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MISSISSIPPIAN FORAMINIFERA OF THE SOUTHERN CANADIAN ROCKY MOUNTAINS, ALBERTA

by

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Mississippian Foraminifera of the Southern Canadian Rocky Mountains, Alberta

ABSTRACT

Four main foraminiferal range zones, two concurrent-range zones and one assemblage zone are recognized in Mississippian strata of the Canadian Rocky Mountains; they are, the *Endothyra tumula, Endothyra lanceolata, Endothyra zelleri* [*Endothyra symmetrica*] and *Endothyra kleina* Range Zones, the *Endothyra tumula-Endothyra spinosa,* and *Endothyra zelleri-Endothyra? banffensis* Concurrent-range Zones and the *Endothyra spiroides* Assemblage Zone. Faunas of these zones range in age from late Kinderhookian to early Chesterian.

Twelve new endothyroid species are described, of which seven are named. Another species, *Endothyra symmetrica* E. J. Zeller (preoccupied), is renamed *E. zelleri.* A new genus, *Granuliferelloides,* is erected with the genoholotype, *G. jasperensis.* The endothyrids are associated with species of *Spiroplectammina, Ammodiscus, Tournayella?, Glomospirella, Archaediscus, Palaeotextularia and Permodiscus.*

Sections of Mississippian strata were measured and sampled from the Front Ranges at Banff and Jasper and the Foothills at Moose Mountain. Foraminifera are present in parts of the Livingstone, Mount Head and Etherington Formations at Banff; the Banff, Pekisko and Shunda Formations at Jasper; and the Pekisko and Turner Valley Formations at Moose Mountain.

Foraminifera are found associated with crinoids, corals, brachiopods, bryozoans, molluscs, gastropods, ostracodes and algae, in rocks that reflect shallow water deposition.

INTRODUCTION

During the past thirty-five years a large amount of paleontological work has been carried out on Mississippian rocks in Western Canada. In spite of this, the only detailed microfaunal study is Loranger's (1958) outline of some ostracode zones of the subsurface Mississippian rocks of the Plains. To remedy in part this deficiency, examination of endothyroid and associated Foraminifera from selected stratigraphic sections of Mississippian rocks in the Foothills and Front Ranges in the Rocky Mountains in Alberta was undertaken.

After their appearance in Early Mississippian time, the Endothyridae developed rapidly into a large and diversified group. Various species are valuable as zonal indices, for they have limited vertical ranges and are widespread. Extensive investigations of the Endothyridae carried out in North America, Europe and Asiatic Russia indicate that the evolutionary development of the family has been cosmopolitan.

Endothyroid genera of the Mississippian strata of the Alberta Rocky Mountains are *Granuliferella, Granuliferelloides,* and *Endothyra.* They are found with the nonendothyroid genera *Spiroplectammina, Ammodiscus, Tournayella*?, *Glomospirella, Archaediscus, Palaeotextularia and Permodiscus.* Of these, only *Granuliferella, Endothyra* and *Ammodiscus* have been previously recorded from the Mississippian rocks of the North American Cordillera. The zonal significance of the nonendothyrids has yet to be established, but from limited study they appear to have restricted vertical ranges.

A major contribution to the knowledge of North American endothyrids was made by E. J. Zeller (1950) and D. E. N. Zeller (1953), who described the endothyrids of the type Mississippian rocks in the Mississippi Valley. Their investigations formed the groundwork for later studies, including one on endothyroid faunas of the United States Cordillera (Zeller, 1957).

Zeller (1950) and Zeller (1953) found that the rocks of the Mississippi Valley contained distinctive endothyrids of Kinderhookian, Osagian, Meramecian and Chesterian ages. The faunas showed marked evolutionary changes, and although Zeller (1957) was not able to correlate his zones of the Cordillera with those of the Mississippi Valley, he found similar evolutionary trends of the endothyrids in each area. Armstrong's (1958) and Woodland's (1958) studies of the Mississippian endothyrids of the western United States have verified Zeller's concept of the developmental pattern of the Endothyridae.

This report extends these microfaunal studies into the southern Canadian Rockies and is based primarily on samples collected from Mississippian sections in the Front Ranges at Banff and Jasper, and in the Foothills at Moose Mountain. Supplementary information was obtained from samples of sections on Bighorn Creek, Mount Rae, Mount Darrah and Crowsnest Ridge (Fig. 1) that were loaned by the University of Alberta. A few Foraminifera were also obtained from cores of Bear Beaumont No. 1 and Shell Cadotte No. 1 wells, from the Alberta Plains region.

Sampling and Laboratory Procedures

The Mississippian sections exposed on Mount Rundle and Tunnel Mountain at Banff, on Canyon Creek in the Moose Mountain dome, and on Morro Creek near Jasper were measured and sampled. On Mount Rundle samples were taken systematically every five feet. In the other three sections they were taken at approximately 20-foot intervals or at each visible change in lithology.

At least one thin section (1 to 1½ inches by 2 inches) cut perpendicular to the bedding was made from each sample in order to determine whether

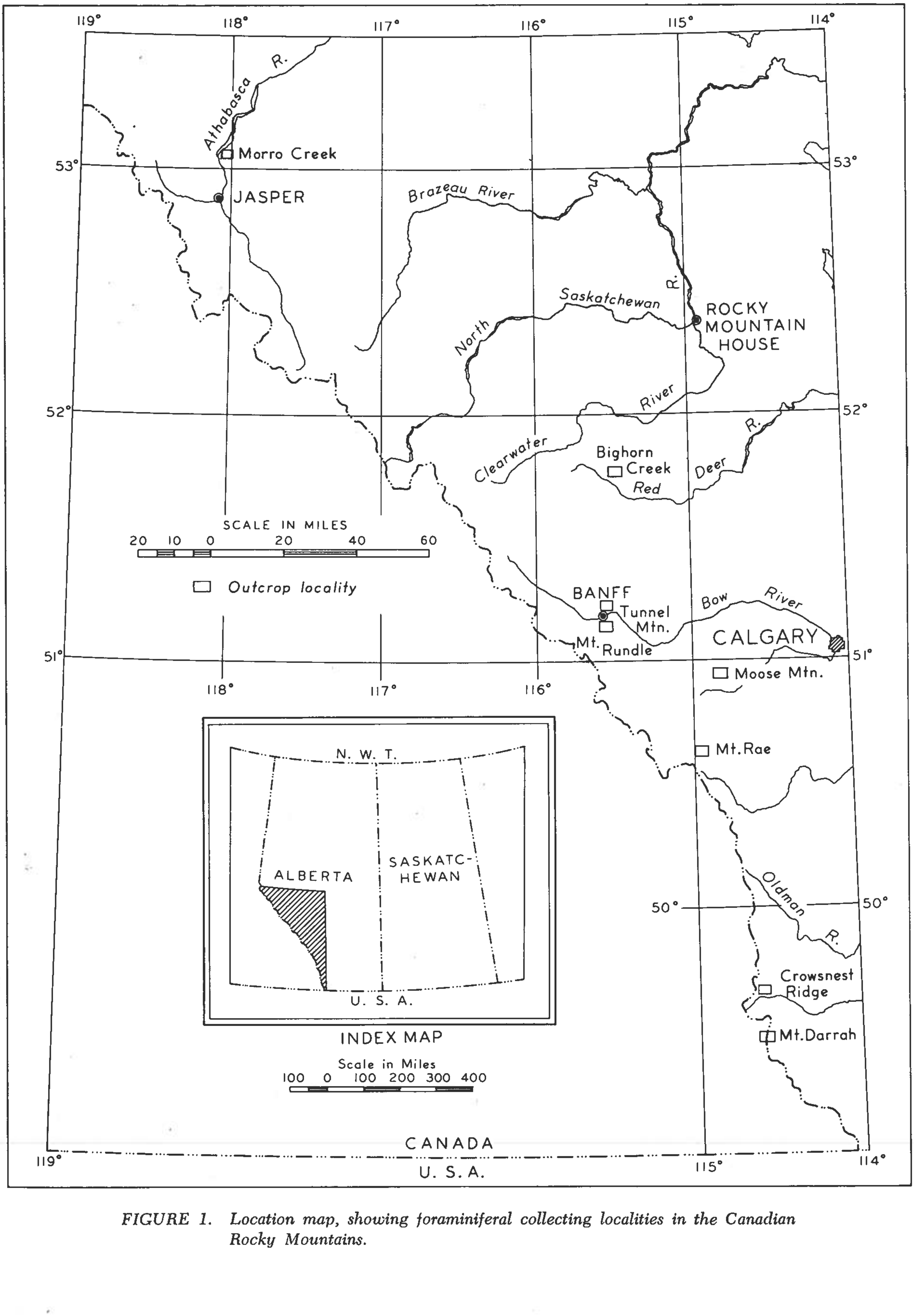

FIGURE 1. Location map, showing foraminiferal collecting localities in the Canadian Rocky Mountains.

Foraminifera were present. Additional thin sections were made if Foraminifera were present to ensure more accurate identification of the species. In some cases secondary dolomitization or silicification had either destroyed or made unidentifiable any fossil material that may have originally been present.

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STRATIGRAPHIC NOMENCLATURE OF THE MISSISSIPPIAN STRATA

Many of the Mississippian formation names used in the Mountains have also been applied to the Plains and Foothills areas. This is in some instances unfortunate, for direct correlation between the Mountains and Plains is hindered both by facies changes and by lack of paleontologic control. Considerable confusion has arisen so that some discussion of stratigraphic terminology is necessary to enable fuller understanding of that used in this report. A detailed and comprehensive history of the nomenclature of the Mississippian strata is given by Moore (1958).

Front Ranges of the Southern Rocky Mountains

In the Mississippian rocks of the Front Ranges between Banff and the Crowsnest Pass two major units can be recognized: a lower recessive unit represented by the Exshaw and Banff Formations, and an upper, predominantly resistant unit represented by the Rundle Group.

The type sections of the Banff Formation and Rundle Group are on Mount Rundle at Banff (Kindle, 1924), and a more accessible section on adjacent Tunnel Mountain has been established as supplementary type section of the Rundle Group (Beales, 1950). The type Banff Formation is composed of three unnamed lithologic units, and the Rundle Group of the Livingstone, Mount Head and Etherington Formations (Fig. 2). These last three formations have their type localities in the Mount Head area, south of Banff. The Livingstone Formation was divided by Douglas (1953) into two members, an upper, called Turner Valley, and a lower, called Pekisko. Later, the lower beds of the Turner Valley were separated as a third, Shunda, member in 1955 by the Alberta Society of Petroleum Geologists Carboniferous Committee (see Moore, 1958). Lithologic equivalents of the Livingstone Formation are found in the lower 1480 feet of the Rundle Group at Banff. However, time equivalents of at least part of the type Pekisko may be found in the upper Banff Formation at Mount Rundle. Correlation of these units is hindered by the predominantly unfossiliferous nature of the beds. Lithologically, members of the Mount Head Formation of the type area are equated with the Mount Head and upper Livingstone Formations at Banff. On a faunal basis, however, the type upper members correlate with the lower and middle beds of the Mount Head Formation at Banff, and although not known with certainty, the lower members probably correlate with the upper beds of the Livingstone Formation at Banff. The upper part of the Mount Head Formation at Banff is equated faunally to the lower part of the type Etherington Formation (Nelson, 1961).

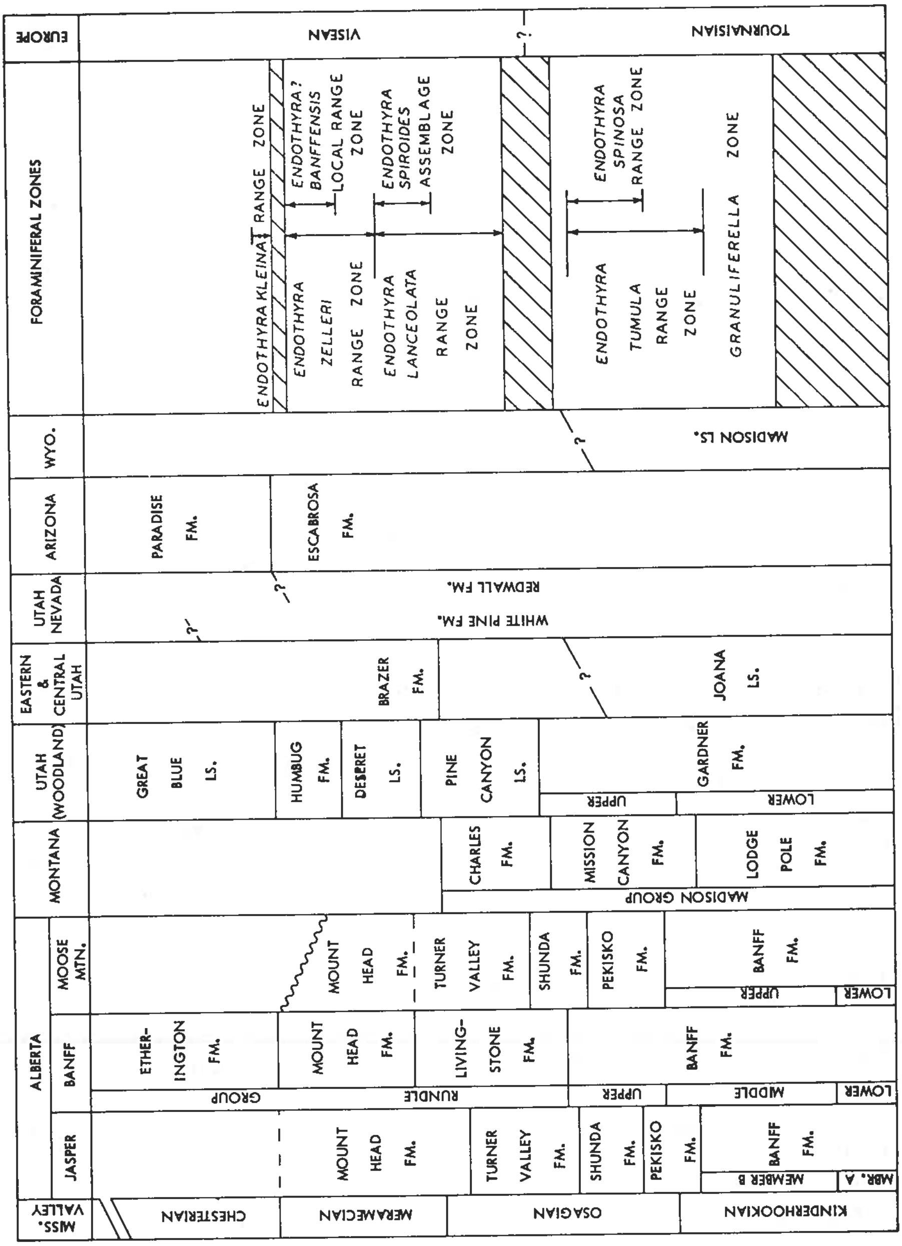

FIGURE 2. Correlation chart of Mississippian rock units and endothyroid zones.

Plains and Foothills of Southern Alberta

The Mississippian rocks of the southern Foothills and Plains can be divided into two gross lithologic units analogous to the Banff and Rundle units of the Mountains. The Plains Banff is lithologically similar to that of the Mountains, but the Plains Rundle is composed mainly of primary dolomites, reflecting a more evaporitic phase of deposition away from the present Mountains. The formations of the Plains Rundle Group are, in ascending order: Pekisko, Shunda, Turner Valley and Mount Head (Fig. 2).

Differences of opinion exist as to where to draw the Banff-Rundle contact in some areas where the Pekisko is present. Moore (1958) considered the Pekisko and overlying Shunda Formation of the Plains both time and lithologic equivalents of the type Banff upper-middle and upper members, respectively, whereas Nelson and Rudy (1959) equated the Jasper Pekisko and Shunda Formations to the Banff upper member only. Moore (1958) placed the Banff-Rundle contact at the base of the Pekisko unit of the Plains region and suggested use of an arbitrary cut-off to allow adjustment of the contact in areas where the Pekisko is absent; Nelson and Rudy placed the Banff-Rundle contact at the top of the Shunda Formation (upper Banff-equivalent). Penner (1958, 1959) accepted Moore's (1958) correlation of the Pekisko and Shunda with the type Banff upper-middle and upper members of Beales (1950), and wished to place the Banff-Rundle contact at the base of the Pekisko Formation of the Plains, but at the base of the upper unit of the middle member of the type Banff Formation. The usage of formational boundaries in a time-stratigraphic sense is not followed here, and, following Moore, the Banff-Rundle contact is placed at the base of the Pekisko Formation beneath the Plains and in the southern Foothills, and at the base of the Livingstone Formation in the Bow Valley region. This contact cannot be placed at the top of the Shunda, as this unit most likely lenses out within the Livingstone Formation south of the Bow River (Green, 1962); nor can it be placed everywhere at the base of the Pekisko, as this unit lenses out within the Banff Formation in the Front Ranges north of the Bow River (Nelson and Rudy, 1959; Green, 1962).

Front Ranges between Banff and Jasper

Brown (1952) made a comprehensive study of the Mississippian strata at Jasper, which he divided in ascending order into the Banff, Rundle and Greenock Formations, and pointed out, from a faunal analysis, that his lower Rundle Formation included considerable Banffian strata at the base. More recently, Nelson and Rudy (1959) have worked out the relationship between the Banff and Jasper Mississippian strata. They used the names Pekisko and Shunda (Fig. 2) for the lower part of Brown's Rundle, as proposed by Moore (1958), but included these units in the Banff Formation. The term "Rundle" was retained for beds overlying the Shunda and underlying the Greenock Formation. They designated the lower and upper parts of the Brown's Banff Formation as members A and B, respectively. Drummond (1961) used the names Turner Valley and Mount Head for the "Rundle" of Nelson and Rudy, although use of the term Mount Head in this region may be open to question.

COLLECTING LOCALITIES

Mount Rundle and Tunnel Mountain

In the initial phase of the study, the Banff Formation was systematically sampled at its type locality on Mount Rundle, and the Rundle Group at its supplementary type locality on Tunnel Mountain near Banff, Alberta. Detailed lithologic descriptions of these sections are given by Beales (1950), and some of his measured footages of the Rundle Group are included in figure 3.

The composite Mississippian section at Banff comprises 3715 feet of calcareous shales, limestones, and siltstones. It is divided into the following formations, in descending order:

Rundle Group

- Etherington Formation (255 feet)—silty, dolomitic limestone and minor siltstone;
- Mount Head Formation (480 feet)—cherty, dolomitic limestone;
- Livingstone Formation (1480 feet)—coarse, crinoidal limestone with dolomite and dolomitic limestone;

Banff Formation (1500 feet)—silty and cherty limestone and minor calcareous shale.

The most prolific foraminiferal assemblages were observed in the Mount Head Formation and uppermost beds of the Livingstone Formation (Fig. 3). Rare specimens were found in the Etherington Formation. Of 146 samples thin sectioned from the Rundle Group at Banff, only 36, or 24 per cent, contained Foraminifera; none from the type Banff Formation contained Foraminifera.

Moose Mountain

The Mississippian rocks forming Moose Mountain are part of a Paleozoic inlier in the middle of the Foothills (Beach, 1943). They thus form a potentially valuable link in correlating between the Mississippian rocks of the Plains and Front Ranges. Samples were collected on the east flank of the Moose Mountain dome from outcrops along Canyon Creek (Secs. 27, 28, Tp. 23, R. 7, W. 5th Mer.), about 25 miles southwest of Calgary. The Mississippian formations there are, in descending order:

Mount Head Formation (400 feet)—cryptocrystalline dolomite with associated anhydrite;

Turner Valley Formation (370 feet)—crinoidal limestone grading upwards into dolomitic limestone and dolomite;

Shunda Formation (190 feet)—lithographic limestone and dolomite;

Pekisko Formation (340 feet)—crinoidal and oolitic limestone;

Banff Formation (510 feet)—argillaceous, cherty limestone grading into crinoidal limestone in the upper part.

The Moose Mountain section is not particularly fossiliferous. Foraminifera were noted (Fig. 4) only in the middle and upper parts of the Pekisko Formation and in the lowermost beds of the Turner Valley Formation. Of 62 samples thin sectioned, Foraminifera were found in 10, or 16 per cent.

Morro Creek, Jasper

As a check on the extent of potential zonal indices, samples were collected from Mississippian rocks at Morro Creek, Jasper. The section is essentially that described by Brown (1952), but the lower part of his original Rundle Formation was assigned the member names Shunda and Pekisko by Moore (1958). These units were raised to formation status by Drummond (1961), and the names Turner Valley and Mount Head were applied to the upper part of the Rundle Group. Drummond's usage is followed in this report. The Morro Creek section (Fig. 4) can be divided into the following units, in descending order:

Mount Head(?) Formation (410 feet)—mainly dolomitic limestone;

Turner Valley Formation (210 feet)—coarse, crinoidal, oolitic and algal limestone;

Shunda Formation (250 feet)—oolitic, crinoidal limestone;

Pekisko Formation (140 feet)—coarse, crinoidal limestone;

Banff Formation

Member B (450 feet)—argillaceous, cherty limestone with coarse, crinoidal limestone in the upper part;

Member A (180 feet)—calcareous shale.

Foraminifera were found (Fig. 4) in the upper part of member B of the Banff Formation, the lowermost beds of the Pekisko Formation, and in the Shunda and Turner Valley Formations. Of 94 predominantly limestone samples thin sectioned, Foraminifera were found in 21, or approximately 19 per cent. None of the dolomitized beds of the Mount Head(?) Formation was thin sectioned.

EVOLUTION OF THE ENDOTHYRIDAE IN WESTERN CANADA

The forerunners of the Endothyridae are not known with certainty. Reitlinger (1958) has suggested that there were two lines of development from an unknown ancestor in the Devonian, one branch leading through the Late Devonian genus *Quasiendothyra* and *Endothyra communis* to the planispiral group of *Endothyra* species, the other to the plectogyroidly coiled species of *Endothyra*. It is noted that there is a significant gap in the history of the planispiral endothyrids through the lower Tournaisian, so that the relationship of the Visean planispiral forms to the Late Devonian septate forms is not clear.

The same problem involving the origin of the planispirally coiled *Endothyra* species confronts North American investigators. The Late Devonian septate planispiral form *Nanicella*—so far noted in the mid-continent area and Alberta Plains (Henbest, 1935; Loranger, 1954)—has been suggested as one possible ancestor, but, as in the U.S.S.R., there is a gap in the record of the planispiral group of *Endothyra* species in the Early Mississippian and no continuous evolutionary sequence from *Nanicella* is traceable. Early Mississippian species differ markedly from the Devonian form by being plectogyroidly coiled; thus, another line of development other than that from *Nanicella* may be involved in their development.

In Western Canada, as well as in the United States Cordillera, the Mississippian is characterized by certain endothyroid assemblages. For example, Lower Mississippian assemblages are made up of *Granuliferella* species with single-layered walls, followed by plectogyroidly coiled species of *Endothyra*. Massive mound- or hook-like secondary deposits present throughout the outer volutions distinguish the species of *Endothyra*. In contrast, Upper Mississippian assemblages are characterized by planispirally as well as plectogyroidly coiled species of *Endothyra*, possessing deposits of a different kind. The lower assemblages have species with a single hamulus in the ultimate chamber; the upper ones have species with diagnostic thick basal layers on the chamber floors. Detailed discussion of the faunas is therefore divided into three parts corresponding to early (Kinderhookian and early Osagian), middle (late Osagian and Meramecian) and late (Chesterian) Mississippian. In tracing the development of the Canadian Rocky Mountain Endothyridae, several gaps in the geologic record are found; as these gaps also exist in sections of the United States Cordillera and mid-continent area, much of the evolutionary history of the North American Endothyridae remains enigmatic.

Early Mississippian (Kinderhookian and Early Osagian) Faunas

The earliest endothyrid observed in Western Canada is *Granuliferella tumida* E. J. Zeller. From this species, or a similar one, primitive plectogyroidly coiled species such as *Endothyra tumula* (Pl. 1, Fig. 1) developed, in turn giving rise to the main evolutionary line of the Endothyridae.

A subsidiary line from *Granuliferella tumida* is traceable to the thick-walled species of *Granuliferella* (e.g. *G. granulosa*) and the genus *Granuliferelloides.*

Early plectogyroidly coiled *Endothyra* species are of several types: some species are characterized by massive secondary deposits in the form of symmetrical mounds (tumuli) on the chamber floors and others by highly asymmetrical chambers *(E.? morroensis).* Species with hook-shaped deposits (e.g. *E. spinosa*) developed from the 'tumulate' endothyrids. The trend in the development of hamuli was towards an increase in their size (e.g. in *E. tuberculata*) with some subsequent resorption in the early portions of the test. In late Mississippian species the hamulus is present only in the ultimate chamber.

Following the appearance of *E. tumula* and the associated fauna, there is a significant gap in the geologic record in Western Canada, and succeeding *Endothyra* species show late Osagian affinities.

Middle Mississippian (Late Osagian and Meramecian) Faunas

Middle Mississippian endothyrids are distinguished from those of Early Mississippian age by the large number of planispirally coiled species, and by the characteristics of the secondary deposits of both plainispirally and plectogyroidly coiled *Endothyra* species which are usually present only as small nodes on the chamber floors, or as a thin hamulus in the ultimate chamber.

In the group of planispirally coiled endothyrids, two main lines of development are found—one towards increased angulation of the periphery and evolute coiling of the outer whorls, cf. *E. zelleri* (Pl. 7, Fig. 12) and and later *Endothyra* sp. (Pl. 10, Fig. 13); the other towards increased wall and septal thickness and test sphericity (e.g. *E. robusta*).

Other evolutionary trends among the middle Mississippian *Endothyra* species have also been observed, including changes in coiling expansion rates, septation and secondary deposits.

Changes in coiling pattern in the planispiral group were from even to uneven rates of expansion. This change is well exemplified by comparing the respective early, middle, and late Meramecian species, *E.* sp. C (Pl. 5, Fig. 22), *E. zelleri* (Pl. 7, Fig. 13) and *E. macra* (Pl. 12, Fig. 6), the last-named species having a characteristic tightly coiled initial portion. Changes in expansion rates in the plectogyroidly coiled group led to the increased distortion of the coiling plane (cf. *E.* sp. D, Pl. 6, Fig. 16; *E. incrassata*, Pl. 7, Fig. 11 and *E.* sp., Pl. 10, Fig. 5).

The trend in septation involved a shortening of the septa due to resorption of the septal ends, a phenomenon which is best illustrated by comparing the early and late Meramecian planispiral forms *E.* sp. C and *E.* sp. (Pl. 10, Fig. 18).

The majority of Meramecian species are characterized by a hamulus in the ultimate chamber as well as by additions to the posterior tips of the septa. A general trend was towards resorption of the hamulus, so that in late Meramecian species it is replaced by discontinuous layers or low mounds on the chamber floors. This type of deposit became well developed in Chesterian species.

Late Mississippian (Chesterian) Faunas

Species of *Endothyra* of Chesterian age are characterized by a plecto-gyroid coil and prominent thick, basal secondary layers on the chamber floors (Zeller, 1950). Only rudimentary deposits of this kind are evident in the early Chesterian *E. kleina* of this report.

FORAMINIFERAL ZONES OF THE CANADIAN ROCKY MOUNTAINS

A number of Mississippian foraminiferal zones were recognized by Zeller (1957) in sections from Arizona northward through Utah into Montana. Subsequently, Armstrong (1958) and Woodland (1958) recognized these zones in New Mexico and Utah, respectively. In the Canadian Rocky Mountains, indices of Zeller's *Endothyra* [*Plectogyra*] *tumula, Endothyra spiroides* and *Endothyra zelleri* [*Endothyra summetrica*] Zones and of Woodland's *Endothyra lanceolata* assemblage and *Endothyra* [*Plectogyra*] *kleina* Zone have been observed (Fig. 2). Although *Granuliferella* species have been described from the Plains and Mountains of Alberta, present data are insufficient to outline the *Granuliferella* Zone. It is noted that this zone is based on the presence of the genus to the exclusion of all other Endothyridae.

In this report the terms range zone, concurrent-range zone and assemblage zone are used to qualify the more general term zone, as recommended by the American Commission on Stratigraphic Nomenclature (1961). Except for the *Granuliferella* Zone, as defined by Zeller (1957), previously established Lower and Mississippian zones of the United States Cordillera are based on the ranges of the index species and are thus essentially range zones.

Local range zones of the above index fossils and the associated Foraminifera are discussed in chronological order.

Endothyra tumula Range Zone

The *Endothyra tumula* Range Zone has been recognized at Morro Creek and Moose Mountain, and some associated species are also found in the limited interval that was examined at Bighorn Creek. At Morro Creek (Fig. 4) the zone extends from the upper part of member B of the Banff Formation to the lower part of the Turner Valley Formation. The associated fauna includes *Granuliferella granulosa, Granuliferelloides jasperensis, Endothyra? morroensis, E. spinosa* and *Spiroplectammina* sp. At Moose Mountain (Fig. 4) the zone spans the upper part of the Pekisko Formation and the zonal species is associated with a fauna including *Granuliferelloides* sp. and *E.* sp. cf. *E. spinosa.* At Bighorn Creek, *Granuliferelloides jasperensis, Granuliferella* sp. and *Endothyra tumula* are found in the lower part of the Shunda Formation.

Endothyra tumula-Endothyra spinosa Concurrent-range Zone

Endothyra spinosa is a significant species of the associated assemblage of *E. tumula* at Morro Creek and Moose Mountain. The range zone of this species approximates to the upper part of the *Endothyra tumula* Range

Zone, the concurrent-range zone spanning most of the Shunda Formation. At Moose Mountain, the *Endothyra spinosa* Range Zone is limited to a short interval of the Pekisko Formation in the upper part of the *Endothyra tumula* Range Zone.

Endothyra lanceolata Range Zone

Above the Lower Mississippian *Endothyra tumula* Zone and below the Upper Mississippian *Endothyra zelleri* Zone, a fauna typified by *E. lanceolata* has been obtained. This fauna has been recognized in the lowermost Turner Valley Formation at Moose Mountain (Fig. 4) and in the upper and lower parts of the Livingstone and Mount Head Formations, respectively, at Tunnel Mountain (Fig. 3). The simplicity of the faunal assemblage at Moose Mountain (Pl. 5, Figs. 7, 9, 10) is reminiscent of Woodland's Pine Canyon assemblage, which is characterized by *E. lanceolata* and the larger, but similar, *E. turgida*. On the other hand, the assemblage at Tunnel Mountain is more complex, being made up of various planispirally and plectogyroidly coiled species.

Endothyra spiroides Assemblage Zone

Many of the planispirally and plectogyroidly coiled endothyrids associated with *E. lanceolata* in its middle and upper range at Tunnel Mountain are similar to unnamed species of the *Endothyra spiroides* Zone of the United States Cordillera; they are accordingly designated as the *Endothyra spiroides* zonal assemblage. The fauna at Tunnel Mountain includes the large plectogyroidly coiled species, *E.* sp. D, the planispirally coiled species, *E.* sp. C and *E.* sp. E, as well as several additional undescribed endothyrids (see Pl. 6).

Endothyra zelleri Range Zone

The *Endothyra zelleri* Range Zone extends from 130 to 415 feet above the base of the Mount Head Formation at Tunnel Mountain (Fig. 3), and elements of the associated fauna have been recognized at Mount Rae in the upper 50 feet of the same formation. The associated fauna at Tunnel Mountain is diverse and includes *E. robusta, E. incrassata, E. macra, E. flatile, E. arrecta,* and *E.? banffensis*. At Mount Rae, *Endothyra macra* and *E. robusta* are found with species of *Tournayella*?, *Archaediscus, Glomospirella* and *Ammodiscus.*

Endothyra zelleri-Endothyra? banffensis Concurrent-range Zone

Endothyra? *banffensis* is a diagnostic species of the upper Mount Head Formation at Tunnel Mountain and its local range coincides with the upper part of the *Endothyra zelleri* Range Zone (Fig. 3).

Endothyra kleina Range Zone

The zone of *E. kleina* is limited to a short interval in the lowermost beds of the Etherington Formation at Tunnel Mountain (Fig. 3). The index fossil is associated only with other small plectogyroidly coiled *Endothyra* species.

CORRELATION AND AGE OF THE FORAMINIFERA

North American Cordillera

In the United States Cordillera, Zeller (1957) outlined two Lower Mississippian zones: the *Granuliferella* and *Endothyra tumula* Zones, and three Upper Mississippian zones: the *Endothyra spiroides, Endothyra zelleri* [*Endothyra symmetrica*] and *Paramillerella* Zones. Later, Woodland (1958) recognized in Utah three of Zeller's zones: the *Granuliferella, Endothyra tumula* and *Endothyra zelleri* Zones. In addition, he introduced another Upper Mississippian zone—that of *Endothyra kleina.*

The *Granuliferella* Zone was first recognized by Zeller (1957) in the Madison Limestone of Utah and Wyoming and the Joana Limestone of Utah (Fig. 2). Woodland (1958) based his *Granuliferella* Zone on the local range of the genus, so that it overlaps the local range of *Endothyra tumula*; thus, his zone is not necessarily wholly correlative with that of Zeller. Woodland's zone extends through the upper Gardner Limestone of central Utah. As previously noted, data are insufficient at present to outline the zone (as Zeller defined it) in Alberta.

The *Endothyra tumula* Zone was established from several localities in the United States Cordillera. In Montana the zone spans the upper 100 to 200 feet of the Lodgepole Formation and the lower 300 to 400 feet of the Mission Canyon Formation (Fig. 2). In Wyoming and Utah it extends from 200 to 700 feet, and from 500 to 1000 feet, respectively, above the base of the Madison Limestone. Woodland outlined an *Endothyra tumula* Subzone of the *Granuliferella* Zone, extending through part of the upper Gardner Limestone in Utah.

In the Canadian Cordillera, the *Endothyra tumula* Range Zone has been recognized at Morro Creek and Moose Mountain (p. 12). Two distinct faunal assemblages, coinciding with the lower and upper parts of the *Endothyra tumula* Range Zone, have been recognized at Morro Creek. *Granuliferella granulosa, Granuliferelloides jasperensis* and *Endothyra*? *morroensis* characterize the lower assemblage and *E. spinosa* and *E. tuberculata* the upper. At Moose Mountain the fauna cannot be as readily divided into distinct assemblages; however, rare *E. spinosa* and related forms are found associated with *E. tumula* in the upper part of its range.

Faunas from the lower part of the *Endothyra tumula* Range Zone in the United States Cordillera (Fig. 2) are comparable to those of the lower assemblage at Morro Creek, the most marked similarity being found in the upper Gardner fauna of central Utah (Woodland, 1958). Species of the upper part of the *Endothyra tumula* Range Zone in Wyoming are characterized by the same type of secondary deposits as *E. spinosa* (e.g. *E. trachida* and *E.* sp., Zeller, 1957, Pl. 81, Figs. 1, 3) and are considered comparable with that species.

In Woodland's Provo Rock Canyon section, the *Granuliferella* and *Endothyra tumula* Zones are succeeded, in the Pine Canyon Formation (Fig. 2), by a sparse faunal assemblage typified by *E. lanceolata.* In sections studied by Zeller (1957), *E. tumula* is succeeded above an unfossiliferous interval by a fauna which is considered later in age than the Pine Canyon fauna and which is typified by *E. spiroides.*

A sparse assemblage similar to that of the Pine Canyon Formation, and containing *E. lanceolata,* has been found in the lower part of the Turner Valley Formation at Moose Mountain. *Endothyra lanceolata* has also been recognized in the upper Livingstone and lower Mount Head Formations at Tunnel Mountain but in that section, it is associated with a more diverse fauna than at Moose Mountain. Many of the Tunnel Mountain species are, in fact, similar to species found throughout the range of *E. spiroides* in the United States Cordillera and are correlative with the fauna of that zone. In the United States, the *Endothyra spiroides* Range Zone is extensive, encompassing strata from about 400 to 700 feet above the base of the Redwall Formation in Utah and Nevada, and elsewhere in Utah spanning the interval from 2000 to 2600 feet above the base of the Brazer Limestone and the interval from 100 to 150 feet above the base of the White Pine Formation.

The *Endothyra zelleri* Range Zone (Fig. 2) succeeds that of *Endothyra spiroides* in the upper Brazer Formation of Utah and the Redwall Limestone of Nevada (extending through 500 to 600 feet, and 50 feet, of strata, respectively). The zone is also found from 600 to 800 feet above the base of the Escabrosa Limestone of the Chiricahua Mountains, Arizona (Zeller, 1957). Woodland (1958) outlined the zone in the upper Deseret and lower Humbug Formations of Utah, where it spans about 400 feet of strata.

At Tunnel Mountain, *E. zelleri* is found in strata immediately above those containing *E. lanceolata,* the range zone extending through the middle of the Mount Head Formation. Two assemblages have been recognized within the range zone.

Species characterizing the lower assemblage are comparable to those associated with *E. zelleri* in the United States Cordillera, whereas the species found in the upper assemblage of the *Endothyra zelleri* Zone have not previously been reported from the Cordillera (e.g. *E.? banffensis, E. flatile* and *E. arrecta*).

The *Endothyra kleina* Range Zone was first outlined from the lower Great Blue Limestone of Utah (Woodland, 1958) and is based on occurrences of the species immediately above and below a 600-foot covered interval. At Tunnel Mountain rare specimens have been found through a short interval in the lower part of the Etherington Formation; thus, as yet, the zone is poorly defined.

The Mississippi Valley Region

In the Mississippi Valley region, endothyroid faunas of the Kinderhook, Osage, Meramec and Chester Series can be readily differentiated from one another, for each series has characteristic species (Zeller, 1950).

The earliest *Endothyra* species in the type region are found in the Kinderhookian (Chouteau-equivalent) Gilmore City Limestone and Humbolt Ooolite. These species are plectogyroidly coiled and show a high asymmetry of chamber inflation. Succeeding *Endothyra* species from the lower Osagian St. Joe Limestone, as well as from the upper Osagian Keokuk Formation, are also plectogyroidly coiled but they have more evenly inflated chambers and are notably smaller and thinner walled than the Kinderhookian species. None of the type Lower Mississippian endothyrids has diagnostic secondary deposits.

Meramecian endothyroid faunas are distinct from those of the Lower Mississippian because of the abundance of planispirally coiled species and the presence of various types of secondary deposits. *Endothyra* species of the Meramecian Salem, St. Louis and Ste. Genevieve Formations are similar to each other and only minor variations in the secondary deposits and coiling exist within the plectogyroidly and planispirally coiled groups. Chesterian faunal assemblages are in turn easily distinguished from those of Meramecian age, for although both assemblages possess secondary deposits there is a significant difference in the manner of deposition; also, planispirally coiled *Endothyra* species are rare to absent, being replaced in the upper part of the Chester by species of *Millerella*.

Species of the type Kinderhookian are not duplicated in sections so far studied in the Cordillera; however, the assemblage coinciding with the lower part of the range of *Endothyra tumula*, and including *E. anteflexa* (E. J. Zeller) and *Granuliferella granulosa*, is close in age to the Mississippi Valley fauna. *Endothyra anteflexa*, like the type Kinderhookian species, is characterized by its asymmetrically inflated chambers and lack of diagnostic secondary deposits; *Granuliferella granulosa* has its counterpart in the thick-walled *Endothyra* species of the Humbolt Oolite (Zeller, 1950). *Endothyra tumula* and the fauna associated with the upper range of this species (e.g. *E. spinosa*) have no correlatives in the type region, but on the basis of the late Kinderhookian age of the fauna coinciding with the lower range, it is considered to be early Osagian.

The only typical Osagian faunas of the Cordillera are found in sections at Moose Mauntain and in central Utah (Woodland, 1958), where the sparse foraminiferal assemblage characterized by *E. lanceolata* succeeds the earlier *E. tumula.* Like the fauna of the St. Joe Limestone and the Keokuk Formation, this Cordilleran assemblage is made up of a few closely related plectogyroidly coiled species in which secondary deposits are subdued or absent. The fauna at both Cordilleran localities is found in strata above and below unfossiliferous intervals, so that its age cannot be determined with certainty. Woodland (1958) may be close in assigning an early Meramecian age to the fauna, as species associated with *E. lanceolata* in the upper part of its range at Tunnel Mountain show definite early Meramecian affinities. The Tunnel Mountain assemblage, however, is more complex than that of the other Cordilleran sections, and it would be equally reasonable to consider the Moose Mountain and Utah assemblages as late Osagian.

The St. Louis and Ste. Genevieve Formation faunas are similar to the fauna coinciding with the lower part of the range of *E. zelleri* at Tunnel Mountain. Like the type Meramecian fauna, plectogyroidly and planispirally coiled species of *Endothyra* from Tunnel Mountain are characterized by a large hamulus in the ultimate chamber, the presence of which can be explained by tracing the development of such secondary deposits through the earlier Mississippian species *E. tumula* and *E. spinosa.* The fauna coinciding with the upper range of *E. zelleri*, and including *E.? banffensis* and *E.* sp. aff. *E. omphalota,* has not been recorded elsewhere in the Cordillera; however, considering the age of the overlying *Endothyra kleina* fauna, a very late Meramecian age is indicated for it.

Endothyra kleina and closely related small, plectogyroidly coiled species found in the lower part of the Etherington Formation in the Tunnel Mountain section are typical of the early Chesterian endothyrids of the type region (see Zeller, 1950).

Intercontinental Correlation

Typical Tournaisian and Visean foraminiferal assemblages of Eurasia listed in the following paragraphs are based mainly on investigations of the British and Russian authors: Reitlinger (1958), Reitlinger and Voloshinova (1959), Dorkina (1959), Voloshinova *et al.* (1959) and Cummings (1961, and in George, 1960). Reitlinger (1958) has presented an excellent outline of the evolutionary sequence of the Endothyridae and related genera in the U.S.S.R.

As they are not included in this report, simple tubular and sac-like Foraminifera are not discussed, although they make up part of the upper Devonian and Tournaisian foraminiferal assemblages.

Some septate Foraminifera have been reported from Devonian strata in Russia; for example, *Nanicella* has been found in Frasnian strata (Bykova and Polenova, 1955) and *Quasiendothyra* species and *Endothyra communis* characterize the Fammenian as well as lower Tournaisian strata. Species of *Quasiendothyra* continue through the Tournaisian, but are associated with a more diverse fauna in the upper part of the stage. Primitive *Endothyra* species with no diagnostic secondary deposits and reminiscent of the granuliferellids of this continent are found with closely related species of *Glomospiranella, Septaglomospiranella* (originally *Endothyra? primaeva* Rauser-Cernoussova), *Tournayella* and *Septatournayella* in the lower Tournaisian foraminiferal suites. Middle and upper Tournaisian assemblages are made up of more diverse septate faunas, including plectogyroidly coiled *Endothyra* species with diagnostic secondary deposits (e.g. *E. spinosa, E. tuberculata*), species of *Chernyshinella, Spiroplectammina, Brunsiina, Septabrunsiina* and some early glomospiranellids and tournayellids.

Lower and middle Visean assemblages are more complex than those of the preceding upper Tournaisian. *Endothyra* species, both planispirally and plectogyroidly coiled, are found with the closely related genera *Endothyranopsis, Cribrospira, Bradyina* and *Endothyranella.* In addition, primitive fusulinids, *Eostaffella* and *Parastaffella,* occur with the nonendothyrids *Archaediscus, Forschia, Forschiella, Permodiscus, Tetrataxis* and members of the Textulariidae.

In the Cordilleran region of North America the general evolutionary sequence of the Endothyridae is the same as that in Eurasia, and associated genera occupy the same relative positions in the stratigraphic column. As exact correlation on the basis of the *Endothyra* species alone has certain limitations, however, only assemblages are considered in the discussion below.

The *Quasiendothyra-Endothyra communis* assemblage from Upper Devonian to lower Tournaisian strata has not been encountered in North America. Although not directly correlative, the fauna of the *Granuliferella* Zone of this continent is probably close in age to that of the lower Tournaisian. Middle and Upper Tournaisian assemblages are well represented in North America, a typical assemblage being found at Morro Creek, Jasper. The diagnostic fauna of this section (upper Kinderhookian to lower Osagian) includes the Asiatic *Endothyra* species, *E. spinosa* and *E. tuberculata,* as well as *E.? morroensis* (a chernyshinellid-like form), *Spiroplectammina, Tournayella?, Granuliferella* and *Granuliferelloides.*

Typical lower Visean faunas are found in the upper Livingstone and Mount Head Formations at Tunnel Mountain. There, the assemblage is characterized by planispirally and plectogyroidly coiled *Endothyra* species —of which one has affinities to the lower-middle Visean species, *E. omphalota*—and the nonendothyrids *Archaediscus, Permodiscus, Palaeotextularia, Tournayella*? and *Glomospirella.*

Comparison of Foraminiferal and Megafaunal Zones

The Mississippian megafaunal zones of the Canadian Rocky Mountains are based mainly on brachiopods and corals. Studies have been carried out by Laudon *et al.* (1952), Brown (1952), Raasch (1958), Harker and Raasch (1958), and more recently by Nelson (1958, 1959a, 1959b, 1960 and 1961).

Correlation of the foraminiferal and megafaunal zones of the Mississippian sections at Morro Creek and Tunnel Mountain and Mount Rae is discussed below, but as precise stratigraphic positioning of the megafaunas from the Moose Mountain section is uncertain, correlation of the various faunal zones is not warranted.

Brown (1952) recognized four faunules in the area around Morro Creek, three of which lie within the Banff Formation and Rundle Group. These are, in ascending order, the *Spirifer* sp. cf. *S. cascadensis, S. albertensis* and *Composita esplanadensis* (or S. *minnewankensis*) faunules. The S. sp. cf. S. *cascadensis* faunule (*Spirifer marionensis* Zone of Harker and Raasch, 1958) is known from the lower beds of member B of the Banff Formation. The *S. albertensis* faunule (*Spirifer missouriensis* Zone of Harker and Raasch, 1958; *Platyrachella rutherfordi* Zone of Nelson, 1961) extends through the major part of member B and probably through the lower half of the Pekisko Formation. The *S. minnewankensis* faunule (*Camarotoechia cobblestonensis* Zone of Harker and Raasch, 1958; *Lithostrotionella micra* and *Lithostrotion mutabile* Zones of Nelson, 1961) is characterized by a fauna obtained mainly from the middle beds of the Shunda Formation but probably extends down into the Pekisko and up into the lower part of the Turner Valley Formation (Nelson, 1961).

The age of the faunas of the two lower zones is Kinderhookian and that of the uppermost, Osagian (Brown, 1952; Nelson, 1961). The *Endothyra tumula* Range Zone extends through the upper part of the *Spirifer missouriensis* and lower part of the *Spirifer minnewankensis* Zones and thus may be considered as extending across the Kinderhook-Osage boundary. This positioning is in agreement with zonal records from the United States.

Nelson (1958, 1959b, 1960 and 1961) outlined several megafaunal zones in the Rundle Group of the Front Ranges, but only those recognized at Tunnel Mountain are discussed here.

The Livingstone Formation, the lowest rock unit with which this study is actively concerned, contains three zones: the *Spirifer banffensis* Zone, an unnamed zone, and the *Lithostrotion sinuosum* Zone, in ascending order. The last-mentioned zone coincides with most of the *Endothyra lanceolata* Range Zone and part of the *Endothyra spiroides* Assemblage Zone. Although Nelson considered the fauna of the *Lithostrotion sinuosum* Zone to be mainly late Osagian, the Foraminifera suggest more strongly an early Meramecian age (p. 18).

The megafaunal zones of the Mount Head Formation are, in ascending order, the *Spirifer bifurcatus, Echinoconchus biseriatus, Girtyella indianensis* and *Gigantoproductus brazerianus* Zones. The *Spirifer bifurcatus* Zone overlaps with the upper part of the *Endothyra spiroides* Assemblage Zone, and the *Echinoconchus biseriatus* Zone coincides fairly closely with the *Endothyra zelleri* Range Zone. Both the megafauna and Foraminifera of these zones are considered Meramecian in age.

Three megafaunal zones are found in strata of the Etherington Formation, the faunas of which are Chesterian in age (Nelson, 1961). *Endothyra kleina*, found in the lower part of the Etherington Formation, is a typical early Chesterian species, an age designation that is in agreement with that of the megafauna.

It is interesting to note that Nelson (1961) collected faunas of the *Gigantoproductus brazerianus* Zone at the Mount Head-Etherington contact in the Mount Rae section, south of the Banff area, and approximately 100 feet below the top of the Mount Head Formation at Tunnel Mountain. Although only part of the Mount Rae section was examined, elements of the associated fauna of the lower part of the *Endothyra zelleri* Range Zone were found from 40 to 50 feet below the top of the Mount Head Formation, whereas at Tunnel Mountain this fauna occurs 200 to 300 feet below the top of the same formation.

LITHOLOGY AND PALEOCOLOGY

Endothyridae and related Foraminifera are found associated with crinoids, corals, brachiopods, bryozoans, molluscs, gastropods, ostracodes and algae: in rocks that reflect shallow water deposition.

Edie (1958), in relating the lithology and depositional environment of Plains Mississippian rocks, noted marked facies changes in the Lodgepole, Mission Canyon and Charles Formations of southeastern Alberta and southern Saskatchewan. The rocks of each facies—representing basin, open marine shelf, barrier bank and lagoon environments—have a characteristic faunal assemblage. Illing (1959) also found rocks representative of these same environments in the Moose Mountain section of the Foothills. More recently, Walpole and Carozzi (1961) made a petrographic study of the Rundle Group of the Front Ranges in the Ram River area, and although their interpretation of the lithologic succession differs somewhat from Illing's (1959), they recognized facies representing open marine, shoal and lagoonal environments.

The calcareous shales and argillaceous limestones of the type Banff and parts of the Lodgepole Formations represent normal marine sediments, according to Illing (his phases A and B). Such sediments are notably lacking in Foraminifera. In a typical sequence the argillaceous limestones grade into dark, crinoidal limestones with a fine-grained matrix (Illing's phase C) that are characteristic of the uppermost type Banff strata (Fig. 3), of the upper Banff and lower Pekisko Formations of Moose Mountain, and of member B of the Banff Formation at Jasper (Fig. 4). The environment in which these sediments were laid down was apparently not conducive to foraminiferal life.

Endothyridae and associated Foraminifera are most abundant in oolitic and medium-grained, crinoidal limestone. These limestones were deposited in a shoal environment, and represent the first stages of restricted deposition (Illing's phases D and E). Such lithologic types are to be found in parts of the Livingstone and Mount Head Formations at Tunnel Mountain (Fig. 3), in the Pekisko and Turner Valley Formations at Moose Mountain, and in parts of the Banff, Pekisko, Shunda and Turner Valley Formations at Jasper (Fig. 4).

A more evaporitic phase of carbonate deposition is represented by dark, algal, pelleted and commonly dolomitized limestones, which were presumably laid down in a lagoonal environment. This type of lithology is found in the Shunda Formation at Moose Mountain and in part of the Turner Valley Formation at Jasper (Fig. 4). Foraminifera are absent from such rocks and also from the closely related anhydrite, primary dolomites and chalky limestones of the true evaporitic facies.

CONCLUSIONS

Foraminifera of the family Endothyridae are useful zonal fossils because of their rapid evolutionary changes and world-wide distribution. Other Foraminifera associated with the endothyrids are restricted to certain intervals in the stratigraphic column and may also prove of correlative value in Mississippian rocks.

Four main foraminiferal range zones, two concurrent-range zones and one assemblage zone have been recognized in the Canadian Rocky Mountains; they are, the *Endothyra tumula, Endothyra lanceolata, Endothyra zelleri* and *Endothyra kleina* Range Zones and the *Endothyra tumula-Endothyra spinosa* and *Endothyra zelleri-Endothyra*? *banffensis* Concurrent-range Zones and the *Endothyra spiroides* Assemblage Zone. Elements of the *Granuliferella* Zone were observed, but present data are insufficient to outline it.

The *Granuliferella* Zone, lowest Mississippian endothyroid zone of the United States Cordillera, is based on the presence of the genus to the exclusion of all other Endothyridae. Succeeding it in many sections is the *Endothyra tumula* Range Zone, which is a widely recognized zone of the Cordilleran region. *Endothyra tumula* has been found in the Morro Creek, Jasper, and Moose Mountain sections in Alberta, where the upper part of its range overlaps with that of *Endothyra spinosa*. The fauna associated with both species is thought to be late Kinderhookian to early Osagian in age.

Throughout the Cordillera, there is a gap in the foraminiferal record above the *Endothyra tumula* Range Zone. This unfossiliferous interval is followed in Alberta and Utah by rocks containing *Endothyra lanceolata*. In Alberta this species has been observed in the Foothills (Moose Mountain) as well as in the Front Ranges (Tunnel Mountain), but only at the latter locality does it have an extended stratigraphic range. *Endothyra* species associated with *E. lanceolata* at Tunnel Mountain are late Osagian to early Meramecian in age, the fauna of the coinciding *Endothyra spiroides* Assemblage Zone being typically early Meramecian.

The *Endothyra zelleri* Range Zone is found in strata immediately above those containing *Endothyra lanceolata* (and the *Endothyra spiroides* assemblage) at Tunnel Mountain and the associated fauna of the lower part of the zone is broadly correlative with Meramecian St. Louis and Ste. Genevieve formational faunas of the type region. *Endothyra zelleri* is overlapped in the upper part of its range by the local range zone of *Endothyra*? *banffensis*. Although not recognized elsewhere in the Cordillera, the fauna of the *Endothyra zelleri-Endothyra*? *banffensis*

Concurrent-range Zone is probably very late Meramecian in age, as based on the early Chesterian age of the overlying *Endothyra kleina* fauna.

At Tunnel Mountain *Endothyra kleina* is limited to a short interval in the lower Etherington Formation and represents the youngest identifiable species of the study. The range zone was first recognized in the lower Great Blue Limestone of Utah and the fauna is typically early Chesterian.

Typical Eurasian Tournaisian and Visean assemblages have been found in the Morro Creek and Tunnel Mountain sections of this report. The Lower Mississippian fauna associated with *Endothyra tumula* at Morro Creek, Jasper, is correlated with middle and upper Tournaisian faunas, and the upper Mississippian fauna at Tunnel Mountain is broadly correlated with the lower to middle Visean faunas.

Of particular importance in this study has been the recognition of the *Endothyra tumula* Range Zone in both the Foothills and Front Ranges, thus enabling a tentative correlation to be made between the two areas, although further study of intervening sections is necessary for more precise control.

FORMAL DESCRIPTIONS

Order Foraminiferida Zborzewski, 1834

Family Ammodiscidae Reuss, 1862

Genus Ammodiscus Reuss, 1861

Ammodiscus spp.

Plate 5, figure 19; Plate 6, figure 10; Plate 7, figure 9

Figured specimens: PF. 0003 (RG 57-1-75), PF. 0004 (RG 57-1-66), Livingstone Formation; PF. 0040 (RG 57-1-30), Mount Head Formation; Tunnel Mountain, Alberta.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus Glomospirella Plummer, 1945

Glomospirella spp.

Plate 7, figures 2, 6; Plate 12, figure 8

Figured specimens: PF. 0005 (RG 57-1-33), PF. 0006 (RG 57-1-32), Mount Head Formation, Tunnel Mountain, Alberta; PF. 0007, Mount Head Formation, Mount Rae, Alberta.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Family Archaediscidae Cushman, 1928

Genus Archaediscus Brady, 1873

Archaediscus sp. A

Plate 7, figures 1, 3

Test small and rectangular with a broadly rounded periphery; initial chamber spherical, followed by a second coiled tubular chamber consisting of five whorls; coiling planes of whorls varying about 10 to 20 degrees from each other; height of test 0.19 to 0.28 mm.; width, 0.08 to 0.09 mm.; wall composed of an outer radial hyaline layer and an inner dark, finely granular layer approximately one-sixth the thickness of outer layer; aperture formed by open end of the tubular chamber.

Figured specimens: PF. 0015, 0016 (RG 57-1-33), Mount Head Formation, Tunnel Mountain, Alberta.

Occurrence: *Archaediscus* sp. A is sparsely represented in the Canadian Rocky Mountains. It is found in the upper two-thirds of the Mount Head Formation at Tunnel Mountain, Alberta.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ARCHAEDISCUS sp.

Plate 12, figures 3, 5

Figured specimens: PF. 0014, 0017, Mount Head Formation, Mount Rae, Alberta.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus PERMODISCUS Chernysheva, 1948

This genus is differentiated from *Archaediscus* on the basis of its planispiral coil.

PERMODISCUS sp.

Plate 11, figure 5

Test minute and rectangular with a broadly rounded periphery; initial chamber spherical, followed by a second tubular chamber coiled in a single plane through two volutions; diameter of test 0.18 mm.; width, 0.08 mm.; diameter of initial chamber 0.035 mm.; wall composed of an outer radial hyaline layer and an inner dark, finely granular layer approximately one-sixth the thickness of outer layer; aperture formed by open end of the tubular chamber.

Only one specimen of *Permodiscus* has been noted.

Figured specimen: PF. 0018 (RG 57-1-18), Mount Head Formation, Tunnel Mountain, Alberta.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Family TOURNAYELLIDAE Dain, 1953

The Tournayellidae are a group of pseudoseptate foraminifers which are variously coiled from glomospiral to plainispiral, the glomospiral members being ancestral. Typical of Eurasian Tournaisian strata, the tournayellids have not been previously reported from North America.

Genus TOURNAYELLA Dain, 1953

TOURNAYELLA? NONCONSTRICTA, n. sp.

Plate 7, figures 4, 5; Plate 8, figures 7, 8; Plate 12, figure 4

Test discoidal and evolute with a broad umbilical depression on either side; periphery rounded; initial chamber spherical, followed by a coiled tubular chamber made up of six to eight whorls; coiling planispiral, showing slight rotation of the axis; in the early portion, indentation of the wall barely discernible, becoming more pronounced in the outer portion; average diameter of test 1.20 mm.; secondary deposits consisting of irregular layering on the chamber floors, and a hook rarely present in the terminal portion behind the aperture; wall granular and calcareous with large inclusions, some portions appearing layered; aperture unconstricted and formed by open end of the tubular chamber.

Holotype: (Pl. 7, Fig. 5), PF. 0008, diameter 0.82 mm.
Paratypes: (Pl. 7, Fig. 4), PF. 0009, diameter 1.20 mm.
(Pl. 8, Fig. 7), PF. 0002, diameter 1.40 mm.
(Pl. 8, Fig. 8), PF. 0010, diameter 1.13 mm.
(Pl. 12, Fig. 4), PF. 0011, diameter 1.34 mm.

Locality of holotype and paratypes: PF. 0002, 0008, 0009, 0010 (RG 57-1-30), Tunnel Mountain, Alberta; PF. 0011, Mount Rae, Alberta. All specimens from the Mount Head Formation.

Occurrence: *Tournayella*? *nonconstricta* is a common species of the Mount Head Formation at Tunnel Mountain and Mount Rae.

Remarks: This species differs from the genotype, *Tournayella discoidea* Dain (Dain, in Pokorny, 1958), in having more pronounced septation, more regularity of coil, and an open, unconstricted aperture.

The name of the species refers to the unconstricted nature of the aperture.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Family TEXTULARIIDAE Ehrenberg, 1839

Genus SPIROPLECTAMMINA Cushman, 1927

In Russia, coarse-grained, calcareous species of *Spiroplectammina* have been noted in strata of Tournaisian to Moscovian age (Lipina, 1948; Reitlinger, 1950). In North America, arenaceous members of the genus are recorded from strata of Pennsylvanian to Recent age (Cushman, 1950).

SPIROPLECTAMMINA sp.

Plate 1, figures 7, 13

Test composed of a spirally coiled initial portion and a linear biserial terminal portion. Spiral portion consisting of a spherical proloculus, followed by a single whorl with five chambers. Biserial portion made up of six to eight chambers in each row, increasing in width uniformly; septa slightly curved and extending just over half the width; average length 0.67 to 0.86 mm.; wall coarsely granular and calcareous; aperture simple and at base of apertural face.

Figured specimens: PF. 0019, 0020 (RG 60-1-34), Banff Formation, Morro Creek, Alberta.

Occurrence: *Spiroplectammina* sp. has been observed in the upper and lower beds of the Banff and Pekisko Formations, respectively, at Morro Creek, Alberta.

Remarks: Formal identification of the Morro Creek specimens has not been possible. However, those specimens that have a relatively well preserved biserial portion are comparable to *Spiroplectammina tchernyshinensis* Lipina from the Russian upper Tournaisian strata. The latter species, like *Spiroplectammina* sp., is characterized by a coarse-grained, calcareous wall structure as well as a biserial portion consisting of six to eight chambers in each row and measuring about 0.80 mm. in length.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus PALAEOTEXTULARIA Schubert, 1920

PALAEOTEXTULARIA sp.

Plate 9, figure 12; Plate 11, figure 6

Repository: Research Council of Alberta Micropaleontology Type Collection.

Family ENDOTHYRIDAE Brady, 1884

Genus ENDOTHYRA Phillips, 1846

Type Species: *Endothyra bowmani* Phillips, 1846, Geol. and Polytech. Soc. West Riding Yorkshire, Proc. 1844-45, vol. 2, p. 277, fig. 1; not *Endothyra bowmanni* Phillips—Brown, 1843, The Elements of Fossil Conchology, p. 17, pl. 6, fig. 2.

Controversy concerning the author, scope and name of the genus *Endothyra* has been in progress since establishment of the genus in the last century. Two paleontologists, Brown (1843) and Phillips (1846), described a microfossil called *Endothyra* from the lower Carboniferous limestone of England, but each outlined a different type species. Brown's figure was that of an apparent planispiral form with four whorls and up to nineteen chambers in the outer whorl. He called it "*Endothyra bowmanni* Phillips," indicating that he considered Phillips the author. Phillips' form, on the other hand, is that of a "skew-coiled" form with two whorls and eight chambers in the outer whorl. Illustrations of these species were refigured in Henbest (1953) and St. Jean (1957). In 1876 Brady formally revised the genus. He redescribed and refigured Phillips' original specimen, showing that it represented a form coiled in more than one plane.

It was pointed out by Henbest (1953) that Brown's illustration of *E. bowmani* is so schematized as to be unrecognizable, and he stated that application was to be made to the International Commission on Zoological Nomenclature to have *Endothyra* Brown set aside in favor of *Endothyra* Phillips. St. Jean (1957) considers that the full title of Brown's publication indicates that the author did not intend to establish any new genera or species, but that he was drawing upon the work of other authorities to compile a textbook. As such, St. Jean considers that, according to Article 21 of the Rules of Zoological Nomenclature, *Endothyra* Brown has no validity and that Phillips is the author of *Endothyra*. Pokorny (1958) also follows the usage of Henbest, recognizing Phillips as the author of *Endothyra*.

Although at present no reference can be found to any Opinion of the Commission on Zoological Nomenclature setting aside *Endothyra* Brown in favour of *Endothyra* Phillips, the arguments of Henbest (1953) and St. Jean (1957) are here accepted, and Phillips is considered the author of the genus *Endothyra*. This being so, then the genotype of *Endothyra* is a skew-coiled form, and thus *Plectogyra* Zeller (1950) also based on a skew-coiled form, becomes a junior synonym of *Endothyra*. This is not an undesirable situation, as the differentiation of two genera on the basis of asymmetry of coiling, as seen in thin section, is at best questionable. It would perhaps be desirable to retain a name such as *Plectogrya* on a subgeneric level to indicate predominantly skew-coiled species or populations, but as *Plectogyra* is a complete synonym of *Endothyra* this is not possible, and it is not proposed to add here to the confusion of nomenclatorial terms by introducing an additional new subgeneric name.

ENDOTHYRA ARRECTA, n. sp.

Plate 9, figures 9, 10; Plate 10, figure 11

Test ovoid, involute and umbilicate, the umbilical depression being greater on one side; large proloculus, of outside diameter 0.072 mm., followed by two and one-half to three volutions; volution coiling planes in the early portion varying slightly from plane of outer volution; average diameter of test 0.85 mm.; septal count from first to last volution, seven, nine and ten; septa unusually long, arched initially in an anterior direction, but tending to form at right angles to the wall in the outer volution; chambers not significantly inflated between sutures; wall and septa of medium thickness, granular, calcareous and layered; aperture at base of high apertural face.

Holotype: (Pl. 10, Fig. 11), PF. 0043, diameter 0.92 mm.
Paratypes: (Pl. 9, Fig. 10), PF. 0041, diameter 0.82 mm.
(Pl. 9, Fig. 9), PF. 0042, diameter 0.73 mm.

Locality of holotype and paratypes: PF. 0043 (RG 57-1-24), PF. 0041, 0042 (RG 57-1-29), Tunnel Mountain, Alberta, from the Mount Head Formation.

Occurrence: *Endothyra arrecta* has been recognized at several intervals in the upper part of the Mount Head Formation, Tunnel Mountain, Alberta.

Remarks: The unusual length and perpendicular attitude of the septa and the rapid expansion rate of this species serve to differentiate it from other *Endothyra* species of similar size.

The name is derived from the Latin word "*arrectus*" meaning steep or erect, and refers to the septal face.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA? BANFFENSIS, n. sp.

Plate 10, figures 2, 3, 4, 15, 20

Test discoidal with a rounded periphery and broad umbilical depression on both sides; coiling initially involute, becoming evolute in the outer portion; coiling in more than one plane, the degree of rotation of the outer three whorls being very small; proloculus followed by five volutions; average diameter of test 0.45 mm.; septa short due to resorption of septal ends, directed toward the anterior; chambers barely inflated between sutures and numbering 14 to 15 in the outer whorl; wall granular, calcareous and layered; aperture slit-like(?) at base of apertural face.

Holotype: (Pl. 10, Fig. 15), PF. 0077, diameter 0.43 mm.
Paratypes: (Pl. 10, Fig. 2), PF. 0080, incomplete
(Pl. 10, Fig. 3), PF. 0078, diameter 0.45 mm.
(Pl. 10, Fig. 4), PF. 0079, diameter 0.43 mm.
(Pl. 10, Fig. 20), PF. 0228, diameter 0.50 mm.

Locality of holotype and paratypes: PF. 0078, 0079, 0080 (RG 57-1-24); PF. 0077, 0228 (RG 57-1-20), Tunnel Mountain, Alberta, from the Mount Head Formation.

Occurrence: *Endothyra*? *banffensis* is a common species of the upper part of the Mount Head Formation, Tunnel Mountain, Alberta.

Remarks: Because of the evolute nature of its coil, this species has been questionably referred to *Endothyra*. Although such coiling is found rarely in endothyrids it is not typical, and constancy of the feature suggests a later evolutionary development. The coiling habit is similar to that of *Millerella;* however, the relationship of *E.*? *banffensis* to the latter genus is doubtful because of its lack of chomata and differing wall structure.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA FLATILE, n. sp.

Plate 10, figures 1, 12, 17

Test ovoid and involute with a deep umbilical depression on both sides; proloculus, of outside diameter 0.06 mm., followed by three to three and one-half volutions coiled planispirally; diameter ranging from 0.60 to 0.70 mm.; septal count from first to last volution, seven, eight and nine; septa of medium length and arched in an anterior direction; chambers large in relation to test size and inflated between sutures; secondary deposits consisting of a single hamulus on the floor of the ultimate chamber; wall granular, calcareous and layered; aperture at base of apertural face.

Holotype: (Pl. 10, Fig. 12), PF. 0045, diameter 0.68 mm.
Paratypes: (Pl. 10, Fig. 1), PF. 0044, diameter, 0.62 mm.
(Pl. 10, Fig. 17), PF. 0046, diameter 0.62 mm.

Locality of holotype and paratypes: PF. 0045, 0046 (RG 57-1-18), PF. 0044 (RG 57-1-24), Tunnel Mountain, Alberta, from the Mount Head Formation.

Occurrence: *Endothyra flatile* is found throughout the upper part of the Mount Head Formation at Tunnel Mountain, Alberta.

Remarks: This planispiral species approximates to *Endothyra zelleri* and *E. macra* in size but differs from both in having fewer volutions and larger, more inflated chambers.

The name of the species is derived from the Greed word *"flatilus"* meaning blown up or inflated.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA INCRASSATA, n. sp.

Plate 7, figures 10, 11, 17

Test ovoid, involute and umbilicate, the umbilical depression being greater on one side; proloculus, of outside diameter 0.048 mm., followed by four and one-half to five volutions coiled in different planes, the degree of rotation of the coiling planes being considerable; average diameter of test 0.82 mm.; septa of medium length and directed slightly toward the anterior; chambers large and inflated between sutures; secondary deposits consisting of prominent additions to the posterior tips of the septa, thorn-like projections on the chamber floors and usually a hamulus in the ultimate chamber; wall granular, calcareous and layered; apertural face rounded with slit-like aperture at base.

Holotype: (Pl. 7, Fig. 11), PF. 0103, diameter 0.82 mm.
Paratypes: (Pl. 7, Fig. 10), PF. 0105, diameter 0.86 mm.
(Pl. 7, Fig. 17), PF. 0104, diameter 0.84 mm.

Locality of holotype and paratypes: PF. 0103, 0104 (RG 57-1-30), PF. 0105 (RG 57-1-32), Tunnel Mountain, Alberta, from the Mount Head Formation.

Occurrence: *Endothyra incrassata* ranges through a short interval in the middle of the Mount Head Formation at Tunnel Mountain, Alberta.

Remarks: The diagnostic features of this large, plectogyroidly coiled species are the thorn-like secondary deposits on the chamber floors and the thick secondary additions to the posterior tips of the septa. The lowest specimen stratigraphically (Pl. 7, Fig. 10) exhibits the most extensive deposition; those from higher beds (Pl. 7, Fig. 11) show evidence of resorption of both basal and septal deposits.

The name is derived from the Latin word *"incrassatus"* meaning thickened and refers to the nature of the septal deposits.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA KLEINA (Woodland)

Plate 11, figures 8, 9

Plectogyra kleina Woodland, 1958, Jour. Paleont., vol. 32, no. 5, p. 799, pl. 99, figs. 1, 4, 6.

Test small and involute with an umbilicus on one side; proloculus followed by two volutions coiled in different planes, the degree of rotation of the coiling planes being moderate; maximum diameter of test 0.32 mm.; average diameter, 0.27 mm.; septa long and curved toward the anterior; chambers inflated between sutures and numbering about six in the outer volution; secondary deposits appearing as layers on the chamber floors and in some specimens as low mounds; wall finely granular, calcareous and layered; aperture at base of apertural face.

Hypotypes: PF. 0164, diameter 0.34 mm.
PF. 0165, diameter 0.24 mm.

Locality of hypotypes: PF. 0164 (RG 57-1-17), PF. 0165 (RG 57-1-15), Tunnel Mountain, Alberta, from the Etherington Formation.

Occurrence: Rare specimens of *Endothyra kleina* are the only identifiable endothyrids found in the Etherington Formation at Tunnel Mountain, Alberta.

Remarks: *Endothyra kleina* (Woodland) was originally described from the lower Great Blue Limestone of central Utah (Woodland, 1958). The average diameter of the Tunnel Mountain representatives is the same as that of the Utah type species.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA LANCEOLATA Woodland

Plate 5, figures 8, 10, 13, 18, 21; Plate 6, figure 14

Endothyra lanceolata Woodland, 1958, Jour. Paleont., vol. 32, no. 5, p. 800, pl. 101, figs. 1-3.

Test small, ovoid, involute and umbilicate, the umbilical depression being greater on one side; proloculus, of outside diameter 0.045 mm., followed by two volutions coiled in different planes, the degree of rotation of these planes being small; maximum diameter of test 0.45 mm.; average diameter, 0.38 mm.; septa noticeably long and thin, and directed slightly toward the anterior; chambers in the outer volution numbering seven to eight; wall finely granular, calcareous and layered; aperture at base of apertural face.

Hypotypes: PF. 0093, diameter 0.45 mm.
PF. 0094, diameter 0.45 mm.
PF. 0095, diameter 0.36 mm.
PF. 0096, diameter 0.34 mm.
PF. 0097, diameter 0.40 mm.
PF. 0098, diameter 0.43 mm.

Locality of hypotypes: PF. 0093, Mount Darrah, Alberta, from the Livingtone Formation; PF. 0094 (RG 59-2-31), Moose Mountain, Alberta, from the Turner Valley Formation; PF. 0095, 0096 (RG 57-1-87), PF. 0097 (RG 57-1-75), PF. 0098 (RG 57-1-51), Tunnel Mountain, Alberta, from the Livingstone Formation.

Occurrence: *Endothyra lanceolata* is known from several localities in the Canadian Rocky Mountains. Rare specimens have been observed at Moose Mountain in the lowermost beds in the Turner Valley Formation, and at Mount Darrah in the upper beds of the Livingstone Formation. At Tunnel Mountain, *E. lanceolata* is common in the upper 480 feet of the Livingstone Formation.

Remarks: *Endothyra lanceolata* was first described from the Pine Canyon Formation of central Utah. This species is distinctive because of its small size, thin wall and septa, and few volutions. The spear-shaped addition described by Woodland (1958) as being characteristic of the species is considered to be only a broken chamber and has been discounted as a feature.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA MACRA E. J. Zeller

Plate 9, figure 8; Plate 12, figure 6

Endothyra macra E. J. Zeller, 1957, Jour. Paleont., vol. 31, no. 4, p. 702, pl. 80, figs. 7, 14.

Endothyra macra E. J. Zeller—Armstrong, 1958, Jour. Paleont., vol. 32, no. 5, p. 975, pl. 127, fig. 4.

Test discoidal with a subangular periphery, involute and umbilicate on both sides; coiling planispiral, exhibiting a close-coiled initial portion and a more open-coiled outed portion; proloculus, of outside diameter 0.048 mm., followed by four volutions; maximum diameter of test 0.70 mm.; septal count from first to fourth volution, six, eight, ten and eleven; septa of medium length and curved toward the anterior; wall finely granular, calcareous, and layered; aperture slit-like at base of apertural face.

Hypotypes: PF. 0066, diameter 0.70 mm.
PF. 0086, diameter 0.68 mm.

Locality of hypotypes: PF. 0066 (RG 57-1-29), Tunnel Mountain, Alberta, from the Mount Head Formation; PF. 0086, Mount Rae, Alberta, from the Mount Head Formation.

Occurrence: Specimens of *Endothyra macra* are not common, but have been observed through a limited interval in the middle part of the Mount Head Formation, and thus in the middle of the *Endothyra zelleri* Zone. The species also is known from beds 40 to 50 feet below the top of the same formation at Mount Rae.

Remarks: *Endothyra macra* has been recorded from the upper Brazer Limestone of Utah (upper part of the *Endothyra zelleri* Zone) and the Arroyo Penasco Formation of New Mexico. The species is differentiated from *Endothyra zelleri* and *E.* sp. C by its close-coiled initial portion. Development within the group of small planispiral *Endothyra* species was in the direction of increased tightening of the initial portion, so that *E. macra* represents a late member of the group. The average diameter of the Alberta representatives is about 0.10 mm. larger than that of the specimens described from the United States Cordillera.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA? MORROENSIS, n. sp.

Plate 2, figures 1, 2, 8, 9

Test small, ovoid and umbilicate on one side; coiling in the initial whorls in various planes, the axis of the plane going through a 90-degree shift between the penultimate and ultimate whorls; two to two and one-half volutions; chambers asymmetrically inflated, and numbering about six in the outer volution; septa very short and arched in the anterior direction; secondary deposits present in some specimens as nodes on the chamber floors; wall finely granular, calcareous and layered; aperture slit-like at base of apertural face.

Holotype: (Pl. 2, Fig. 2), PF. 0227, diameter 0.41 mm.
Paratypes: (Pl. 2, Fig. 1), PF. 0087, diameter 0.41 mm.
(Pl. 2, Fig. 8), PF. 0089, diameter 0.30 mm.
(Pl. 2, Fig. 9), PF. 0090, diameter 0.24 mm.

Locality of holotype and paratypes: PF. 0087, 0227 (RG 60-1-34), Banff Formation, PF. 0089, 0090 (RG 60-1-50), Shunda Formation, Morro Creek, Alberta.

Occurrence: *Endothyra*? *morroensis* is most common in the lower half of the Shunda Formation, but is found also in the upper part of the Banff Formation, Morro Creek, Alberta.

Remarks: Small, primitive endothyrids belonging to the Eurasian genus *Chernyshinella* are characterized, as is *Endothyra*? *morroensis*, by highly inflated, asymmetrical chambers and extremely short septa. However, the chernyshinellids have no differentiated wall components and possess a cribrate aperture. For the present, the small Morro Creek species is included in the group of Lower Mississippian *Endothyra* species possessing asymmetrical chambers and short septa. One such species is *E. anteflexa* (E. J. Zeller), from the lower part of the *Endothyra tumula* Zone of the United States Cordillera. Zeller's species is differentiated from *E.*? *morroensis* by having a greater number of volutions and a more regular coiling habit. Other species with asymmetrical chambers are found in the Lower Mississippian (Kinderhook) strata in the type region of the Mississippi Valley (Zeller, 1950).

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA sp. aff. E. OMPHALOTA Rauser-Cernoussova and Reitlinger

Plate 11, figures 3, 14

Test very large, subglobular and umbilicate on one side; involute; coiling in more than one plane, the axis of the planes shifting markedly between the inner and outer portions; coiling of the outer two whorls nearly planispiral; proloculus, of outside diameter 0.07 mm., followed by four and one-half volutions; diameter of test 1.36 mm.; septa thick and curved slightly toward the anterior; wall granular, calcareous and layered; secondary deposits present as tumuli on the floors of last few chambers.

Figured specimen: PF. 0178 (RG 57-1-18), Tunnel Mountain, Alberta, from the Mount Head Formation.

Occurrence: The description is based on rare specimens from the upper part of the Mount Head Formation, Tunnel Mountain, Alberta.

Remarks: *Endothyra* sp. aff. *E. omphalota* is the largest endothyroid representative in the Mississippian Cordilleran strata. It belongs to the same group of large, subglobular species as *E. robusta,* but differs from the latter, earlier species by lacking a hamulus, and by having a larger diameter and a more distorted coiling plane.

This large Alberta species is comparable to the Russian middle Visean species *E. omphalota* in test shape, coiling habit and wall thickness, but has a smaller average diameter (1.36 mm. as compared with 1.60 mm. for the Russian species) and less extensive secondary deposits. It is noted, however, that the deposits are of the same type as those found in the Russian species.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra robusta, n. sp.

Plate 7, figure 15; Plate 8, figures 1, 3, 4;

Plate 11, figure 13; Plate 12, figure 15

Test subglobular, involute and umbilicate on both sides; proloculus of outside diameter 0.048 mm., followed by four volutions; coiling planispiral but showing slight rotation of the plane in the initial portion; average diameter of test 1.20 mm.; septa thick and directed only slightly toward the anterior; chambers barely inflated between sutures and numbering about ten to twelve in the outer whorl; secondary deposits consisting of a broad-based hamulus in the ultimate chamber, unresorbed bases in some of the preceding chambers, and additions to the posterior tips of the septa; wall granular, calcareous and layered; aperture at base of apertural face.

Holotype: (Pl. 8, Fig. 4), PF. 0173, diameter 1.29 mm.
Paratypes: (Pl. 7, Fig. 15), PF. 0172, diameter 1.08 mm.
(Pl. 8, Fig. 1), PF. 0210, diameter 1.06 mm.
(Pl. 8, Fig. 3), PF. 0174, diameter 1.12 mm.
(Pl. 11, Fig. 13), PF. 0179, diameter 1.02 mm.
(Pl. 12, Fig. 15), PF. 0183, diameter 1.20 mm.

Locality of holotype and paratypes: PF. 0172, 0173, 0174, 0210 (RG 57-1-30), Tunnel Mountain, Alberta; PF. 0179, Crowsnest Ridge, Alberta; PF. 0183, Mount Rae, Alberta. All specimens from the Mount Head Formation.

Occurrence: *Endothyra robusta* is a common species of the middle Mount Head Formation, and also of the interval examined in the upper part of the same formation at Mount Rae and Crowsnest Ridge, Alberta.

Remarks: This Alberta species is one of the largest endothyrids of the Cordilleran region. It belongs to the same group of hamulus-bearing *Endothyra* species as the United States Cordilleran species, *E. hamula* Woodland and *E. prodigiosa* Armstrong, but has a more globular outline and thicker wall than either of these species.

Endothyra robusta bears a closer relationship to the Eurasian Visean genus *Endothyranopsis* than any previously described North American endothyrids. Although cognizant of the similarity of features of *Endothyranopsis* and *Endothyra robusta,* such as the subglobular test and thick wall and septa, the Alberta species is referred to *Endothyra* because of the distinct endothyroid wall structure and prominent secondary deposits.

The name is derived from the Latin word "*robustus*" meaning strong or robust.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra spinosa Chernysheva

Plate 2, figures 3, 4

?*Endothyra spinosa* Chernysheva, 1940, Soc. Nat. Moscou, Bull., tome 48, (sec. géol. tome 18), no. 5-6, p. 126, pl. 2, fig. 12.

Test discoidal with a rounded periphery; initial portion involutely coiled, becoming evolute in the outer portion; umbilical depression greater on one side; coiling in more than one plane, the degree of rotation of the planes varying considerably; average diameter of test 0.54 mm.; septa directed anteriorly; chambers inflated and numbering eight to nine in the outer volution; diagnostic hook-shaped secondary deposits present on the chamber floor of outer whorls; wall finely granular, calcareous and layered; aperture slit-like at base of apertural face.

Hypotypes: PF. 0108, diameter 0.56 mm.
PF. 0109, diameter 0.54 mm.

Locality of hypotypes: PF. 0108, 0109 (RG 60-1-50), Morro Creek, Alberta, from the Shunda Formation.

Occurrence: *Endothyra spinosa* is common through the lower half of the Shunda Formation at Morro Creek, Alberta.

Remarks: *Endothyra spinosa* was first recognized in the Tournaisian strata of Russia. The Morro Creek specimens represent the first reported occurrence of this species in North America. Except for a slightly larger average diameter, these Alberta specimens bear a marked resemblance to the type species.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA sp. cf. E. SPINOSA Chernysheva

Plate 4, figures 1, 12, 14

?*Endothyra spinosa* Chernysheva, 1940, Soc. Nat. Moscou, Bull., tome 48, (sec. géol. tome 18), no. 5-6, p. 126, pl. 2, fig. 12.

Several poorly preserved specimens comparable to *Endothyra spinosa* have been noted in the Moose Mountain section. Long hook-shaped secondary deposits characteristic of the type species are present in the outer whorls, but details of the volution and chamber numbers are not known.

Figured specimens: PF. 0198, 0199, 0200 (RG 59-2-22), Moose Mountain, Alberta, from the Pekisko Formation.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA TUBERCULATA Lipina

Plate 3, figures 2, 4

Endothyra tuberculata Lipina, 1948, Akad. Nauk. S.S.S.R., Inst. Geol. Nauk, Trudy, Moscow, 1948, fasc. 62 (geol. ser. no. 19), p. 253, pl. 19, figs. 1, 2.

Test ovoid, involute and umbilicate, the umbilical depression being greater on one side; proloculus followed by four volutions; coiling in more than one plane, the degree of rotation of the coiling planes being moderate; average diameter of test 0.74 mm.; septa of medium length and directed toward the anterior; chambers inflated between sutures and numbering about seven in the outer volution; secondary deposits consisting of thick-based hamuli in all chambers of the outer volution and unresorbed bases in the preceding chambers; wall granular, calcareous and layered; aperture slit-like at base of apertural face.

Hypotypes: PF. 0083, diameter 0.72 mm.
PF. 0195, diameter 0.82 mm.

Locality of hypotypes: PF. 0083, 0195 (RG 60-1-83), Morro Creek, Alberta, from the Turner Valley Formation.

Occurrence: *Endothyra tuberculata* is found in a limited interval in the Turner Valley Formation, Morro Creek, Alberta.

Remarks: *Endothyra tuberculata* was first recognized in upper Tournaisian strata of the Russian platform area. Reitlinger (1958) pointed out that this species is the main progenitor of the Visean plectogyroidly coiled endothyrids, with development from it being in the direction of enlargement of the hamuli close to the aperture and subsequent resorption in the preceding chambers. The thick-based hamuli present throughout the outer volution make the species distinctive. The Alberta specimens differ from the type specimens only by having a somewhat larger diameter.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra tumula (E. J. Zeller)

Plate 1, figures 1, 4, 5; Plate 2, figure 17; Plate 3, figures 11, 15;

Plate 4, figures 7, 9, 11

Plectogyra tumula E. J. Zeller, 1957, Jour. Paleont., vol. 31, no. 4, p. 697, pl. 77, figs. 5, 6, 11; pl. 79, figs. 7, 8, 9, 12, 23; pl. 82, figs. 3, 4, 16, 17.

Plectogyra tumula E. J. Zeller—Woodland, 1958, Jour. Paleont., vol. 32, no. 5, p. 798, pl. 101, figs. 12, 14, 15; pl. 102, fig. 13.

Test discoidal to ovoid, involute and umbilicate, the umbilical depression being greater on one side; proloculus followed by three to four volutions; coiling in more than one plane, the degree of rotation of the planes varying considerably; average diameter of test 0.65 mm.; septa of moderate length and arched in the anterior direction; chambers inflated between sutures and numbering five to seven in the outer whorl; secondary deposits consisting of massive, symmetrical tumuli on the chamber floors; wall finely granular, calcareous and layered; aperture slit-like and at base of apertural face.

Hypotypes: PF. 0112, diameter 0.72 mm.
PF. 0113, diameter 0.68 mm.
PF. 0114, diameter 0.72 mm.
PF. 0115, diameter 0.76 mm.
PF. 0128, diameter 0.58 mm.
PF. 0129, diameter 0.60 mm.
PF. 0138, diameter 0.75 mm.
PF. 0191, diameter 0.65 mm.
PF. 0224, diameter 0.63 mm.

Locality of hypotypes: PF. 0115 (RG 60-1-31), PF. 0128, 0129 (RG 60-1-37), PF. 0224 (RG 60-1-50), Morro Creek, Alberta, from the Banff, Pekisko and Shunda Formations, respectively; PF. 0138, 0191, Bighorn Creek, Alberta, from the Shunda Formation; PF. 0112, 0113, 0114 (RG 59-2-22), Moose Mountain, Alberta, from the Pekisko Formation.

Occurrence: *Endothyra tumula* is found in the Banff, Pekisko and Shunda Formations at Morro Creek, Alberta, in the upper part of the Pekisko Formation at Moose Mountain, Alberta, and in the interval of the lower Shunda Formation that was examined at Bighorn Creek.

Remarks: *Endothyra tumula* (E. J. Zeller) has been recognized at several localities in the United States Cordillera, where it is a zonal index of the Lower Mississippian. Specimens described in this report display a great deal of variation in number of volutions and coiling habits, and classification has thus been based solely on possession of massive secondary deposits; it is noted that a similar variability exists among *E. tumula* specimens of the United States Cordillera. The Morro Creek representatives have more massive secondary deposits and fewer volutions than those from Moose Mountain and are unquestionably earlier members of the tumulate group.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA ZELLERI, n. name

Plate 7, figures 7, 12, 13, 14

Endothyra symmetrica E. J. Zeller, 1957, Jour. Paleont., vol. 31, no. 4, p. 701, pl. 75, figs. 13, 14, 19; pl. 78, figs. 8, 9; pl. 80, fig. 6.
Endothyra symmetrica E. J. Zeller—Woodland, 1958, Jour. Paleont., vol. 32, no. 5, p. 800, pl. 101, figs. 7, 9, 10.
not *Endothyra symmetrica* Morozova, 1949 (in Toomey, 1959, Cushman Foundation Foram. Res. Contrib., vol. 10, pt. 3, p. 105).

Test discoidal with a subangular periphery, involute and umbilicate on both sides; proloculus, of average outside diameter 0.05 mm., followed by four to four and one-half volutions; coiling planispiral; average diameter of test 0.55 mm.; septal count from first to last volution, seven, eight, ten and eleven. Septa of medium length and curved toward the anterior; chambers inflated between sutures; secondary deposits consisting of a hamulus in the ultimate chamber and occasional low, unresorbed bases on the floors of preceding chambers; wall finely granular, calcareous and layered; aperture slit-like and at base of apertural face.

Hypotypes: PF. 0047, diameter 0.60 mm.
PF. 0049, diameter 0.54 mm.
PF. 0050, diameter 0.62 mm.
PF. 0051, diameter 0.60 mm.

Locality of hypotypes: PF. 0047 (RG 57-1-33), PF. 0049, 0050, 0051 (RG 57-1-30), Tunnel Mountain, Alberta, from the Mount Head Formation. Formation.

Occurrence: *Endothyra zelleri* is a diagnostic species of the middle Mount Head Formation, Tunnel Mountain, Alberta.

Remarks: *Endothyra zelleri* was first recognized in the United States Cordillera and is a zonal index in the Upper Mississippian. This species is characterized by a relatively even coil expansion rate which distinguishes it from associated endothyrids of similar size such as *E. macra* and *E. flatile*. Only specimens with four volutions and a septal count approximating that of the type species are included in *E. zelleri*. The Alberta specimens have a slightly larger average diameter than their United States Cordilleran counterparts.

The name *Endothyra symmetrica* E. J. Zeller (1957) is preoccupied by *E. symmetrica* Morozova (Toomey, 1959); consequently, the species has been renamed in honor of one of North America's foremost endothyroid experts, E. J. Zeller.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra sp. A

Plate 1, figures 2, 3, 6

Test discoidal with a rounded periphery and broad umbilical depression on both sides; mainly evolute; proloculus of outside diameter 0.06 mm., followed by four volutions; coiling in more than one plane, the degree of rotation of the planes varying from small to considerable; average diameter of test 0.72 mm.; septa of medium length and curved toward the anterior; chambers large and inflated between sutures; secondary deposits consisting of rare tumuli on the chamber floors; aperture slit-like and at base of high apertural face.

Figured specimens: P. 0116, 0117, 0118 (RG 60-1-34), Morro Creek, Alberta, from the upper part of the Banff Formation.

Occurrence: *Endothyra* sp. A is found in a limited interval of the upper part of the Banff Formation, Morro Creek, Alberta.

Remarks: Formal naming of the species has not been made because of insufficient complete specimens. Although similarities of the chamber size and structure suggest a close relationship to *Endothyra tumula* (cf. *Endothyra* sp. A, Pl. 1, Figs. 2, 3 and *Endothyra tumula*, Pl. 1, Fig. 1), *Endothra* sp. A differs from the latter by possessing fewer tumuli.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra sp. B

Plate 3, figures 9, 10

Test discoidal with a rounded periphery; involute in the inner portion, the outer two whorls being evolutely coiled; proloculus, of outside diameter

0.03 mm., followed by four to five volutions coiled in variable planes initially, but becoming nearly planispiral in the outer portion; average diameter of test 0.62 mm.; septa of moderate length, relatively thick and curved anteriorly; chambers barely inflated between sutures and numbering about eleven in the outer volution; secondary deposits consisting of rare low nodes on the chamber floors; wall finely granular, calcareous and layered; aperture slit-like and at base of apertural face.

Figured specimens: PF. 0137, 0197 (RG 60-1-83), Morro Creek, Alberta, from the Turner Valley Formation.

Occurrence: *Endothyra* sp. B is found in the lower part of the Turner Valley Formation, Morro Creek, Alberta.

Remarks: This species is recorded from only the one interval at Morro Creek where it is found with a fauna that is new to the Cordillera. The close-coiling habit, numerous septa and planispiral coiling of the outer whorls serve to differentiate it from associated endothyrids. Variations of the coiling plane appear to be the same in all specimens.

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA sp. C

Plate 5, figure 22; Plate 6, figures 1, 3

Test discoidal, involute and umbilicate on both sides; coiling planispiral; proloculus, of outside diameter 0.06 mm., followed by three to three and one-half volutions; average diameter of test 0.60 mm.; septa long and arched in an anterior direction; septal count approximately seven, nine and ten; secondary deposits consisting of small nodes on the chamber floors and a thin hamulus in the ultimate chamber; wall granular, calcareous and layered; aperture slit-like at base of rounded apertural face.

Figured specimens: PF. 0062 (RG 57-1-75), PF. 0055, 0056 (RG 57-1-66), Tunnel Mountain, Alberta, from the Livingstone Formation.

Occurrence: *Endothyra* sp. C is the most common planispiral form in the upper Livingstone Formation at Tunnel Mountain.

Remarks: The species belongs to the same group of medium-sized, planispirally coiled *Endothyra* species that includes *E. zelleri;* however, it has a more rounded periphery and apertural face and more rapid expansion rate than either *E. zelleri* or other closely related, later species.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra sp. D

Plate, 6, figures 8, 16, 19

Test subglobular and involute with a greater umbilical depression on one side; proloculus, of outside diameter 0.065 mm., followed by four volutions coiled in more than one plane, the degree of rotation of the planes being moderate; average diameter of test 0.84 mm., maximum diameter, 0.94 mm.; septa long and curved anteriorly; secondary deposits consisting of small nodes on the chamber floors, slight additions to the posterior tips of the septa and a thin hamulus in the ultimate chamber; chambers large and inflated between sutures; wall granular, calcareous and layered; aperture at base of high, rounded apertural face.

Figured specimens: PF. 0125 (RG 57-1-65), PF. 0126, 0127 (RG 57-1-41), Tunnel Mountain, Alberta, from the Livingstone and Mount Head Formations, respectively.

Occurrence: This species is found in the upper beds of the Livingstone and lower beds of the Mount Head Formations at Tunnel Mountain, Alberta.

Remarks: *Endothyra* sp. D belongs to the same group of large, plectogyroidly coiled *Endothyra* species as the later *E. incrassata,* but differs from the latter in having more subdued secondary deposits and a smaller degree of coiling plane distortion.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Endothyra sp. E

Plate 6, figures 6, 11, 13, 15

Test discoidal, involute and umbilicate on both sides; coiling planispiral; proloculus followed by three to three and one-half volutions; average diameter of test 0.75 mm.; septa of medium length and directed only slightly toward the anterior; chambers inflated between the sutures; secondary deposits consisting of a hamulus in the ultimate chamber; wall granular, calcareous and layered; aperture slit-like at base of relatively high, rounded apertural face.

Figured specimens: PF. 0057, 0059, 0206, 0207 (RG 57-1-41), Tunnel Mountain, Alberta, from the Mount Head Formation.

Occurrence: *Endothyra* sp. E is a diagnostic species of the lower part of the Mount Head Formation, Tunnel Mountain, Alberta.

Remarks: No well-oriented sagittal sections have been found and details of the septal count are indeterminate. In size and wall thickness, this species occupies an intermediate position between the smaller planispiral forms such as *E. zelleri* and the larger ones such as *E. robusta.*

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA spp.

Plate 1, figure 8; Plate 2, figures 6, 7, 13-15, 18-20; Plate 3, figures 1, 3, 5-8, 12; Plate 4, figures 3-6, 10, 13, 15-17; Plate 5, figures 1-7, 9, 11, 12, 14-17, 20; Plate 6, figures 2, 4, 5, 7, 9, 12, 17, 18; Plate 7, figures 8, 16; Plate 8, figures 2, 5, 6, 9; Plate 9, figures 1-7, 11, 13-15; Plate 10, figures 5, 9, 10, 13, 16, 18, 19, 21; Plate 11, figures 1, 2, 4, 7, 10-12; Plate 12, figures 1, 2, 7, 9-14

Repository: Research Council of Alberta Micropaleontology Type Collection.

ENDOTHYRA? spp.

Plate 4, figure 8; Plate 10, figures 6, 7, 8

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus GRANULIFERELLA E. J. Zeller, 1957

GRANULIFERELLA GRANULOSA E. J. Zeller

Plate 1, figures 9, 11, 12; Plate 2, figures 5, 10

Granuliferella granulosa E. J. Zeller, 1957, Jour. Paleont., vol. 31, no 4, p. 695, pl. 77, figs, 1, 7, 14, 19, 20; pl. 78, fig. 2; pl. 79, figs. 3-5, 20-22; pl. 81, figs. 4, 5, 7, 8, 10; pl. 82, figs. 6, 7.
Granuliferella granulosa E. J. Zeller—Woodland 1958, Jour. Paleont., vol. 32, no. 5, p. 796, pl. 89, figs. 7, 8, 12, 14.

Test ovoid, involute and umbilicate with a greater depression on one side; large proloculus, of average outside diameter 0.06 mm., followed by two volutions coiled in different planes, the degree of rotation of the planes being small; average diameter of test 0.50 mm.; septa stubby and curved only slightly in the anterior direction; chambers barely inflated between sutures; secondary deposits consisting of occasional additions to the posterior tips of the septa; wall coarsely granular, calcareous and of a single layer; aperture slit-like and at base of apertural face.

Hypotypes: PF. 0026, diameter 0.38 mm.
PF. 0226, diameter 0.34 mm.
PF. 0030, diameter 0.60 mm.
PF. 0031, diameter 0.56 mm.
PF. 0032, diameter 0.66 mm.

Locality of hypotypes: PF. 0030, 0031, 0032 (RG 60-1-37), Pekisko Formation, PF. 0026 (RG 60-1-55), PF. 0226 (RG 60-1-50), Shunda Formation, Morro Creek, Alberta.

Occurrence: The species is found in the lowermost bed of the Pekisko Formation and throughout much of the Shunda Formation at Morro Creek, Alberta.

Remarks: *Granuliferella granulosa* was originally described from the Mission Canyon Formation of Montana and the Madison Limestone of Utah and Wyoming. At Morro Creek, specimens from the lower bed of the Pekisko Formation are notably larger than those from the overlying Shunda Formation.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Granuliferella tumida E. J. Zeller

Plate 3, figures 16, 17, 21

Granuliferella tumida E. J. Zeller, 1957, Jour. Paleont., vol. 31, no. 4, p. 696, pl. 77, figs. 3, 21, 22; pl. 81, figs. 14, 15, 17, 18.
Granuliferella tumida E. J. Zeller—Woodland, Jour. Paleont., vol. 32, no. 5, p. 797, pl. 100, figs. 6, 7.

Test ovoid, involute and umbilicate, with a greater umbilical depression on one side; proloculus followed by two and one-half to three volutions; volution coiling planes showing a small degree of rotation; average diameter of test 0.60 mm.; septa of medium length and directed toward the anterior; chambers large in relation to test size, slightly asymmetrical and inflated between sutures, numbering about seven in the outer volution; secondary deposits consisting of rudimentary additions to the posterior tips of the septa; wall granular, calcareous and a single layer; aperture slit-like and at base of apertural face.

Hypotypes: PF. 0027, diameter 0.54 mm.
PF. 0028, diameter 0.60 mm.
PF. 0029, diameter 0.60 mm.

Locality of hypotypes: PF. 0027, 0028, 0029, Peace River region, Alberta, Shell Cadotte No. 1 well (Lsd. 16, Sec. 23, Tp. 85, R. 19, W. 5th Mer.) from 468 feet above the base of the Banff Formation.

Remarks: *Granuliferella tumida* was first recognized in the Joana Limestone of Utah and the basal Madison Limestone of Wyoming. The description presented above is based on a few free specimens which were obtained from well samples. *Granuliferella tumida* is an early representative of the granuliferellids and is differentiated from other species of the genus by having a thinner wall, and larger, more inflated chambers.

Repository: Research Council of Alberta Micropaleontology Type Collection.

Granuliferella sp.

Plate 3, figure 13

Repository: Research Council of Alberta Micropaleontology Type Collection.

Genus Granuliferelloides, n. gen.

Type species: *Granuliferelloides jasperensis*, n. sp.

Granuliferella Zeller(?)—Woodland, 1958 (part), Jour. Paleont., vol. 32, no. 5, p. 797.

The test is plectogyroidly coiled initially, becoming uniserial. Initial portion made up of one and one-half volutions with six chambers in the outer whorl. Chambers in the uniserial portion numbering about seven and increasing uniformly in size. The wall is thick, coarsely granular, calcareous and of a single layer. Aperture simple and terminal.

Woodland (1958) described a thick-walled uniserial species, *Granuliferella? granulella*, from the upper Gardner Formation of central Utah which he provisionally placed in the genus *Granuliferella*. This species is now referred to *Granuliferelloides*.

Endothyranella differs from *Granuliferelloides* in wall structure, as well as in having a greater number of volutions in the initial coiled portion.

Geologic range: Lower Mississippian.

Habitat: marine; limestone.

Granuliferelloides jasperensis, n. sp.

Plate 2, figures 11, 12, 16; Plate 3, figure 14

Test elongate, initial portion spirally coiled, becoming rectilinear, uniserial in the terminal portion. Spiral portion: coiling plectogyroid showing a small amount of angular distortion; average diameter 0.30 mm.;

volutions one and one-half; chambers moderately inflated and numbering about six in the outer whorl; septa stubby and curved slightly toward the anterior; aperture at base of apertural face. Uncoiled portion: made up of approximately seven chambers, increasing uniformly in size; height of terminal chamber 0.12 mm.; maximum width of uncoiled portion 0.16 mm.; average length 0.67 mm., maximum length, 0.86 mm.; wall as for genus; aperture simple and terminal.

Holotype: (Pl. 2, Fig. 11), PF. 0035, diameter of initial portion 0.28 mm., length of uniserial portion 0.67 mm.

Paratypes: (Pl. 2, Fig. 12), PF. 0036, diameter of initial portion 0.30 mm., uniserial portion incomplete.
(Pl. 2, Fig. 16), PF. 0037, diameter of initial portion 0.32 mm., length of uniserial portion 0.60 mm.
(Pl. 3, Fig. 14), PF. 0038, length of uniserial portion 0.86 mm.

Locality of holotype and paratypes: PF. 0035, 0036 (RG 60-1-57), PF. 0037 (RG 60-1-59), Morro Creek, Alberta; PF. 0038, Bighorn Creek, Alberta. All specimens from the Shunda Formation.

Occurrence: *Granuliferelloides jasperensis* is a common species in the lower and middle beds of the Shunda Formation at Morro Creek and in the basal part of the same formation that was examined at Bighorn Creek, Alberta.

Remarks: *Granuliferelloides jasperensis* differs from *G. granulella* (Woodland) in having a distinctly smaller initial coiled portion.

The name of the species is derived from the locality from which it was first collected, Morro Creek, Jasper, Alberta.

Repository: Research Council of Alberta Micropaleontology Type Collection.

GRANULIFERELLOIDES spp.

Plate 1, figure 10; Plate 4, figure 2

Repository: Research Council of Alberta Micropaleontology Type Collection.

GRANULIFERELLOIDES? sp.

Plate 2, figure 21

This species is characterized by a rudimentary cribrate aperture which differentiates it from true *Granuliferelloides* species.

Repository: Research Council of Alberta Micropaleontology Type Collection.

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Explanation of Plate 1

(all figures about X50)

Morro Creek Section

Upper Beds—Member B, Banff Formation

Figure 1: *Endothyra tumula* (E. J. Zeller); horizontal axial section, PF. 0015 .... (p. 40)

Figures 2, 3, 6: *Endothyra* sp. A; 2, 3—oblique horizontal axial sections. PF. 0116, 0117; 6—vertical axial section, PF. 0118 (p. 42)

Figures 7, 13: *Spiroplectammina* sp.; longitudinal axial sections, PF. 0019, 0020 .... (p. 28)

Figure 8: *Endothyra* sp.; axial section, PF. 0019 (RG 60-1-34)

Figure 10: *Granuliferelloides* sp.; longitudinal axial section PF. 0225 (RG 60-1-34).

Lower Beds—Pekisko Formation

Figures 4, 5: *Endothyra tumula* (E. J. Zeller); 4 — vertical axial section, PF. 0128; 5—horizontal axial section, PF. 0129 (p. 40)

Figures 9, 11, 12: *Granuliferella granulosa* E. J. Zeller; 9, 12—horizontal axial section, PF. 0030, 0031; 11—vertical axial section, PF. 0032 .... (p. 45)

PLATE 1

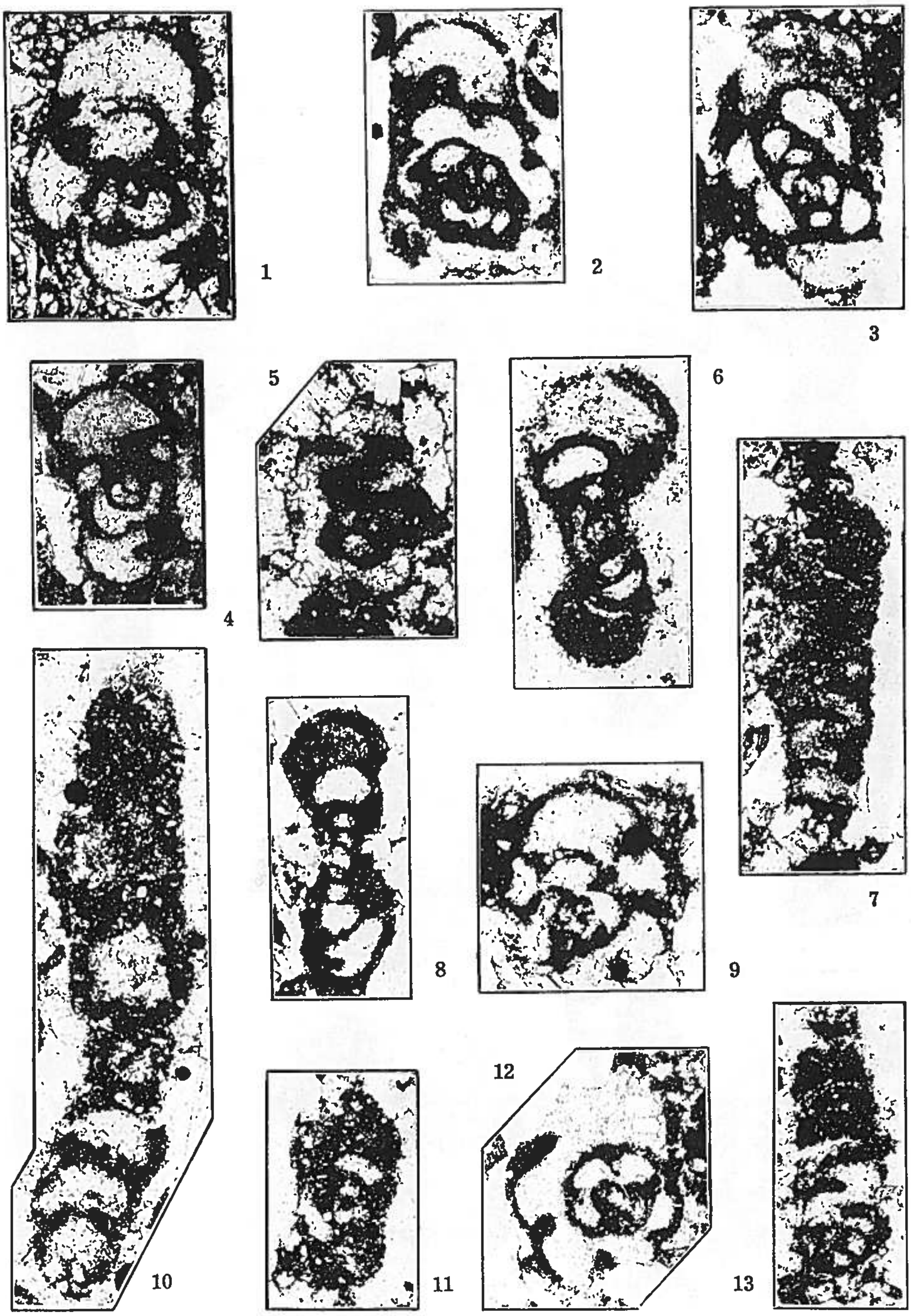
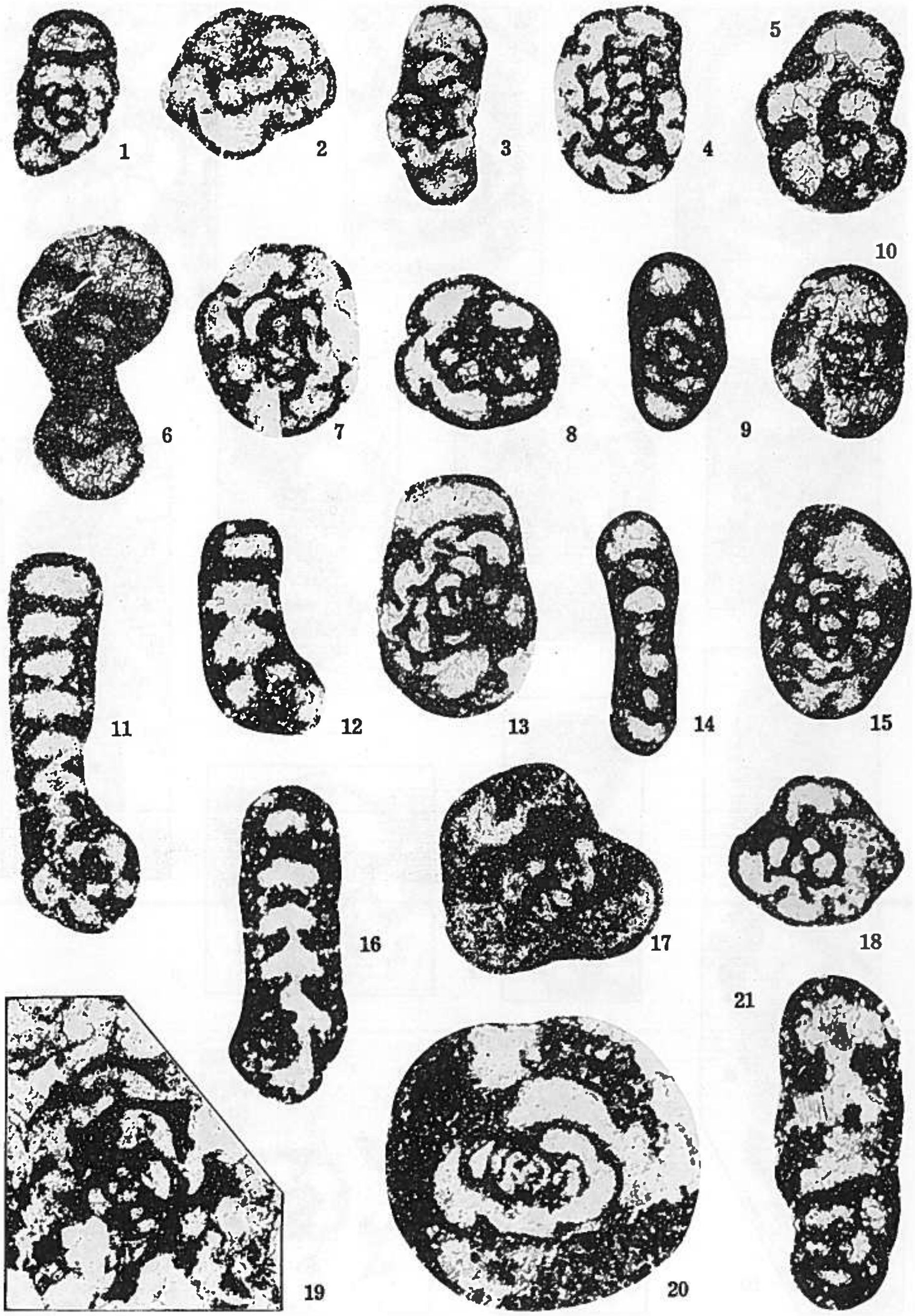


PLATE 2



Explanation of Plate 2

(all figures about X50 unless indicated otherwise)

Morro Creek Section

Upper Beds—Member B, Banff Formation

Figures 1, 2: *Endothyra*? *morroensis*, n. sp., 1—vertical axial section, PF. 0087; 2—horizontal axial section, PF. 0227 (holotype) (p. 35)

Shunda Formation

Figures 3, 4: *Endothyra spinosa* Chernysheva; 3 — vertical axial section, PF. 0108; 4—horizontal axial sectiin, PF. 0109 (p. 38)

Figures 5, 10: *Granuliferella granulosa* E. J. Zeller; horizontal axial sections, PF. 0026, 0226 (X75) .... (p. 45)

Figures 6, 7, 13, 14, 15, 19: *Endothyra* spp.; 6, 14 — vertical axial sections, PF. 0130, 0133; 7, 13, 15, 19 — horizontal axial sections, PF. 0110, 0111, 0134, 0175; 6—(RG 60-1-59); 7, 13, 14, 15—(RG 60-1-55); 19—RG 60-1-61).

Figures 8, 9: *Endothyra*? *morroensis*, n. sp.; 8—horizontal axial section, PF. 0089 (X75); 9—vertical axial section, PF. 0090 (X100) .... (p. 45)

Figures 11, 12, 16; *Granuliferelloides jasperensis*, n. gen., n. sp.; longitudinal axial sections, PF. 0035, 0036, 0037 (11 is the genoholotype) .... (p. 47)

Figure 17: *Endothyra tumula* (E. J. Zeller); horizontal axial section, PF. 0224 .... (p. 40)

Figures 21: *Granuliferelloides*? sp.; longitudinal axial section, showing rudimentary cribrate aperture, PF. 0033 (RG 60-1-50).

Lower Beds—Turner Valley Formation

Figures 18, 20: *Endothyra* spp.; horizontal axial sections, PF. 0131, 0132 (RG 60-1-80).

Explanation of Plate 3

(all figures about X50 unless indicated otherwise)

Morro Creek Section

Lower Beds—Turner Valley Formation

Figures 1, 3, 5-8: *Endothyra* spp.; 1—sagittal section, PF. 0012; 3, 5, 7—oblique horizontal axial sections, PF. 0120, 0196, 0135; 6—vertical axial section, PF. 0121; 8—horizontal axial section, PF. 0136; 3—(X40); (RG 60-1-83).

Figures 2, 4: *Endothyra tuberculata* Lipina; horizontal axial sections, PF. 0083, 0195; 4—(X40) .... (p. 39)

Figures 9, 10: *Endothyra* sp. B; 9—vertical axial section, PF. 0197; 10—horizontal axial section, PF. 0137 .... (p. 42)

Bighorn Creek Section

Lower Beds—Shunda Formation

Figures 11, 15: *Endothyra tumula* (E. J. Zeller); 11—vertical axial section, PF. 0138; 15—horizontal axial section, PF. 0191 (p. 40)

Figure 12: *Endothyra* sp.; vertical axial section, PF. 0139.

Figure 13: *Granuliferella* sp.; horizontal axial section, PF. 0141 (X75).

Figure 14: *Granuliferelloides jasperensis,* n. gen., n. sp.; longitudinal axial section, PF. 0038 .... (p. 47)

Shell Cadotte No. 1 Well
(3400 - 3410 feet)

Upper Beds—Banff Formation

Figures 16, 17, 21: *Granuliferella tumida* E. J. Zeller; 16—horizontal axial section, PF. 0027; 17—vertical axial section, PF. 0028; 21—side view, PF. 0029 (X60) .... (p. 46)

Bear Beaumont No. 1 Well
(1373-1383 feet)

Upper Beds—Ireton Formation (Devonian)

Figures 18, 19, 20: *Nanicella gallowayi* (Thomas) Henbest; 18 — sagittal section, PF. 0024 (X60); 19—side view, PF. 0025 (X75); 20—peripheral view, PF. .0025 (X75).

PLATE 3

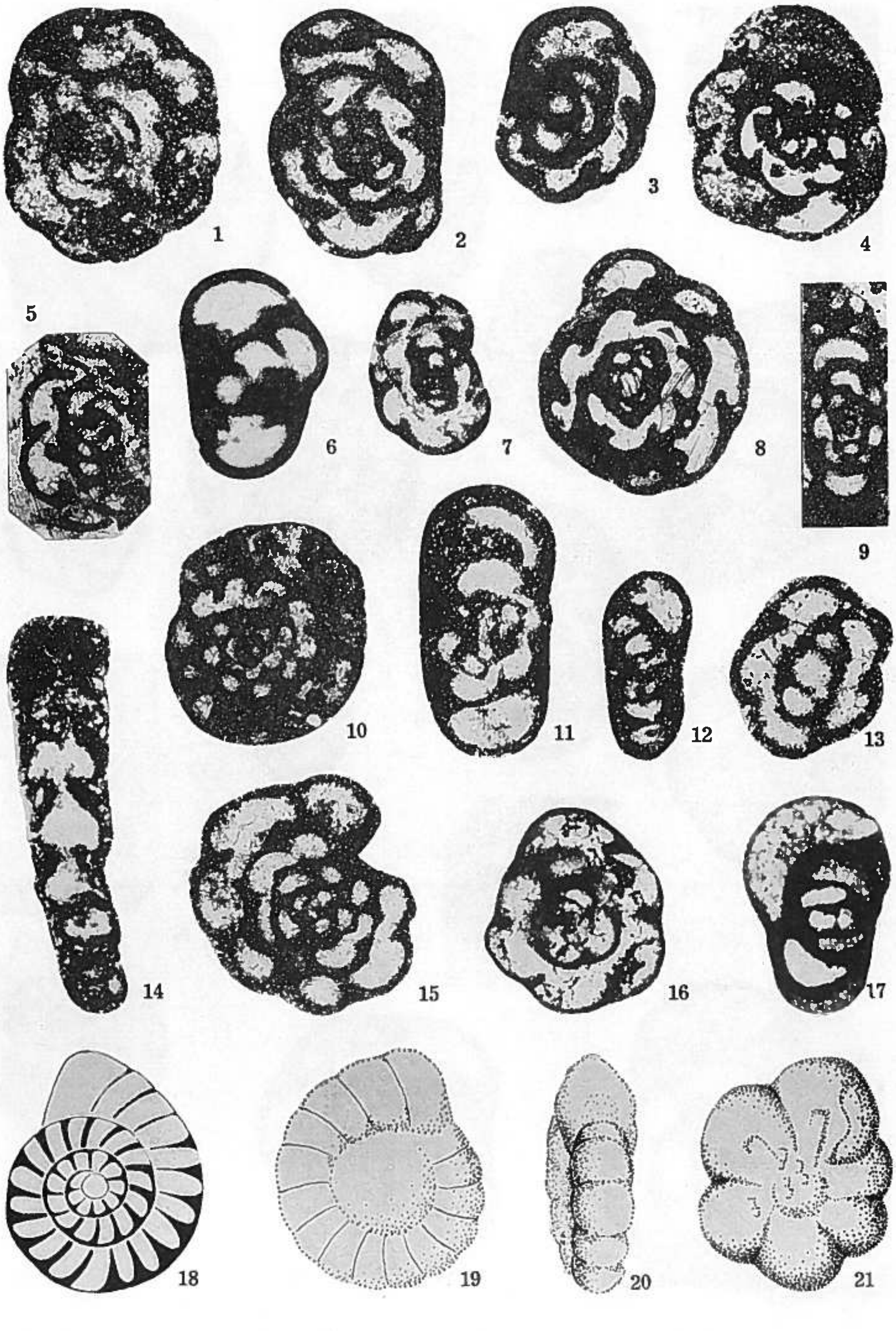
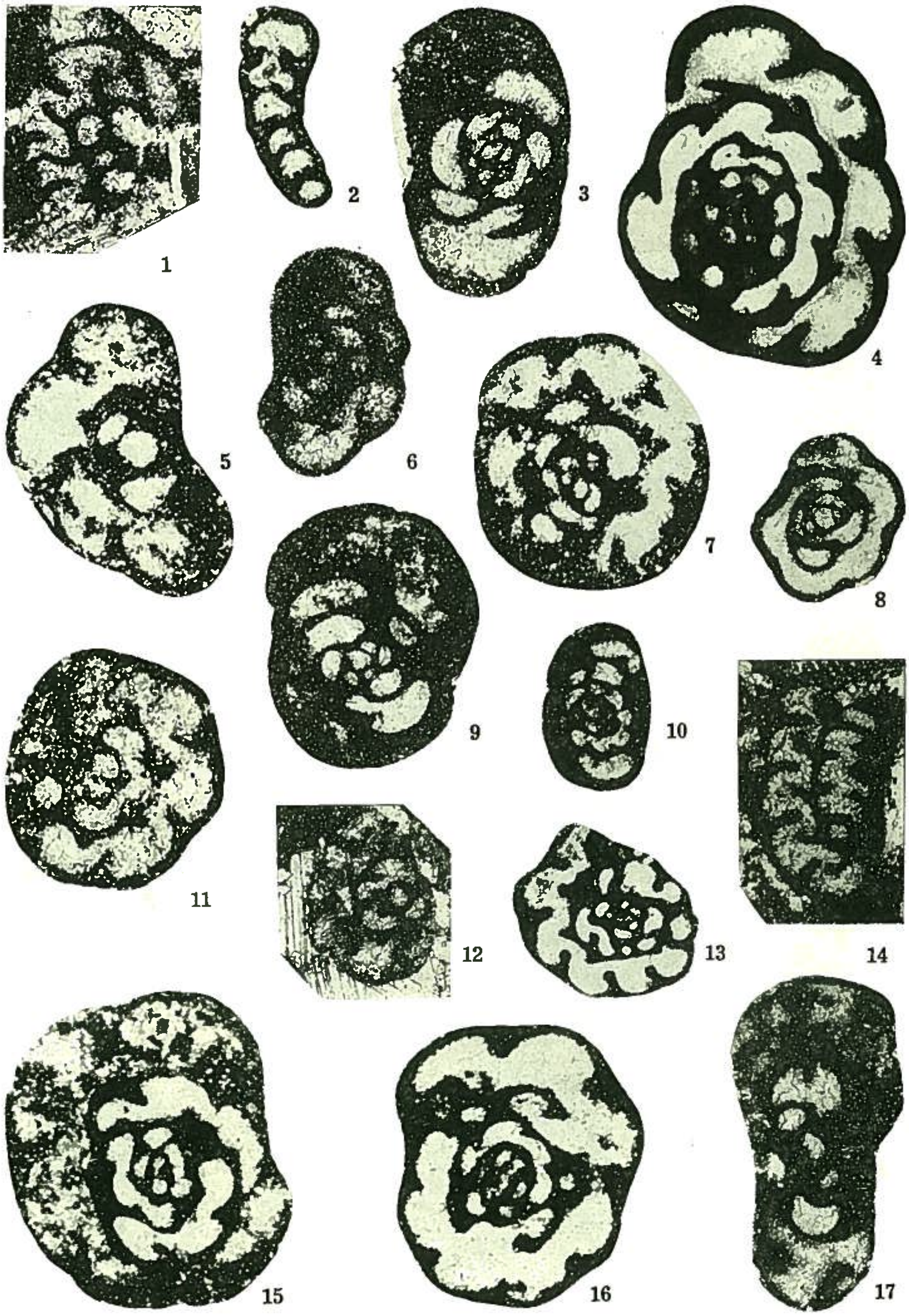


PLATE 4



EXPLANATION OF PLATE 4

(all figures about X50 unless indicated otherwise)

Moose Mountain Section

Pekisko Formation

Figures 1, 12, 14: *Endothyra* sp. cf. *E. spinosa* Chernysheva; oblique horizontal axial sections, PF. 0198, 0199, 0200 .... (p. 39)

Figure 2: *Granuliferelloides* sp.; oblique longitudinal axial section, PF. 0039 (RG 59-2-12).

Figures 3-6, 10, 13, 15-17: *Endothyra* spp.; 3, 10, 17—vertical axial sections, PF. 0201, 0106, 0145; 5, 6, 13—oblique horizontal axial sections, PF. 0203, 0204, 0085, 13—(X40); 4, 15, 16—horizontal axial sections, PF. 0202, 0143, 0144; 5 (RG 59-2-12); 6 (RG 59-2-19); 3, 4, 10, 13, 15, 16 (RG 59-2-22); 17 (RG 59-2-23).

Figures 7, 9, 11: *Endothyra tumula* (E. J. Zeller); 7—horizontal axial section, PF. 0112; 9—vertical axial section, PF. 0013; 11—oblique horizontal axial section, PF. 0114 .... (p. 40)

Figure 8: *Endothyra*? sp.; horizontal axial section, PF. 0091 (RG 59-2-22).

Explanation of Plate 5

(all figures about X50)

Moose Mountain Section

Pekisko Formation

Figures 1-6: *Endothyra* spp.; 2, 5—vertical axial sections, PF. 0146, 0123; 1, 3—horizontal axial sections, PF. 0154, 0147; 4, 6—oblique horizontal axial sections, PF. 0229, 0148; 1-5 (RG 59-2-23); 6 (RG 59-2-25).

Turner Valley Formation

Figures 7, 9, 11: *Endothyra* spp.; 7—horizontal axial section, PF. 0149; 9, 11—vertical axial sections, PF. 0150, 0060; 7, 9 (RG 59-2-31); 11 (RG 59-2-38).

Figure 10: *Endothyra lanceolata* Woodland; horizontal axial section, PF. 0094 .... (p. 33)

Mount Darrah, Alberta

Upper Beds—Livingstone Formation

Figure 8: *Endothyra lanceolata* Woodland; horizontal axial section, PF 0093 .... (p. 33)

Tunnel Mountain Section

Upper Beds—Livingstone Formation

Figures 12, 14-17, 20: *Endothyra* spp.; 12, 17—sagittal sections, PF. 0061, 0063; 14, 16, 20—horizontal axial sections, PF. 0186, 0189, 0153; 15—axial section, PF. 0054; 14, 17, 20 (RG 57-1-74); 12, 15 (RG 57-1-87); 12 (RG 59-1-93).

Figures 13, 18, 21: *Endothyra lanceolata* Woodland; horizontal axial sections, PF. 0095, 0096, 0097 .... (p. 33)

Figure 19: *Ammodiscus* sp.; oblique sagittal section, PF. 0003 (RG 57-1-75).

Figure 22: *Endothyra* sp. C; sagittal section, PF. 0062 .... (p. 43)

PLATE 5

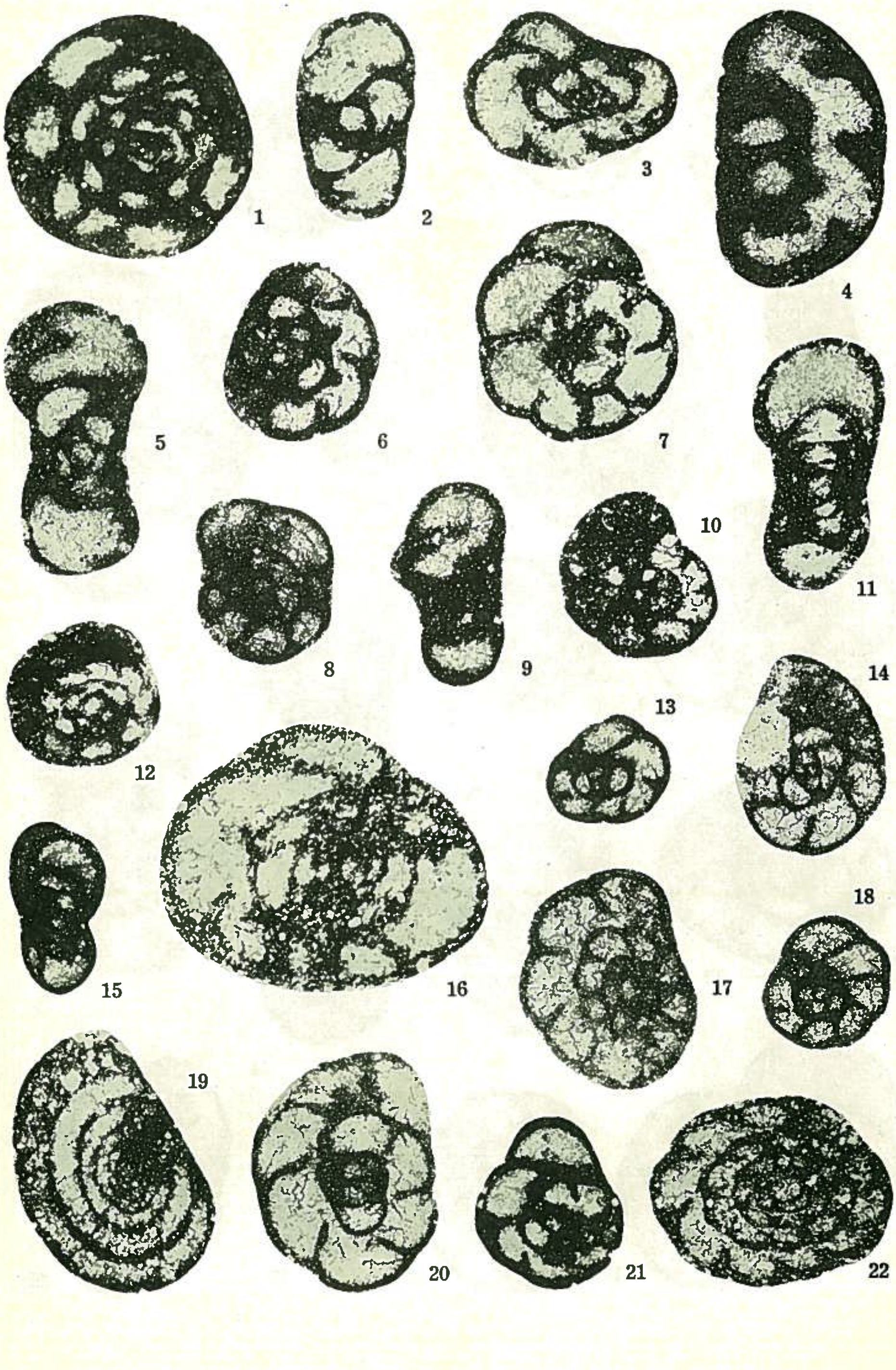
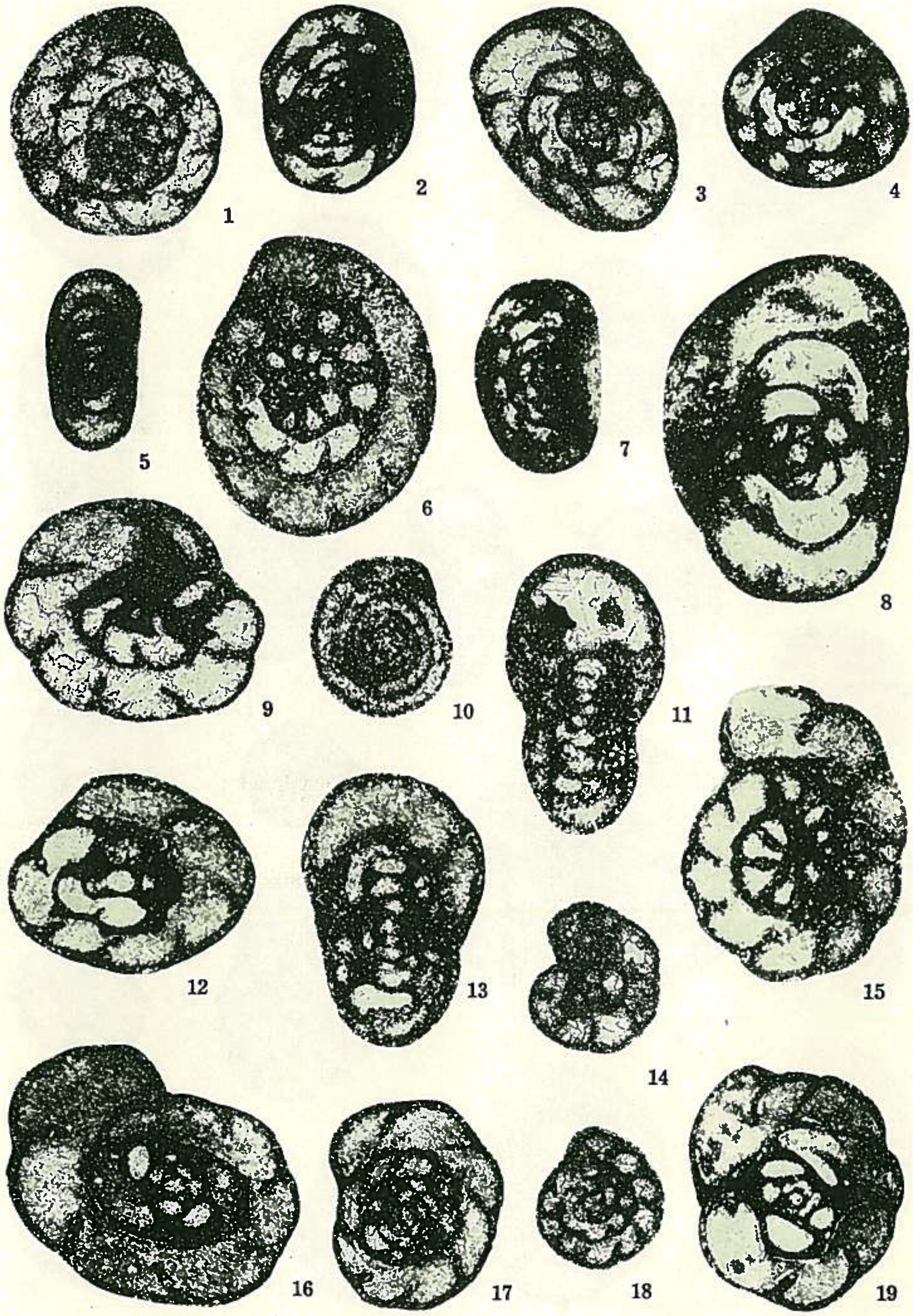


PLATE 6



Explanation of Plate 6

(all figures about X50)

Tunnel Mountain Section

Upper Beds—Livingstone Formation

Figures 1, 3: *Endothyra* sp. C; sagittal sections, PF. 0055, 0056 .. (p. 43)

Figures 2, 4, 5, 7: *Endothyra* spp.; 2, 7—oblique sagittal sections, PF. 0074, 0076; 4—sagittal section, PF. 0203; 5—axial section, PF. 0205; (RG 57-1-66).

Figure 8: *Endothyra* sp. D; axial section, PF. 0125 .... (p. 44)

Figure 10: *Ammodiscus* sp.; sagittal section, PF. 0004 (RG 57-1-66).

Lower Beds—Mount Head Formation

Figures 6, 11, 13, 15: *Endothyra* sp. E; 6, 15—sagittal sections, PF. 0206, 0059; 11, 13—axial sections, PF. 0057, 0207 .... (p. 44)

Figures 9, 12, 17, 18: *Endothyra* spp.; 9, 12—horizontal axial sections, PF. 0208, 0209; 17, 18 — sagittal sections, PF. 0064, 0065; (RG 57-1-41).

Figure 14: *Endothyra lanceolata* Woodland; horizontal axial section, 0098 .... (p. 33)

Figures 16, 19: *Endothyra* sp. D; horizontal axial sections, PF. 0126, 0127 .... (p. 44)

Explanation of Plate 7

(all figures about X50 unless indicated otherwise)

Tunnel Mountain Section

Middle Beds—Mount Head Formation

Figures 1, 3: *Archaediscus* sp. A; axial sections, PF. 0015, 0016 (X100) .... (p. 25)

Figures 2, 6: *Glomospirella* spp.; axial sections, 2—PF. 0005 (RG 57-1-33), 6—PF. 0006 (RG 57-1-32) (X100).

Figures 4, 5: *Tournayella*? *nonconstricta*, n. sp.; 4—axial section, PF. 0009; 5—sagittal section, PF. 0008 (holotype) .... (p. 27)

Figures 7, 12-14: *Endothyra zelleri;* 7, 13, 14—sagittal sections, PF. 0047, 0049, 0050; 12—axial section, PF. 0051 .... (p. 41)

Figures 8, 16: *Endothyra* spp.; 8—axial section, PF. 0048; 16—horizontal axial section, PF. 0102; (RG 57-1-30).

Figure 9: *Ammodiscus* sp.; sagittal section, PF. 0040 (RG 57-1-30).

Figures 10, 11, 17: *Endothyra incrassata,* n. sp.; 10, 11—horizontal axial sections, PF. 0105, 0103; 17—vertical axial section, PF. 0104 (11 is the holotype) .... (p. 32)

Figure 15: *Endothyra robusta,* n. sp.; axial section, PF. 0172 .... (p. 37)

PLATE 7

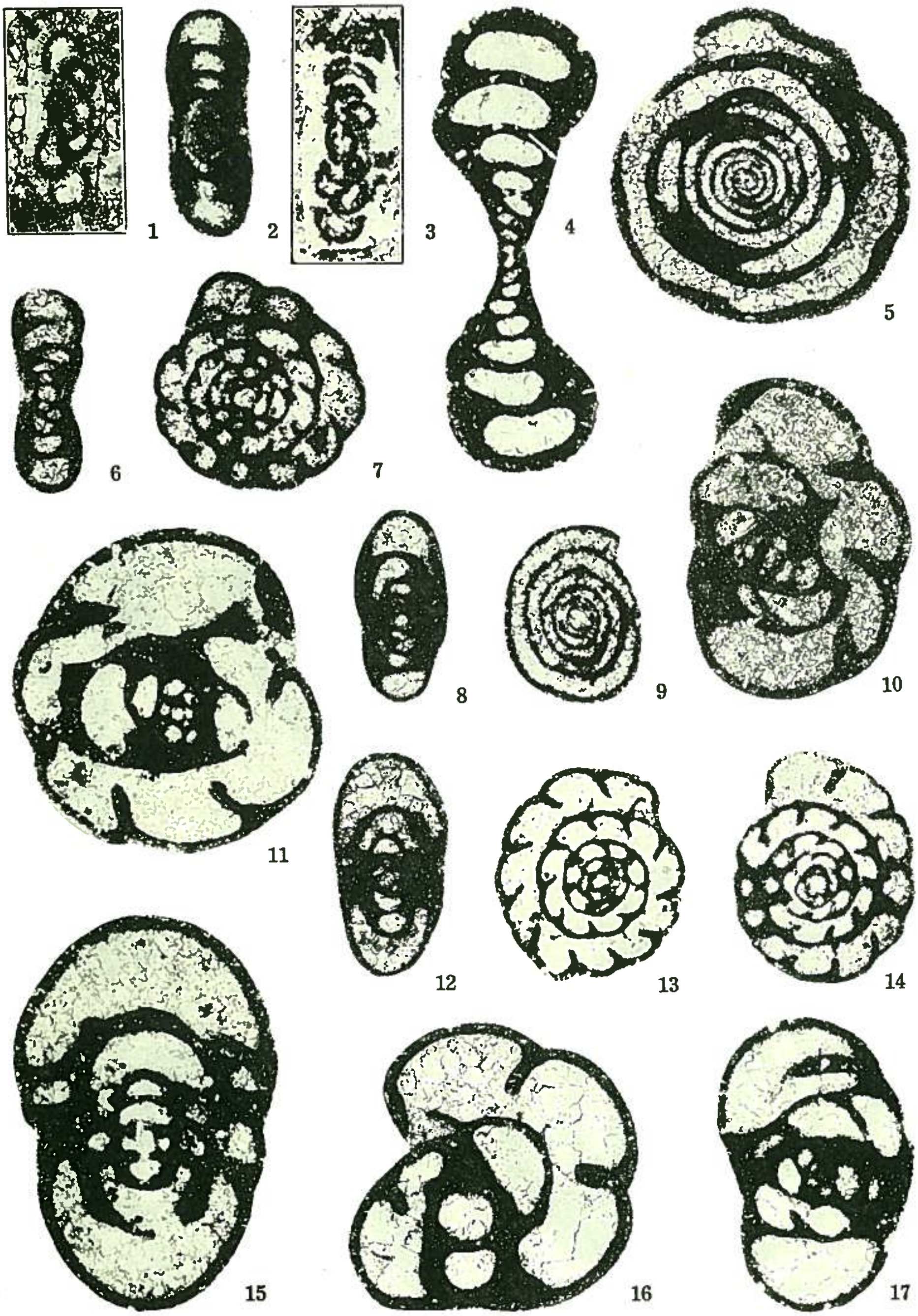
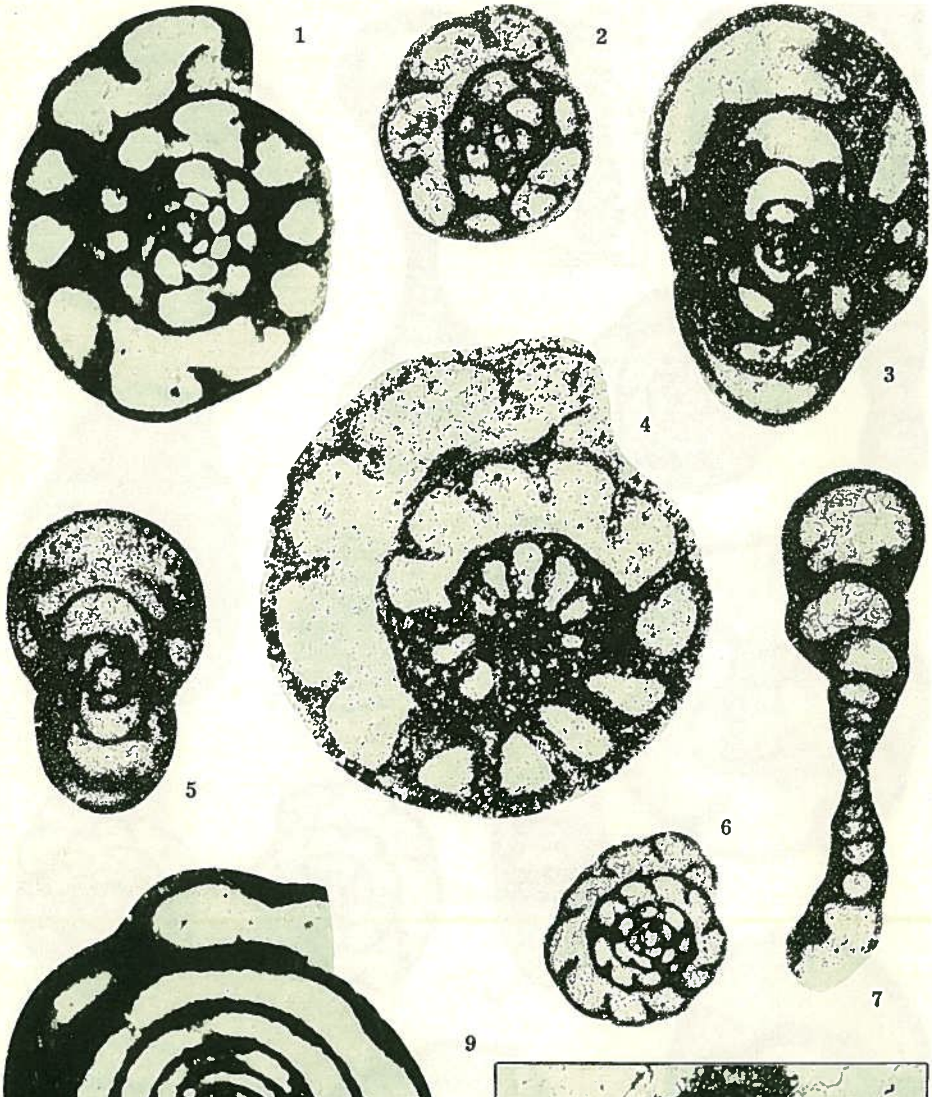


PLATE 8



Explanation of Plate 8

(all figures about X50 unless indicated otherwise)

Tunnel Mountain Section

Middle Beds—Mount Head Formation

Figures 1, 3, 4: *Endothyra robusta*, n. sp.; 1, 4—sagittal sections, PF. 0210, 0173; 3—axial section, PF. 0174 (4 is the holotype) (p. 37)

Figures 2, 5, 6: *Endothyra* spp.; 2—horizontal axial section, PF. 0157; 5—axial section, PF. 0188; 6—sagittal section, PF. 0052; (RG 57-1-30).

Figures 7, 8: *Tournayella*? *nonconstricta*, n. sp.; 7—axial section, PF. 0002; 8—sagittal section, PF. 0010 (X55) .... (p. 27)

Figure 9: *Endothyra* sp.; Enlarged view of PF. 0102 (Pl. 7, Fig. 16) showing thin outer layer (tectum) and granular inner layer; inner tectorium is not clearly differentiated (X240).

Explanation of Plate 9

(all figures about X50 unless indicated otherwise)

Tunnel Mountain Section

Upper Beds—Mount Head Formation

Figures 1-7, 11, 13-15: *Endothyra* spp.; 1, 7, 15—horizontal axial sections, PF. 0211, 0213, 0219; 2-6, 14—sagittal sections, PF. 0215, 0212, 0216, 0217, 0053, 0220; 11—axial section, PF. 0218; 13—vertical axial section, PF. 0214; (RG 57-1-29).

Figure 8: *Endothyra macra* E. J. Zeller; sagittal section, PF. 0066 (p. 34)

Figures 9, 10: *Endothyra arrecta*, n. sp.; horizontal axial sections, PF. 0041, 0042 .... (p. 30)

Figure 12: *Palaeotextularia* sp.; longitudinal axial section, PF. 0022 (RG 57-1-29) (X75).

PLATE 9

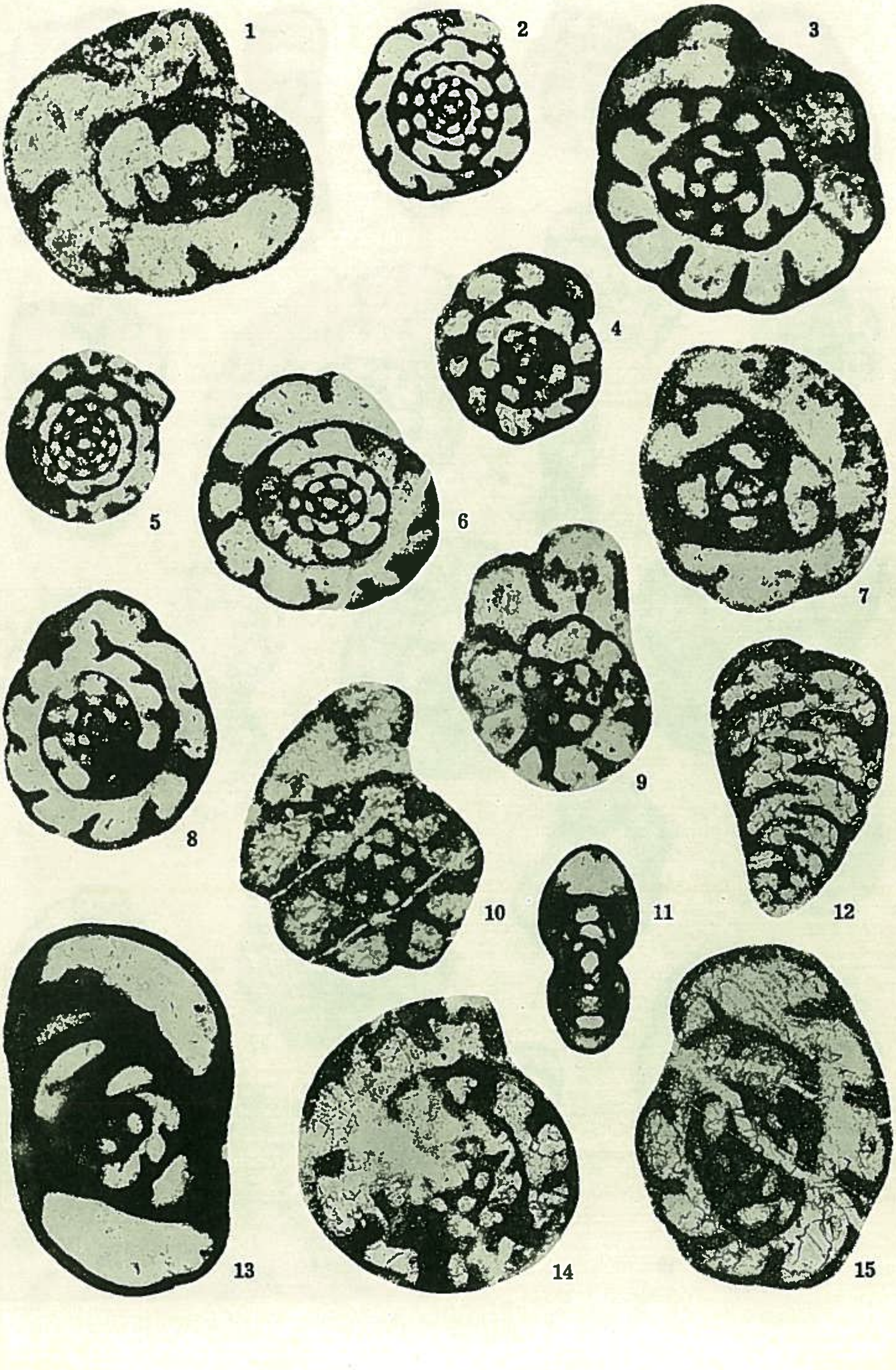
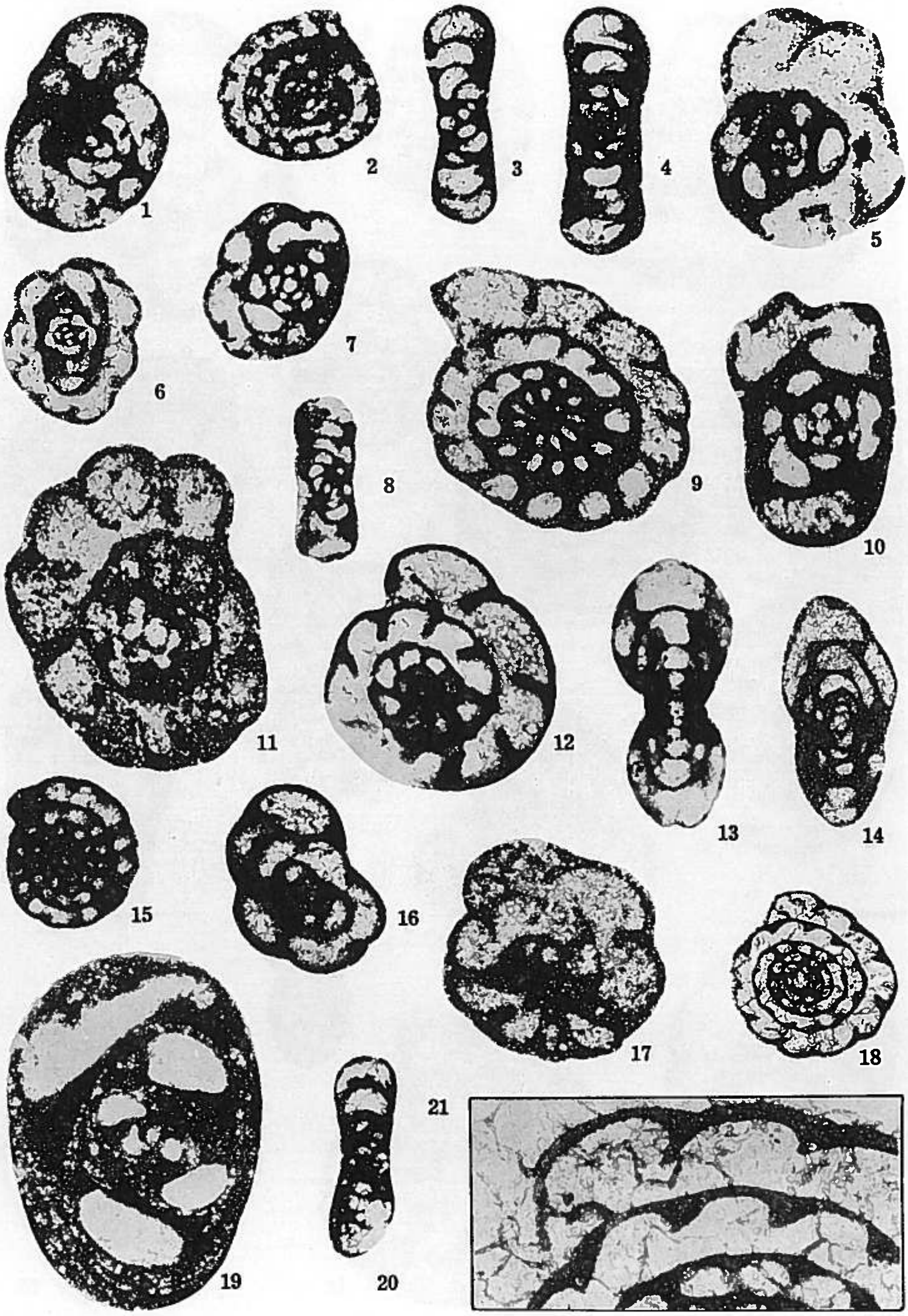


PLATE 10



Explanation of Plate 10

(all figures about X50 unless indicated otherwise)

Tunnel Mountain Section

Upper Beds—Mount Head Formation

Figures 1, 12, 17: *Endothyra flatile*, n. sp.; sagittal sections, PF. 0044, 0045, 0046 (12 is the holotype) .... (p. 31)

Figures 2-4, 15, 20: *Endothyra*? *banffensis*, n. sp.; 2, 15—horizontal axial sections, PF. 0080, 0077; 3, 4, 20—vertical axial sections, PF. 0078, 0079, 0028; 2-4—(X75); (15 is the holotype) .. (p. 30)

Figures 5, 9, 10: *Endothyra* spp.; 5—horizontal axial section, PF. 0160; 9—sagittal section, PF. 0067; 10—vertical axial section, PF. 0161; (RG 57-1-21).

Figures 6, 7, 8: *Endothyra*? sp.; horizontal axial sections, PF. 0075, 0100, 0101 (RG 57-1-24).

Figure 11: *Endothyra arrecta*, n. sp.; horizontal axial section, PF. 0043 (holotype) .... (p. 30)

Figures 13, 16, 18, 19: *Endothyra* spp.; 13—axial section, PF. 0068; 16—horizontal axial section, PF. 0162; 18—sagittal section, PF. 0070; 19—vertical axial section, PF. 0073; (RG 57-1-20).

Figure 14: *Millerella*? sp.; axial section, PF. 0069 (RG 57-1-20).

Figure 21: *Endothyra* sp.; Enlarged view of PF. 0070 (Fig. 18) showing short resorbed septa (about X200).

Explanation of Plate 11

(all figures about X50 unless indicated otherwise)

Tunnel Mountain Section

Upper Beds—Mount Head Formation

Figures 1, 2, 4, 7: *Endothyra* spp.; 1, 7—horizontal axial sections, PF. 0176, 0177; 2—axial section, PF. 0190; 4—sagittal section, PF. 0221; (RG 57-1-18).

Figure 3: *Endothyra* sp. aff. *E. omphalota* Rauser-Cernoussova and Reitlinger; vertical axial section, PF. 0178 .... (p. 36)

Figure 5: *Permodiscus* sp.; axial section, PF. 0018 .... (p. 26)

Figure 6: *Palaeotextularia* sp.; longitudinal axial section, PF. 0023 (X75), (RG 57-1-18).

Figure 14: *Endothyra* sp. aff. *E. omphalota* Rauser-Cernoussova and Reitlinger; Enlarged view of PF. 0178 (Fig. 3) showing the inner dark tectorium, middle light diaphanotheca and outer dark tectum. Radial hyaline layer on outside of tectum is considered superficial (X175).

Lower Beds—Etherington Formation

Figures 8, 9: *Endothyra kleina* (Woodland); oblique horizontal axial sections, PF. 0164, 0165 (X100) .... (p. 33)

Crowsnest Ridge Section

Upper Beds—Mount Head Formation

Figures 10, 11, 12: *Endothyra* spp.; 10—oblique horizontal axial section, PF. 0166; 11—vertical axial section, PF. 0171; 12—sagittal section, PF. 0175.

Figure 13: *Endothyra robusta*, n. sp.; oblique sagittal section, PF. 0179 .... (p. 37)

PLATE 11

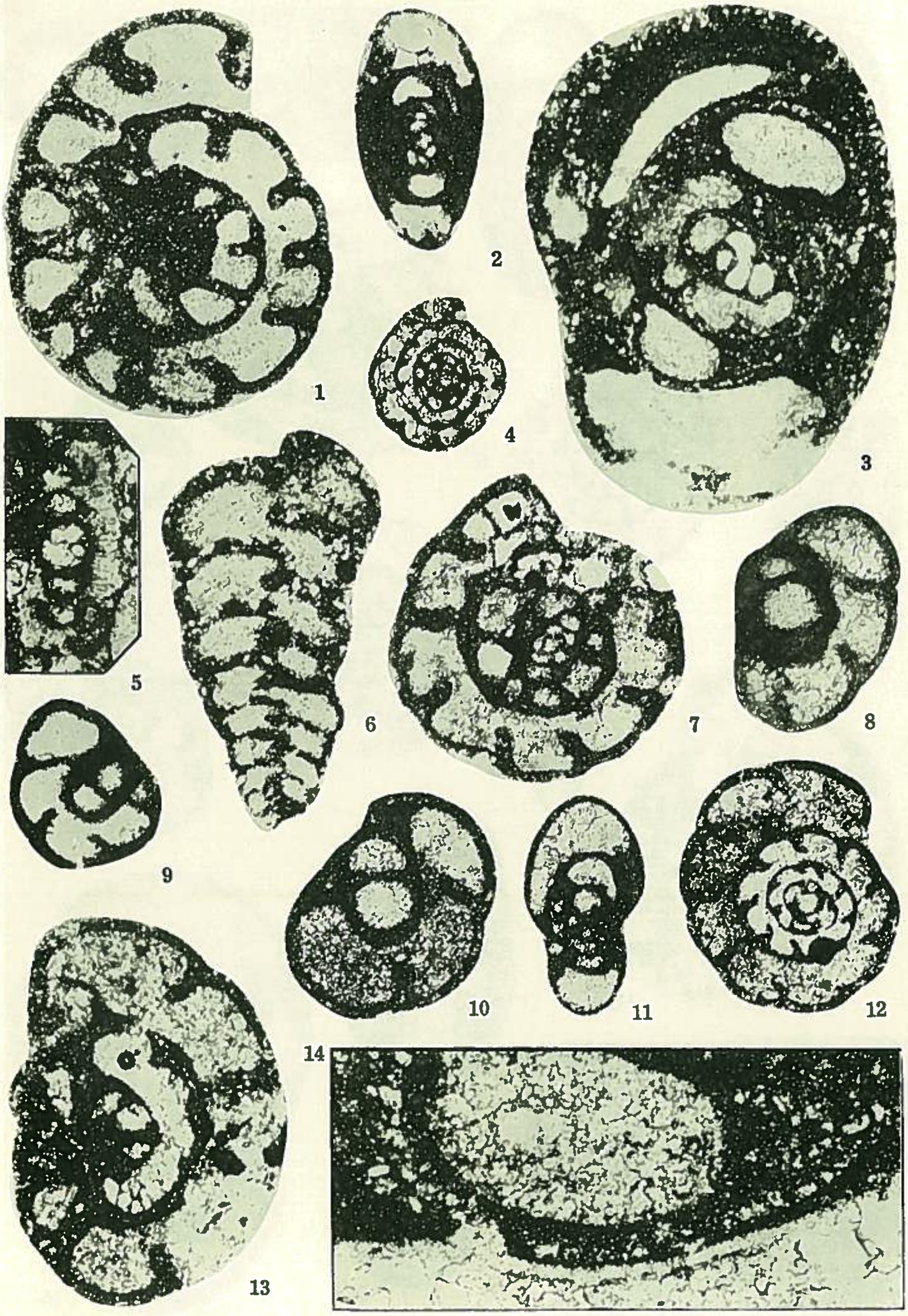
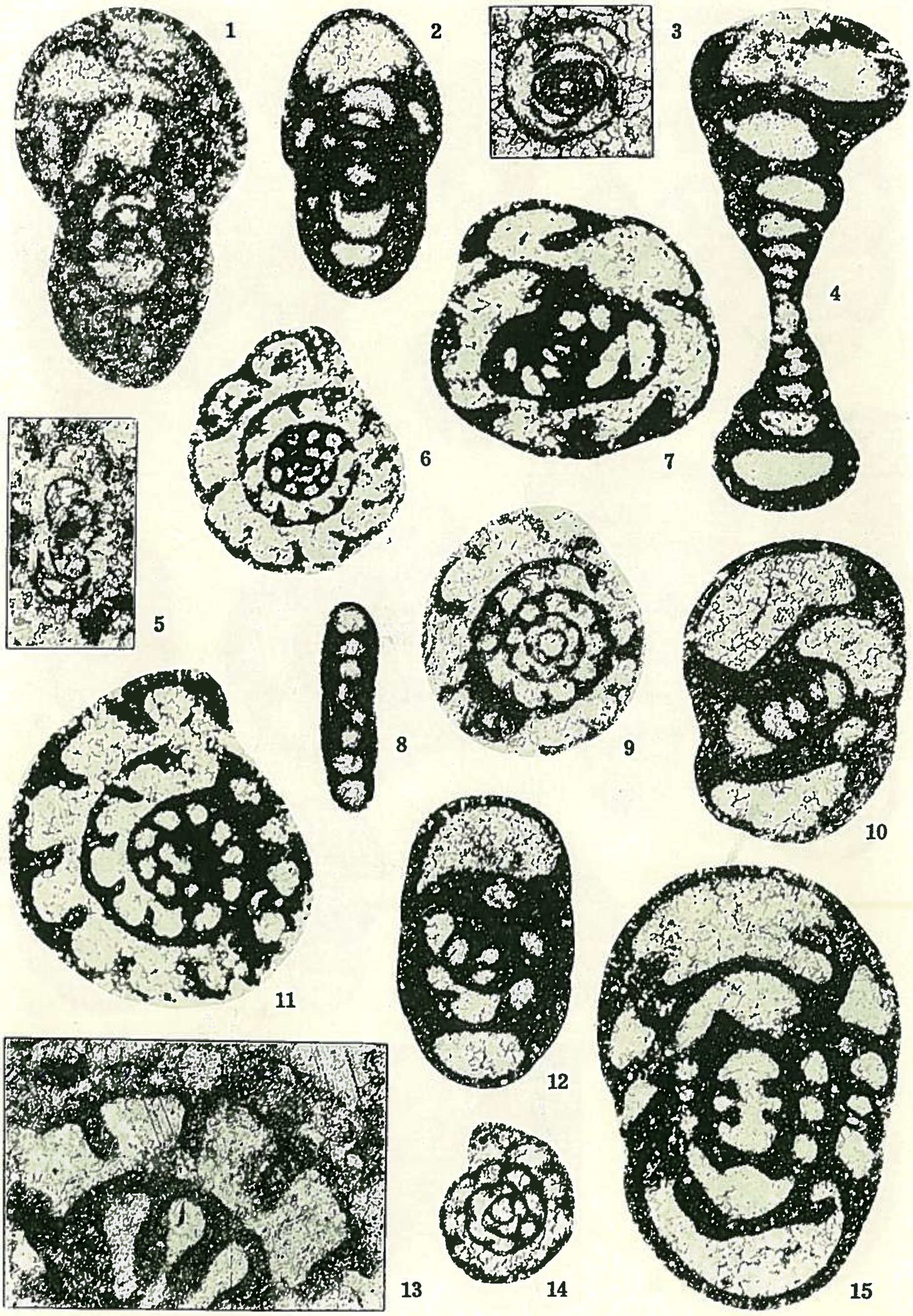


PLATE 12



EXPLANATION OF PLATE 12

(all figures about X50 unless indicated otherwise)

Mount Rae Section

Lower Beds—Mount Head Formation

Figure 1: *Endothyra* sp.; axial section, PF. 0159 (from 400 feet below the top of formation).

Upper Beds—Mount Head Formation

(40 to 50 feet below top)

Figures 2, 7, 9-14: *Endothyra* spp.; 2—axial section, PF. 0180; 7, 14—horizontal axial sections, PF. 0184, 0170; 9, 11—sagittal sections, PF. 0222, 0223; 10, 12—vertical axial sections, PF. 0185, 0187; 13—incomplete sagittal section, PF. 0182.

Figures 3, 5: *Archaediscus* sp.; 3—sagittal section, PF. 0017; 5—axial section, PF. 0014 (X100).

Figure 4: *Tournayella*? *nonconstricta,* n. sp.; axial section, PF. 0011 .... (p. 27)

Figure 6: *Endothyra macra* E. J. Zeller; sagittal section, PF. 0086 (p. 34)

Figure 8: *Glomospirella* sp.; axial section, PF. 0007 (X100)

Figure 15: *Endothyra robusta,* n. sp.; axial section, PF. 0183 .... (p. 37)

FIGURE 3

Distribution and Relative Abundance of Mississippian Foraminifera in the Canadian Rockies

Tunnel Mountain Section

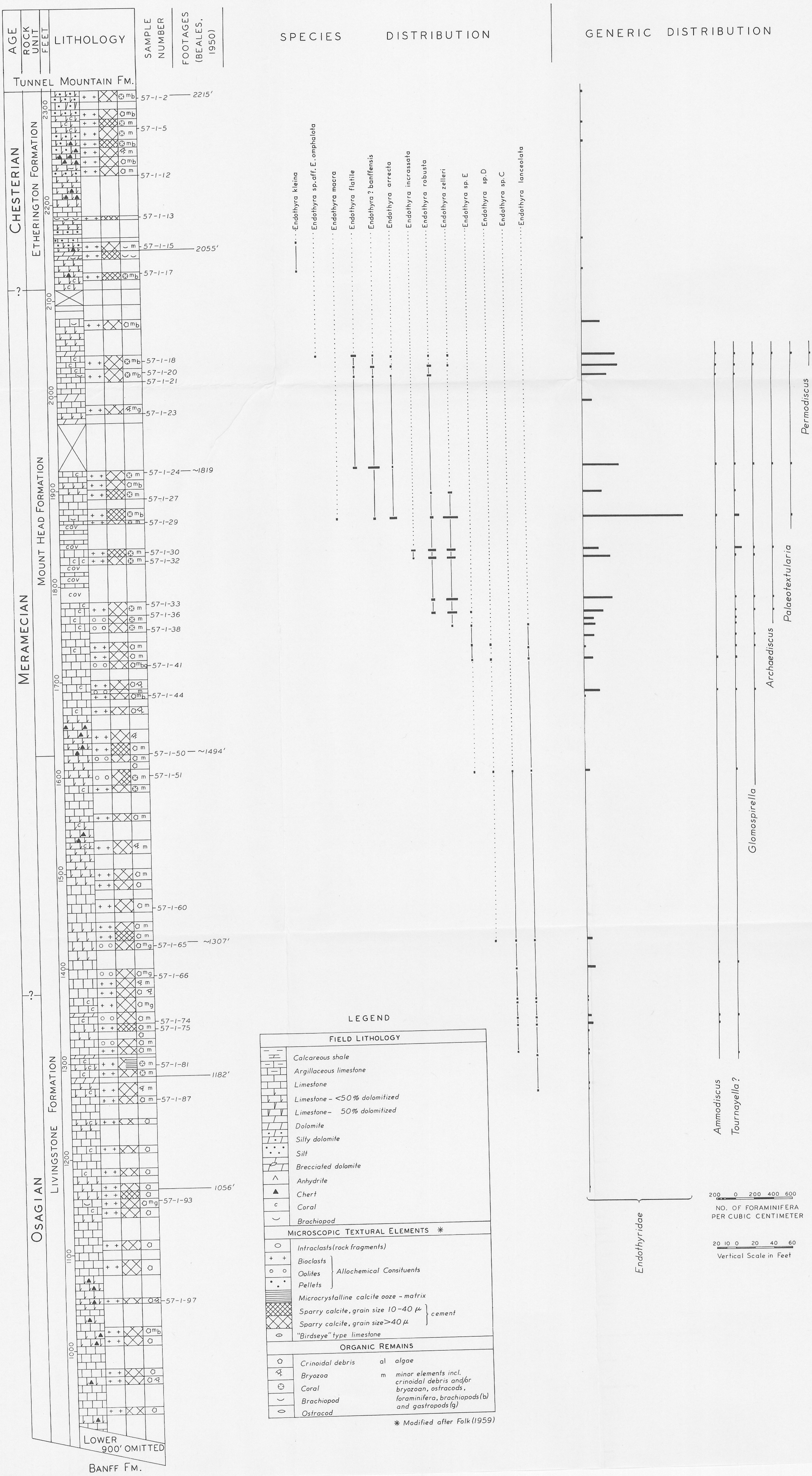


FIGURE 4

Distribution and Relative Abundance of Mississippian Foraminifera in the Canadian Rockies