoussova).
7. Collection 68, Amsden Creek locality, $\times 30$. Recrystallized packstone with a tiny *Planospirodiscus* sp.
8. Collection 64, Amsden Creek locality, $\times 25$. Pelmatozoan packstone with *Eostaffella* sp. and *Eostaffella circuli* (Thompson).



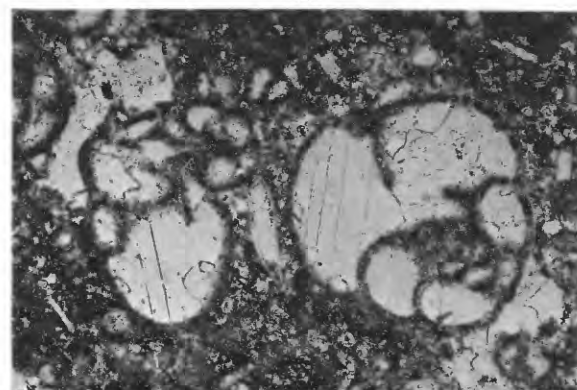
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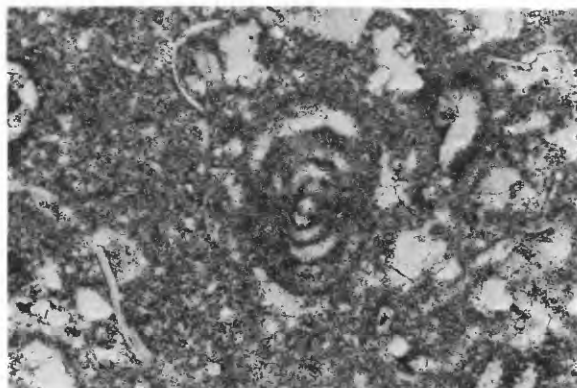
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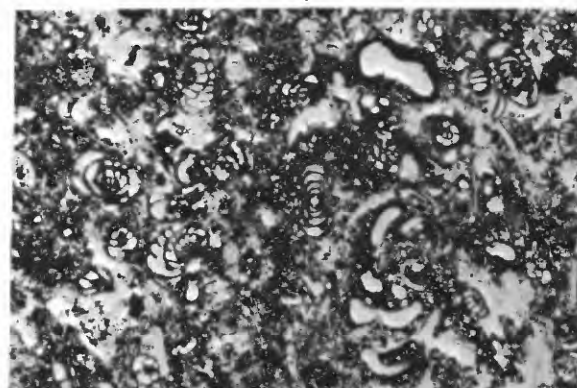
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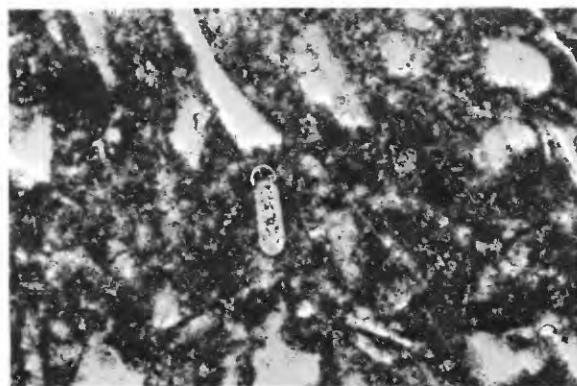
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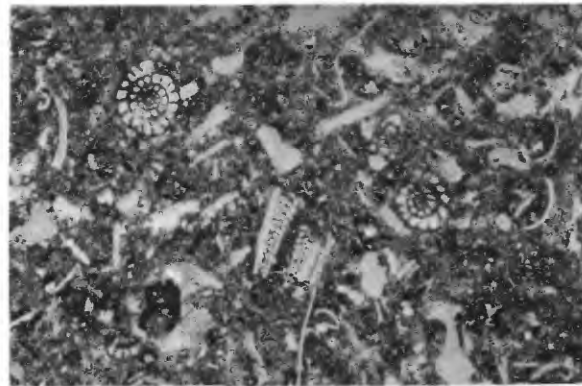
5



6



7



8

REPRESENTATIVE THIN SECTIONS OF FORAMINIFERS AND
ALGAE FROM THE AMSDEN FORMATION