Micropaleontological Zonation (Foraminifers, Algae) and Stratigraphy, Carboniferous Peratrovich Formation, Southeastern Alaska

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CONTENTS

PLATES

FIGURES

Micropaleontological Zonation (Foraminifers, Algae) and Stratigraphy, Carboniferous Peratrovich Formation, Southeastern Alaska

By Bernard L. Mamet[1], Sylvie Pinard[2], *and* Augustus K. Armstrong[3]

ABSTRACT

Stratigraphic, petrographic and micropaleontologic studies of the carbonate sequences of the Mississippian Peratrovich Formation define five informally named members (ascending): cherty spiculite and radiolarite member, lower cherty limestone member, lower limestone member, upper cherty limestone member, and upper limestone member. They define a shoaling-upward sequence having a minimum aggregate thickness of 560 m. The basal part of the formation has no microfossils, and its age cannot be assigned with precision. The first datable bed is late Tournaisian in age (Zone ≥9). It is succeeded by beds of Visean (Zones ≥10, 13, 14, 15, 16_i, 16_s), early Namurian (Zones 17, 18) and debatable Namurian(?) (Zone ≥18–20) age. The affinities of the Peratrovich fauna and flora are as much Tethyan as American, and thus the microfauna forms a bridge between the two domains. Biostratigraphy suggests a Tethyan origin for most of the Carboniferous microfauna, which migrated in successive waves toward North America. This mixed fauna permits reconstruction of the Carboniferous paleogeography and imposes constraints on tectonic models for the North American Cordillera. Paleogeographic reconstructions suggest that the Peratrovich mixed microfauna and its suspect terrane are not derived from Asia. Rather, the rocks and their fauna appear to represent a terrane bordering the Cordilleran geosyncline or a microcontinental fragment in a similar paleogeographic position.

INTRODUCTION

Calcareous foraminifers were recognized during the middle of this century by the Russian school (Rauzer-Chernoussova, 1948a–i) as useful tools for identifying zonation. By the 1960's, they were routinely used for biostratigraphy in Western Europe and in Russia (Mamet, 1962; Conil and Lys, 1964). In North America, Zeller (1957) first recognized the stratigraphic value of these fossils. Subsequently, several authors extended this kind of zonation to the North American Cordillera (Armstrong, 1958; Woodland, 1958, Skipp, 1969; Sando and others, 1969; Mamet and Gabrielse, 1969; Petryk and others, 1970; Armstrong and others, 1970; Mamet and Armstrong, 1972; Brenckle, 1973; Mamet, 1975a; Rich, 1980, 1982; Groves, 1983; Beauchamp and Mamet, 1985; Mamet and others, 1987).

In the Cascade Ranges of the western North America Cordillera, eugeosynclinal deposits are known from southeastern Alaska to California (Irwin, 1972). They transect the states of Washington (Danner, 1970) and Oregon to form an outer belt of the Cordillera, which Monger and others (1972) called the "island belt." The faunas identified in these deposits reflect an association of both American and Tethyan faunas and are of special interest for Mississippian (early Carboniferous) paleogeographic reconstructions.

The Peratrovich Formation crops out as small disconnected faulted inliers in the Prince of Wales Island region (fig. 1), which is part of the Alexander Archipelago of southeastern Alaska. The main purpose of this report is to establish in the Peratrovich a micropaleontological zonation based on foraminifers, similar to that defined by Mamet and Skipp (1970), and to correlate eight stratigraphic sections. These sections were measured and collected by Armstrong on Klawak, Ladrones, Madre de Dios, Peratrovich, Shelikof, and Toti Islands off the west coast of Prince of Wales Island (pls. 18–20). The best Peratrovich exposures are along the coast between low and high tide lines, and access to them is by boat (fig. 2).

This stratigraphic study is based on about 900 thin sections from Armstrong's collections. In addition to identifying specimens for biostratigraphic purposes, the study

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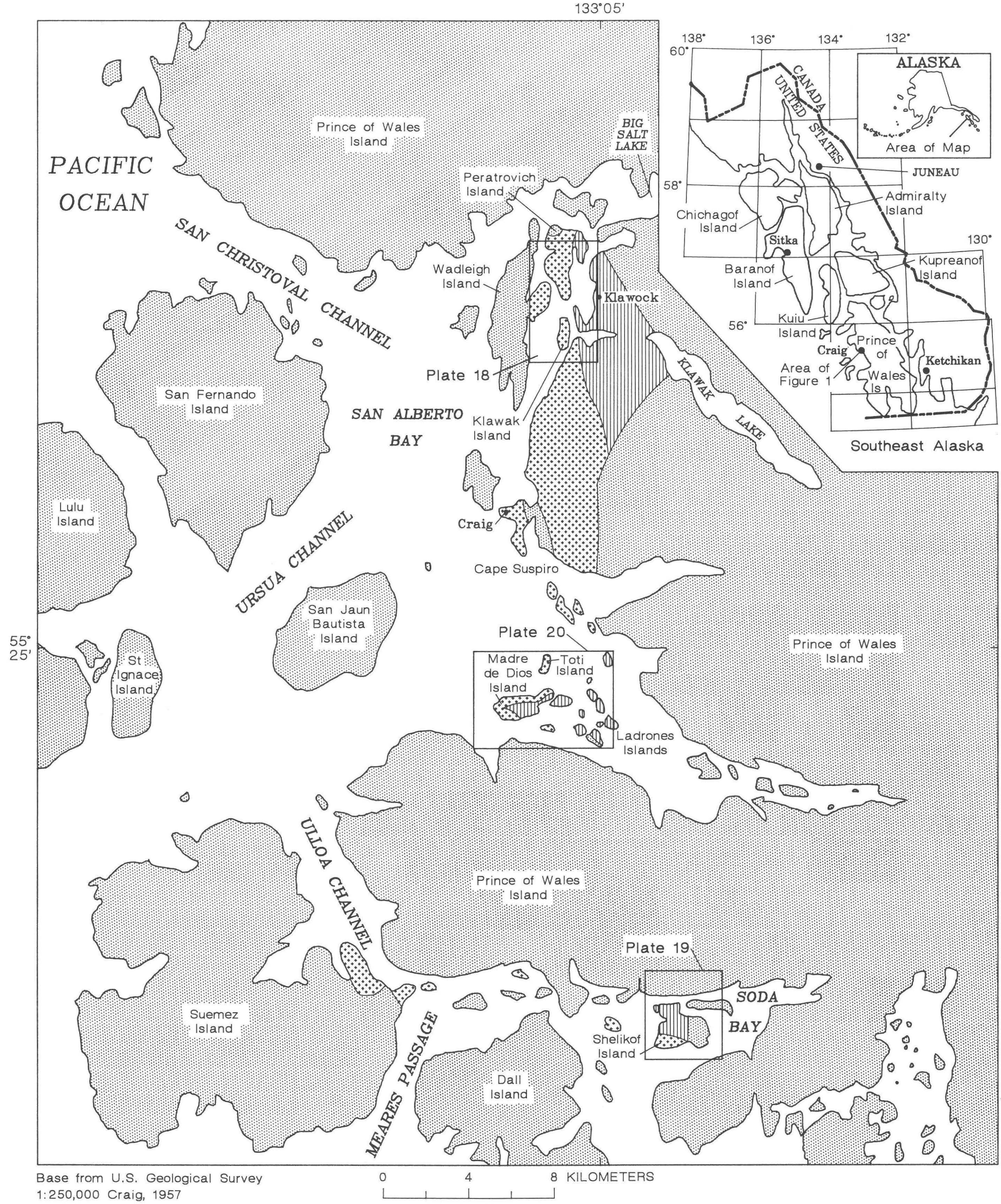

Figure 1. Index map showing islands where Peratrovich Formation (coarse dots) is mapped, southeast Alaska. Overlying Ladrones Limestone or Klawak Formation (ruled) also shown in some areas. Geology from Eberlein and others (1983).

has permitted establishment of a sedimentary model for the sequence of carbonate rocks in the Peratrovich Formation.

PREVIOUS WORK

Early in this century, the Prince of Wales Island region was the object of a preliminary series of geologic investigations directed toward two distinct sectors: one for mining exploration, and the other for stratigraphic studies. In the economic sector, systematic reconnaissance work was initiated by Brooks (1902), Wright and Wright (1908), Smith (1914), and Buddington (1923). In the field of stratigraphy, faunal lists were compiled first by Kindle (1907), then by Edwin Kirk, G.H. Girty, and Rudolf Ruedemann (in Buddington and Chapin, 1929); a systematic study of the brachiopods was undertaken by Kirk (1922, 1925, 1926). These early studies ended with the regional work of Buddington and Chapin (1929).

Mining exploration, related to strategic metals, was briefly revived from 1941 to 1944 (Kennedy and Walton, 1946; Twenhofel and others, 1946, 1949; Warner and others, 1961).

In 1947, G.D. Eberlein initiated a second series of stratigraphic investigations by the U.S. Geological Survey. He extended the compilation of the geologic maps of Sainsbury (1960) and Condon (1961) toward the south. Subsequently, Eberlein and Churkin (1970) divided the Paleozoic rocks exposed on the northwestern coast of Prince of Wales Island into 10 new formations, which they described in detail. Churkin and Eberlein (1975b) also published a 1:63,000-scale map of the Craig C-4 quadrangle region. Herreid and others (1978) added a geologic map of the vicinity of the Craig A-2 quadrangle to the compilation of stratigraphic data of southeastern Alaska. Eberlein and others (1983) compiled a geologic map of the entire Craig quadrangle, and Gehrels and Berg (1984) compiled one of southeastern Alaska.

Figure 2. Typical shoreline and dense conifer forest, Ladrones Island, Alaska. Collecting and studies of the Peratrovich Formation were made between low and high tide levels where rocks are free of soil and vegetation. Field studies were done from outboard motor boats.

On the purely paleontological side, additional faunal lists were published by Ovenshine and Webster (1970) and by J.G. Johnson (in Ovenshine and Webster, 1970). Several other publications illustrate the Paleozoic fauna. They include the description of Late Silurian brachiopods (Kirk and Amsden, 1952) and of Late Ordovician, Silurian, and Early Devonian graptolites (Churkin and Carter, 1970; Churkin and others, 1970, 1971). The Ordovician, Silurian, and Devonian corals were described by Tchudinova and others (1974) and by Oliver and others (1975). The corals of the Peratrovich Formation were studied by Armstrong (1970). Later, Armstrong (1975) compared the Peratrovich corals with those of the Lisburne Group in northern Alaska and found certain similarities between the two faunas. It should be noted that Girty (in Buddington and Chapin, 1929) had also noticed these similarities.

Systematic descriptions of Devonian conodonts were published by Savage (1977a, b, 1981b) and Savage and others (1977). Ordovician conodonts were described by Savage and Savage (1980), and Pennsylvanian conodonts by Savage and Barkeley (1985). Simultaneously, Savage (1981a) and Savage and others (1978) described Devonian brachiopods. Several theses, supervised by Savage, discuss the Late Devonian conodonts (Hobbert, 1980), the conodonts of the Peratrovich Formation (Faulhaber, 1977), the Pennsylvanian conodonts (Barkeley, 1981), and the brachiopods of the Klawak Formation (Vaskey, 1982).

Foraminiferal studies, almost ignored in this area, were initiated by Douglass (1971), who described the Pennsylvanian fusulinids.

ACKNOWLEDGMENTS

Field work and stratigraphic sampling were done in the summer of 1966 by A.K. Armstrong while working in a U.S. Geological Survey field camp headed by G.D. Eberlein and Michael Churkin, Jr. This project was initiated and supervised by George Gryc.

A scholarship from the Natural Sciences and Engineering Research Council of Canada enabled Sylvie Pinard to study these collections under the direction of Bernard L. Mamet at the University of Montreal. She wrote a Master's thesis (1982) on which part of this publication is based.

REGIONAL GEOLOGIC SETTING

On Prince of Wales Island, the Wales Group, consisting of metamorphic rocks, forms the pre-Late Cambrian basement. In the Alexander Archipelago of southeast Alaska, the Wales Group is overlain by a thick sequence of Paleozoic volcanic and sedimentary rocks, estimated at more than 3,000 meters thick by Eberlein and Churkin (1970) and currently referred to as the Alexander terrane. This sequence is exposed on the Prince of Wales Island and on Kuiu, Kupreanof, Admiralty, and Chichagof Islands to the north-northwest. It occupies a north-northwest-trending structural element, flanked on both sides by Mesozoic assemblages.

The Paleozoic strata are Ordovician to Permian in age. The Mississippian rocks consist of the Peratrovich Formation, the Saginaw Bay Formation (part), and the Iyoukeen Formation (Loney and others, 1975).

The Peratrovich Formation at its type locality is exposed in a syncline plunging to the south and faulted on the east side. Despite the fact that the upper and lower contacts are covered, Eberlein and Churkin (1970) consider them to be regionally concordant. The Peratrovich Formation overlies the Devonian Wadleigh Limestone and is overlain by the Pennsylvanian Klawak Formation and Ladrones Limestone.

TECTONIC SETTING

The enigmatic assemblages of rocks and faunas composing the rim of the Pacific, of which the Peratrovich Formation is a part, have given rise to several interpretations.

Before the advent of plate tectonics, Eardley (1947) and Kay (1947) interpreted the Precambrian and Paleozoic rocks as representing autochthonous volcanic arcs developed in a relatively fixed position in the outer part of the Cordilleran geosyncline. Later, other classic eugeosynclinal models were described by White (1959) and by Brew and others (1966).

More recently, three kinds of models have been proposed. The first suggests that various tectonic terranes derived from fragments of Asia, or from a landmass drifting in the paleo-Pacific, finally collided with the North American continent (Wilson, 1968; Danner, 1970; Moores, 1970; Nur and Ben-Avraham, 1977; Brandon, 1980). The second model involves large displacements along transform faults (Monger and Ross, 1971; Monger and others, 1972; Jones and others, 1972; Berg and others, 1972; Irwin and Yole, 1972; Tempelman-Kluit, 1979). In the third model, a group of continental microplates and para-autochthonous island arcs are displaced with respect to North America; this leads to the opening and closing of basins during the Paleozoic, followed in the Mesozoic by displacements along transform faults (Churkin, 1974; Churkin and Eberlein, 1975a). In this paper, we show that the third model is more consistent with the microfaunal data.

STRATIGRAPHY OF THE PERATROVICH FORMATION

The Peratrovich Formation is the name given by Eberlein and Churkin (1970) for the Mississippian rocks exposed in the area of Craig, Alaska. This formation consists of fossiliferous limestones and dolomites. Chert nodules occur throughout the sequence, whereas bedded dark-gray cherts occur only in the lower part. Eberlein and Churkin (1970) divided the formation into three informally named members: the cherty member, the cherty limestone member and the limestone member. We here divide the formation into the following five informally named members (ascending): cherty spiculite and radiolarite member, lower cherty limestone member, lower limestone member, upper cherty limestone member, and upper limestone member (fig. 3).

According to Eberlein and Churkin (1970) and Churkin and Eberlein (1975b), the formation reaches a thickness of 275 to 300 meters. Armstrong (1970) suggested a similar figure, 330 m, based on sections measured on Madre de Dios, Shelikof, and Toti Islands. The estimate of 1,100 m proposed by Faulhaber (1977) is based on measured stratigraphic sections and on conodont intervals. Our study, based on the zoning of foraminifers, indicates a minimum thickness of 560 m. The limestone and cherty limestone members are repeated twice, adding 230 m to Armstrong's estimate (1970). The complex tectonics of the region are not well understood, and the thickness of the radiolarites within the basal part of the formation is not known.

Dunham's classification (1962) of carbonate rocks, modified by Embry and Klovan (1971) is used in this report. Graphic illustrations of eight measured stratigraphic sections, accompanied by estimates of the abundance of carbonate particles and fossil bioclasts, are shown in plates 18–20. Stratigraphic correlation of these sections is shown in figure 3.

Cherty spiculite and radiolarite member

The contact between the Peratrovich Formation and the underlying Wadleigh Limestone is not exposed on Peratrovich Island. In the Madre de Dios and Shelikof Islands

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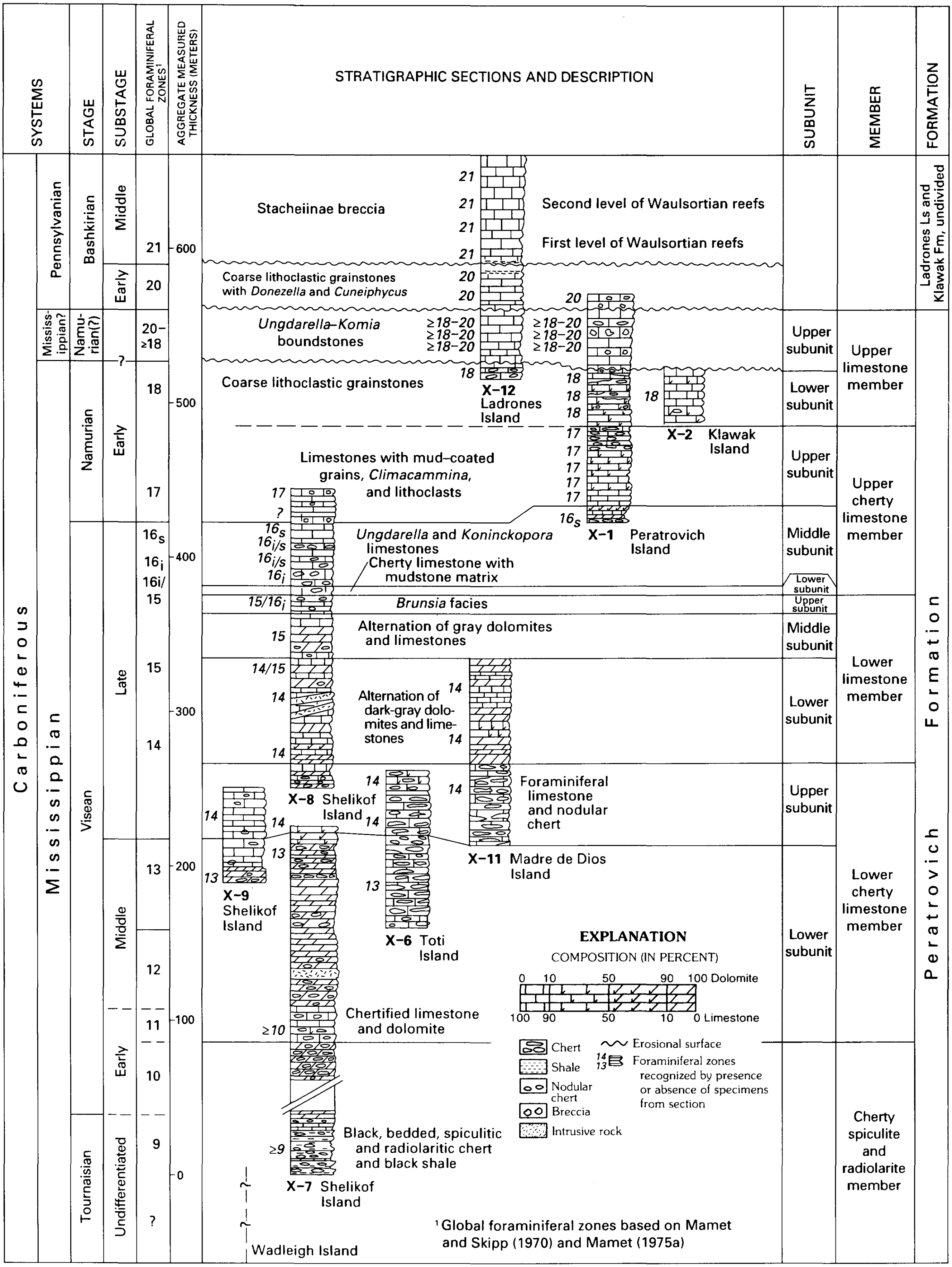
▶ **Figure 3.** Correlation of schematic lithostratigraphic and biostratigraphic sections, based on foraminiferal distribution in the Peratrovich Formation and overlying rocks, southeast Alaska. Detailed stratigraphic sections shown on plates 18–20.



SYSTEMS
STAGE
SUBSTAGE
GLOBAL FORAMINIFERAL ZONES[1]
AGGREGATE MEASURED THICKNESS (METERS)
STRATIGRAPHIC SECTIONS AND DESCRIPTION
SUBUNIT
MEMBER
FORMATION
Carboniferous
Pennsylvanian
Mississippian?
Mississippian
Bashkirian
Namurian(?)
Namurian
Visean
Tournaisian
Middle
Early
Late
Undifferentiated
Stacheiinae breccia
Second level of Waulsortian reefs
First level of Waulsortian reefs
Coarse lithoclastic grainstones with Donezella and Cuneiphycus
Ungdarella–Komia boundstones
Coarse lithoclastic grainstones
X-12 Ladrones Island
X-2 Klawak Island
Limestones with mud-coated grains, Climacammina, and lithoclasts
Ungdarella and Koninckopora limestones
Cherty limestone with mudstone matrix
X-1 Peratrovich Island
Brunsia facies
Alternation of gray dolomites and limestones
Alternation of dark-gray dolomites and limestones
Foraminiferal limestone and nodular chert
X-8 Shelikof Island
X-9 Shelikof Island
X-11 Madre de Dios Island
X-6 Toti Island
Chertified limestone and dolomite
Black, bedded, spiculitic and radiolaritic chert and black shale
X-7 Shelikof Island
Wadleigh Island
EXPLANATION
COMPOSITION (IN PERCENT)
Dolomite
Limestone
Chert
Shale
Nodular chert
Breccia
Intrusive rock
Erosional surface
Foraminiferal zones recognized by presence or absence of specimens from section
Upper subunit
Lower subunit
Middle subunit
Upper limestone member
Upper cherty limestone member
Lower limestone member
Lower cherty limestone member
Cherty spiculite and radiolarite member
Ladrones Ls and Klawak Fm, undivided
Peratrovich Formation
[1] Global foraminiferal zones based on Mamet and Skipp (1970) and Mamet (1975a)

areas, the base of the cherty spiculite and radiolarite member seems to be concordant with the calcareous tuff found in the uppermost part of the Port Refugio Formation (Eberlein and Churkin, 1970).

This lowermost member of the Peratrovich is composed of thin beds of black chert interbedded with black silty shale. The thickness of the chert beds and the amount of chert decrease toward the top of the member. Beds of lenticular micritic limestones are found in the lowermost part of section X-7 on Shelikof Island, where the measured section is 90 m thick. Here the upper part of the member is dolomitized and contains chert nodules. Armstrong (1970) assigned that dolomite to the cherty limestone member of Eberlein and Churkin (1970).

The cherty member of Eberlein and Churkin (1970) is, in part, equivalent to our cherty spiculite and radiolarite member and is estimated to be about 65 m thick. Armstrong (1970), Churkin and Eberlein (1975b), and Vaskey (1982) confirm this thickness. However, Faulhaber (1977) notes 230 m of exposed Devonian Wadleigh Formation and the presence of 750 m of Mississippian radiolarites on the east coast of Wadleigh Island.

The lower part of the cherty spiculite and radiolarite member is devoid of fossils except for sponge spicules and radiolarians. Armstrong (1970) indicated a probable Kinderhookian and (or) Osagean age for the rocks of this part of the member. The dolomites of the upper part of the member contain abundant echinoderms, sponge impressions, and a few corals and brachiopods. Armstrong (in Eberlein and Churkin, 1970) assigned a Tournaisian (Osagean) age for the upper part of the member, based on the assemblage of the foraminifers *Septaglomospiranella* sp., *Septabrunsiina* sp. and *Endothyra* sp. Faulhaber (1977) confirms this age by the presence of the conodonts *Gnathodus bulbosus*, *G. texanus pseudosemiglaber* and *Taphrognathus varians*. The uppermost limestones (Eberlein and Churkin, 1970; Armstrong, 1970) include several foraminifers, including *Archaediscus* sp. and *Globoendothyra* sp., which indicate a Visean (Meramecian) age.

Lower cherty limestone member

The lower cherty limestone member is at least 190 m thick, and about 25 percent of it is nodular chert. In most of the beds the chert appears to selectively replace the limestone while preserving the sedimentary structures and textures.

This member is divided into two subunits (fig. 3) on the basis of the amount of dolomite present. The lower subunit is composed of chertified limestones and abundant dolomites. On Shelikof Island as much as 80 percent of the rock in section X-7 may be dolomite. This subunit is also found in the lower part of sections X-6 and X-9 on Toti and Shelikof Islands, respectively, where the dolomites are less abundant. The limestones are generally packstones with abundant echinoderms and bryozoans and smaller amounts of peloids.

The presence of corals (Rugosa) is recognized throughout this member. Armstrong (1970) illustrated several new species from this subunit of the member, notably *Diphyphyllum venosum*, *D. klawockensis*, *Stelechophyllum? birdi*, and *Faberophyllum girtyi*, associated with *Lithostrotion* (*Siphonodendron*) *warreni*, *Acrocyathus pennsylvanicum*, *Ekvasophyllum* cf. *E. inclinatum*, *E. williamsi*, *Stelechophyllum*? aff. *S.*? *maclareni*, and *Thysanophyllum astraeiforme*, all Meramecian (Visean) in age. (Updated names from Sando's (1983) generic classification of rugose corals are used in this report.)

The upper subunit (foraminiferal chertified limestone with *Issinella* and *Koninckopora*) occurs in the upper parts of sections X-6, X-7, and X-9 on Toti and Shelikof Islands, in the lower half of section X-11 on Madre de Dios Island, and in the basal part of section X-8 on Shelikof Island. The limestones consist mainly of packstones and wackestones with algae (*Issinella* and *Koninckopora*) and echinoderms and grainstones with *Issinella*. Ooids also characterize this subunit of the member.

In addition to the corals reported above, two species described for the first time by Armstrong (1970), *Faberophyllum girtyi* and *Sciophyllum alaskaensis*, were found with *Lithostrotion* (*Siphonodendron*) sp. and *Stelechophyllum banffensis*. These corals are also characteristic of the Visean (Meramecian).

Lower limestone member

The lower limestone member is characterized by limestones that are interbedded with massive dolomite and chert. Chert nodules are rare and limited to the dolomite beds. This sequence is about 120 m thick and constitutes the upper half of section X-11 on Madre de Dios Island and much of the lower part of section X-8 on Shelikof Island. Armstrong (1970) estimated a thickness of 130 m, which is close to our measurements. His studies indicate that the lower limestone member is correlative with the lower part of the limestone member of Eberlein and Churkin (1970). We have subdivided this member into three subunits (fig. 3).

The lower subunit, the thickest of the three, is characterized by alternation of massive dark dolomites and limestones with *Issinella* and *Koninckopora*. These limestones are wackestones with brachiopods, echinoderms, algae, and foraminifers; they are associated with bafflestones containing *Issinella* and (or) *Kamaena*. Some packstones also include echinoderms, bryozoans, brachiopods and foraminifers.

The middle subunit marks the appearance of the light-gray shallow-water facies, an alternation of massive dolomites and light limestones with *Issinella* and *Koninckopora*.

This subunit includes the rock and fossil types of the lower subunit as well as packstones and wackestones composed of pellets, echinoderms, calcispheres and foraminifers. Grainstones formed by oolites, pellets, algae, echinoderms, brachiopods, bryozoans, and foraminifers are also common.

The upper subunit, the *Brunsia* facies, is composed of pelloid wackestones and packstones of ooids, echinoderms, brachiopods, and bryozoans; *Brunsia* is abundant.

Armstrong (1970) observed that corals are less abundant in the rocks of the lower limestone member than in the lower cherty limestone member. He identified *Faberophyllum*, *Petalaxis*, and *Stelechophyllum*. Faulhaber (1977) reported several genera among the conodonts: *Cavusgnathus*, *Gnathodus*, *Hindeodella*, *Neoprioniodus*, *Ozarkodina*, *Polygnathus*, and *Spathognathodus*—a Meramecian assemblage (equivalent to the Visean).

Upper cherty limestone member

The upper cherty limestone member is composed of limestones with minor amounts of dolomite, interbedded with beds of chert nodules. Carbonate beds are thin to medium in thickness. This member forms the upper part of section X-8 on Shelikof Island and the lower part of section X-1 on Peratrovich Island. It is 110 m thick and is divided into three subunits (fig. 3).

The lower subunit is a 10-m-thick cherty limestone with a lime mudstone matrix. The carbonate rocks are pellet-, *Kamaena*-, echinoderm-, brachiopod-, bryozoan-, coral-bearing wackestones.

The middle subunit is a limestone with *Ungdarella* and *Koninckopora* and is composed of echinoderm-, *Koninckopora*-, *Ungdarella*-, and foraminifer-bearing packstones and echinoderm-, pelletoid-, and foraminifer-bearing wackestones. Chert nodules are abundant.

The upper subunit is a limestone with mud-coated grains, *Climacammina*, and lithoclasts. The limestones are composed of mud-coated grains and echinoderm-, pellet-, bryozoan-, brachiopod-, and foraminifer-bearing grainstones and packstones associated with boundstones that include *Ungdarella* and *Komia*. Foraminifers and algae indicate a late Visean to early Namurian age for these rocks.

Upper limestone member

The upper limestone member is a light-gray limestone that has less dolomitic limestone than the lower members and includes light-gray to brown chert beds. The member consists of a composite sequence formed by the upper part of section X-1 on Peratrovich Island, section X-2 on Klawak Island, and the lower part of section X-12 on Ladrones Island, having a total thickness of about 80 m. Armstrong (1970) indicated that the rocks of the member are correlative with the upper part of the limestone member of Eberlein and Churkin (1970), and those reports give a thickness of 80 to 100 m for the rocks of our upper limestone member. Faulhaber (1977) indicated that the upper limestone member is 45 m thick at the type section at the south end of Peratrovich Island and that an additional 30 to 50 m of the member is present below the Klawak Formation. We divided the member into two subunits (fig. 3).

The lower subunit is characterized by coarsely crystalline lithoclast grainstones. The bioclasts are fragments of echinoderms, brachiopods, and bryozoans in a pelletoidal matrix. Boundstones are present in the subunit and are formed by *Ungdarella*. The top of this subunit is marked by an erosional surface.

The upper subunit is composed of massive *Ungdarella*- and *Komia*-bearing boundstones. Its basal bed consists of wackestones with bryozoans, *Ungdarella*, and *Komia* in a pelletoid matrix. The upper part of this subunit consists of *Ungdarella*- and *Komia*-bearing boundstones interbedded with packstones and grainstones containing lithoclasts and bioclasts. This subunit is bound at the top and the base by erosional disconformities.

A discordant contact probably separates the Peratrovich Formation from the Klawak Formation on Peratrovich Island. The field data of Eberlein and Churkin (1970) in the region of the type locality indicate a concordant contact. Subsequently, Armstrong (1970) and Churkin and Eberlein (1975b) indicated the probable presence of a paraconformity. Savage and Barkeley (1985) recorded no Late Mississippian conodont holdovers in the lowest samples of the Klawak and suggested a hiatus between the Peratrovich Formation and the overlying sequence. However, the conodont assemblage of the basal part of the Klawak Formation is stratigraphically not very specific. Savage and Barkeley (1985) report "*Idiognathoides*" *noduliferus* and *Neognathodus bothrops*, two species having a wide range from the Morrowan to the Atokan. On the Ladrones Islands, the Peratrovich Formation is overlain by the Ladrones Limestone, and a paraconformity separates these two units (Armstrong, 1970; Eberlein and Churkin, 1970; Faulhaber, 1977; Barkeley, 1981).

In the upper limestone member, Armstrong (1970) reported the presence of the foraminifers *Pseudoendothyra* sp., *Neoarchaediscus* spp., *Bradyina* spp., *Archaediscus* spp., and *Millerella* sp., and a new species of coral indicating a Chesterian age (Namurian or younger). Faulhaber (1977) noted the occurrence of conodonts from the middle and late Chesterian, notably *Gnathodus girtyi simplex* and *Cavusgnathus altus*. We show herein that part of the member is indeed Chesterian in age and that the uppermost part has a mixed foraminiferal assemblage.

SEDIMENTARY CARBONIFEROUS ENVIRONMENTS OF SOUTHEAST ALASKA

Eight sedimentary environments have been recognized in the Carboniferous sequence of southeastern Alaska and are portrayed below in order of decreasing bathymetry. This depositional model is compared to Wilson's asymmetrical model (1975) and Mamet's model (1972b).

Euxinic basin—This facies is characterized by silicified lime mudstones, wackestones, and associated bedded and nodular black cherts (radiolarites) and organic-rich pyritic black shales. The thin beds exhibit weak cross laminations and fine, regular laminations. The fauna are limited to radiolarians associated with a few rare spicules, ammonoids, and ostracodes.

Marginal basin—As in the preceding environment, silicified lime mudstones and wackestones are common, accompanied by black shales and cherts. The limestones are pyritic, argillaceous, and euxinic. Nodular limestones appear in the uppermost part of this sequence. The fauna are restricted and include rare radiolarians, abundant sponge spicules, and ostracodes. Spiculites are common.

Pelmatozoan meadows—This carbonate platform or ramp facies is composed of echinoderm packstones. Ossicles that are not abraded indicate that the debris accumulated in place. Spicules are rare and are found in chert nodules. Deposition was below the zone of wave action.

Open-marine platform with echinoderms and bryozoans (below the zone of wave action)—Limestones of this platform are primarily echinoderm and bryozoan packstones and wackestones. Fenestellid bryozoans are everywhere, and their fronds are still intact. Plurilocular foraminifers (Tetrataxidae) occur for the first time. These carbonate strata developed below or at the base of the wave-action zone. In this environment, fenestellid bafflestones form Waulsortian mounds, which are common in the Klawak Formation but are not known in the Peratrovich Formation.

Open-marine platform (zone of wave action)—Brachiopods and red algae (rhodophytes) are added to the previous faunal assemblage in this environment. The carbonate rock types are wackestones, packstones, grainstones, and reworked fragments of boundstones. Lithoclasts and allochthonous debris show signs of abrasion.

Fore barrier (zone of wave action)—The fore-barrier environment is shallower than the open-marine platform and is characterized by great faunal and floral diversity associated with channelized ooid grainstones. In addition to the preceding flora, reworked Palaeosiphonocladales, dasycladaceans, *Girvanella*, stromatolites, and *Spongiostromata* are found. Lime mudstones are absent. Fragments of reworked boundstones are common and indicate a high-energy environment.

Algal barrier—Two kinds of carbonate barriers occur in the Peratrovich Formation: (1) rhodophyte (red algae) boundstones, and (2) Palaeosiphonocladale bafflestones. These two carbonate rock types indicate different energy conditions. Boundstones are more resistant to wave action and are associated with packstones and grainstones formed in tidal channels where the algal barrier is in a high-energy environment and contains abundant oolites and proto-oolites. The Palaeosiphonocladale bafflestones are associated with wackestones that were deposited in a calmer lagoonal setting.

Open and restricted lagoon—Wackestones and lime mudstones with pelletoidal matrices are the predominant carbonate rock types. Dolomites with rare pseudomorphs of anhydrite are found in association with these rock types. Foraminifers, brachiopods, and bryozoans become rare, while calcispheres proliferate. Among the algae, the Palaeoberesellaceae abound in the presence of Codiaceae. Birdseye structures are common, and the foraminifers are mainly represented by unilocular forms such as *Earlandia*.

STRATIGRAPHIC DISTRIBUTION OF THE SEDIMENTARY ENVIRONMENTS

Having defined these environments, we apply them to the Carboniferous stratigraphic sequence in the area of western Prince of Wales Island (fig. 4).

Euxinic and marginal basin facies characterize the cherty spiculite and radiolarite member. They are overlain by open-marine facies in a rapid regression near the base of the lower subunit of the lower cherty limestone member, which developed into carbonate platform or ramp facies having abundant echinoderm and bryozoan bioclasts. This facies is followed immediately by a brief episode of restricted lagoonal deposition. A marine transgression restores an open-marine environment for the remainder of the subunit.

The upper subunit of this member has the lowest *Issinella* bafflestone beds that are associated with *Issinella* wackestones and packstones. These are the result of breakdown by wave action.

The lower and middle subunits of the lower limestone member have lithologically similar bafflestones that also include kamaenids and *Koninckopora.* The sedimentary regime of the short-lived *Brunsia* facies, the upper subunit of this member, is difficult to explain. Proliferation of *Brunsia* at the expense of other plurilocular Endothyridae is problematical. It could reflect an abrupt drop in salinity.

The lower and middle subunits of the upper cherty limestone member are fore-barrier facies, and the upper subunit consists of barrier boundstones whose red algae and dasycladaceans are associated with the products of their destruction in an open-marine environment.

The lower and upper subunits of the upper limestone member are lithologically similar to each other and show a progressive increase in the diversity and complexity of the *Ungdarella* boundstone and of the *Ungdarella* and *Komia* remains.

The Ladrones Limestone and Klawak Formation overlie the Peratrovich Formation on different islands and represent a transgressive sequence. The base of each overlying

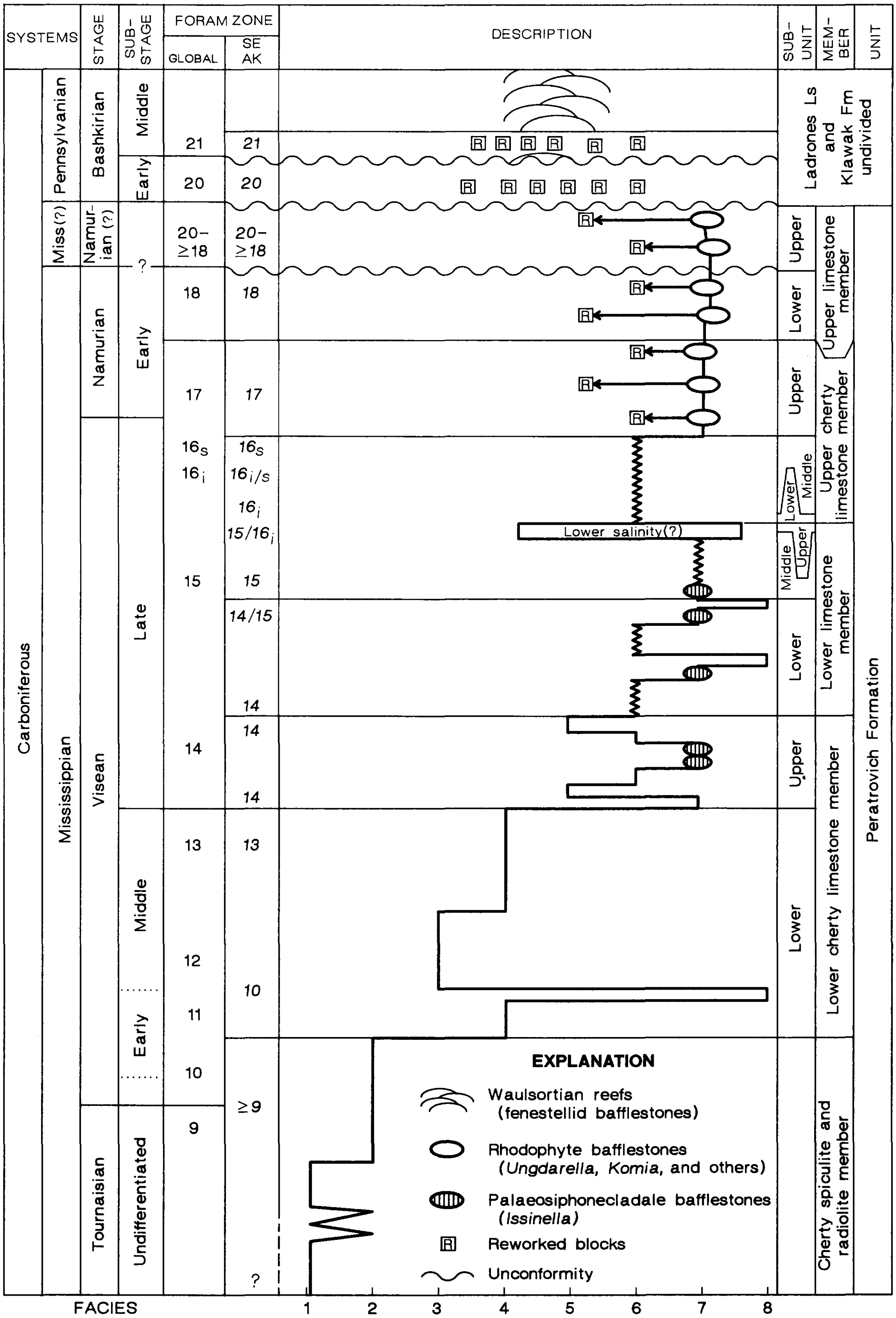


Figure 4. Sequence (heavy line) of depositional facies in the Peratrovich Formation and overlying rocks, southeast Alaska. Arranged in bathymetric order, deepest at left. 1, Euxinic basin; 2, Marginal basin; 3, Pelmatozoan meadows; 4, Open-marine platform (below zone of wave action); 5, Open-marine platform (zone of wave action); 6, Fore barrier (zone of wave action); 7, Algal barrier; 8, Lagoon. Relative positions of global foraminiferal zones (after Mamet and Skipp, 1970; Mamet, 1975a) compared to those of this report (SE AK).

formation is characterized by Waulsortian reefs, which are carbonate mounds formed by the filtration trapping of lime mud by fenestellid bryozoans below the zone of wave action.

The sequence of the eight environments of the Peratrovich Formation represents, in a general way, a regressive sedimentary sequence as interpreted by Armstrong (1970) and Vaskey (1982).

Two major models of carbonate belts have been proposed. One is asymmetrical and has an important barrier that separates basin environments from extensive lagoons (Wilson, 1975). The other model shows a gradual transition between these two environments (Irwin, 1965; Mamet, 1972b).

The strata sequence of the Peratrovich Formation is not consistent with Wilson's model. Nowhere do we observe rigid framework reefs with fore-reef deposits and an extensive (large) slope facies. Instead, the transition from open-marine facies to restricted facies is gradual, and the thin barriers that separate environments are transitional and fluctuate.

The environments are generally consistent with Mamet's model for the Cordillera (1972b), although two differences are observed. No silicified limestones with phosphate nodules, which indicate the euxinic basin margin, and no supratidal evaporites have been seen.

STRATIGRAPHIC DISTRIBUTION OF MICROFOSSILS

The stratigraphic distribution of microfossils in the Peratrovich Formation (Foraminifera, Algae, and incertae sedis) is represented in plate 17. Many characteristic specimens are pictured on plates 1–16.

The identification of foraminifers is based essentially on the systematic works of Cooper (1947), Reitlinger (1950, 1981), Nodine-Zeller (1953), McKay and Green (1963), Conil and Lys (1964), Juferev (1967, 1973), Mamet (1968a, b; 1973), Skipp (1969), Brenckle (1973), Lipina (1973), Sada and Danner (1973), Rich (1974, 1980, 1982), Armstrong and Mamet (1977), Bronnimann and others (1978), Zaninetti and others (1978), Conil and others (1979), Vachard (1981), Vdovenko and others (1981), Brazhnikova and Vdovenko (1983), Groves (1983, 1984), Adachi (1985), Mamet and others (1986), and Brenckle and others (1987). The zonation by foraminifers is based on assemblages of taxa at the generic and species level.

Identification of the algae was based on the descriptions and systematic studies of Fritsch (1945), Johnson and Konishi (1956), Veevers (1970), Mamet and Roux (1974, 1975a, b, 1977, 1978, 1981, 1983), Gayral (1975), Guilbault (1975), Mamet and others (1979), and Mamet and Martínez (1981). The microflora was illustrated in Mamet and Pinard (1985). We here revise the taxonomy following the recent compendium edited by Dubatolov (1987) and Mamet (1990).

The basal part of the Peratrovich Formation is characterized by an assemblage comprising species of the Earlandiidae and Endothyridae associated with a few residual species of Tournayellidae and Tetrataxidae. This fauna is characteristic of the Tournaisian to early Visean and is cosmopolitan.

The basal part of the middle part of the Peratrovich Formation (middle of the lower cherty limestone member) contains a much richer and more diverse fauna. Although the Tournayellidae disappear, there are now, in addition to numerous Earlandiidae, Endothyridae, and Tetrataxidae, representatives of the Archaediscidae, Endothyranopsidae, Forschiidae, Globoendothyridae, and the first primitive Palaeotextulariidae. This assemblage is typical of the middle Visean (Meramecian).

Forschiidae disappear in the middle part of the formation (lower limestone member), and the Endothyranopsidae are gradually impoverished. The abundant and diverse families cited in the middle Visean continue along with Eostaffellidae and Pseudoendothyridae in the late Visean (early Chesterian), an assemblage that is known worldwide.

The upper part of the formation (upper cherty limestone member) has a very rich assemblage that contains at least 14 families: Apterrinellidae, Archaediscidae (with the Archaediscinae and Asteroarchaediscinae), Biseriamminidae, Bradyinidae, Calcivertellidae, Earlandiidae, Endothyridae, Endothyranopsidae, Eolasiodiscidae, Eostaffellidae, Omphalotidae, Palaeotextulariidae, Pseudoendothyridae, and Tuberitinidae. This fauna is indicative of the early Namurian (late Chesterian).

In the uppermost part of the section, still rich in microfossils, the disappearance of the Omphalotidae and the first appearance of the Ozawainellidae probably indicate the base of the Bashkirian.

MICROPALEONTOLOGICAL ZONATION AND OCCURRENCES ELSEWHERE

The distribution of faunal elements shown on plate 17 permits establishment of several stratigraphic divisions within the Peratrovich and its overlying formations. (Parenthetical numbers following genus names refer to the taxa numbers on plate 17.)

The basal part of the Peratrovich Formation is composed of cherty radiolarites. Macrofauna and foraminifers are absent in the radiolarian deep-water facies, precluding an age determination.

The lowest horizon that yields a meager foraminiferal microfauna is in the cherty spiculite and radiolarite member. The environment of deposition and the facies were not favorable for foraminifers and resulted in a limited fauna containing *Endothyra* s.s. (4) associated with *Priscella* (6) and *Pseudotaxis* (7). These three genera, which have very long stratigraphic ranges, appear for the first time at Zone 9 of the upper part of the Tournaisian (Mamet and Skipp, 1970).

In North America, Zone 9 is recognized by the presence of elements of the older fauna cited (Armstrong and Mamet, 1977) and by the addition of *Septaglomospiranella*, *Septabrunsiina*, *Spinotournayella*, *Latiendothyra* and the acme of *Spinoendothyra* (Beauchamp and Mamet, 1985; Mamet and others, 1986). To these fauna are sporadically added *Eoforschia* and *Eotextularia*? (Mamet and others, 1970). In the Tethyan realm, the last two genera proliferate along with *Brunsia*, *Carbonella*, and *Tournayella*. Advanced forms not found in the North American domain, for example, *Lituotubella* and *Pseudolituotubella*, belong to the Forschiidae.

Zone 9 is identified in several carbonate stratigraphic sequences in North America:

1. Lower part of the Anchor Limestone of Nevada (Brenckle, 1973).
2. Upper Shunda Formation and Livingstone Formation of southwestern Alberta (Petryk and others, 1970; Bamber and Mamet, 1978; Mamet, 1976; Beauchamp and Mamet, 1985; Mamet and others, 1986).
3. Upper part of the Escabrosa Limestone of Arizona (Armstrong and Mamet, 1978b, 1988).
4. Lower part of the Mission Canyon Limestone of the Madison Group of Idaho and Montana (Sando and others, 1969) and of the Williston Basin, Montana (Sando and Mamet, 1981).
5. Kinkead Spring Limestone of the Antelope Range, Nevada (Hose and others, 1982).
6. Thunder Springs Member of the Redwall Limestone of Arizona (Skipp, 1969).
7. Madison Limestone of Idaho and Montana (Sando and others, 1969; Lageson and others, 1979).
8. Lower parts of the Prophet and Flett Formations of northeastern British Columbia and southwestern Northwest Territories (Bamber and Mamet, 1978).
9. Lower member of the Wachsmuth Limestone, central Endicott Mountains, Brooks Range, Alaska (Armstrong and Mamet, 1977).

The lower subunit of the lower cherty limestone member of the Peratrovich Formation contains a faunule of early Visean age. This is indicated by the coexistence of *Earlandia* of the *E. vulgaris* group (13) and *Globoendothyra* sp. (14). The two taxa normally first occur at the base of Zone 10.

On a worldwide scale, Zone 10 at the Tournaisian-Visean boundary is marked by the appearance of numerous genera. These cosmopolitan genera include *Dainella*, absent in the Peratrovich Formation, *Eoendothyranopsis*, which is abundant in North America (Mamet and Skipp, 1970), and *Pseudoendothyra*, which is abundant in the Tethys. *Viseidiscus* (Mamet, 1975b) and *Propermodiscus* also appear.

In North America Zone 10 occurs in the following formations:

1. Part of the Anchor Limestone and (or) the Bullion Limestone of Nevada (Brenckle, 1973).
2. The Turner Valley Formation and Livingstone Formation of southwestern Alberta (Petryk and others, 1970; Mamet, 1976; Bamber and Mamet, 1978); and in British Columbia (Mamet and others, 1986).
3. The basal part of the Mount Head Formation of southwestern Alberta (Petryk and others, 1970).
4. The upper part of the Escabrosa Limestone in Arizona and Escabrosa Group in southwestern New Mexico (Armstrong and Mamet, 1978b).
5. The Mission Canyon Limestone of the Madison Group of the northern Cordillera (Sando and others, 1969).
6. The Mooney Falls Member of the Redwall Limestone of Arizona (Skipp, 1969).
7. The lower parts of the Flett, Prophet, and Debolt Formations of northeastern British Columbia and southwestern Northwest Territories (Mamet, 1976; Bamber and Mamet, 1978; Richards, 1989).
8. The dolomitic member of the Wachsmuth Limestone of the Lisburne Group, central Brooks Range, Alaska (Armstrong and others, 1970).
9. The lower part of the Middle Canyon Formation in the Beaverhead Mountains of Idaho (Skipp and others, 1979).
10. The lower part of the Little Flat Formation of southeastern Idaho (Lageson and others, 1979).

No microfauna characteristic of Zones 11 and 12 are found in the middle part of the lower subunit of the lower cherty limestone member of the Peratrovich Formation.

Shallow-water carbonate facies appear in the uppermost part of this subunit concomitant with the appearance of numerous foraminifers and algae. A middle Visean age (Zone 13) is assigned to this part of the section due to the appearance and abundance of *Archaediscus* of the group *A. krestovnikovi* (17), notably *Archaediscus krestovnikovi* (19) and *A. koktjubensis* (18), associated with *Eoendothyranopsis scitula* (25), *Eoforschia* of the group *E. moelleri* (26), and *Globoendothyra* of the group *G. tomiliensis* (29). To this assemblage is added the relatively rare *Septatournayella*? *kennedyi* (40).

Except for *Septatournayella*?, this assemblage is known in Member C of the Prophet Formation and in the lower part of the upper member of the Debolt Formation of northeastern British Columbia (Bamber and Mamet, 1978). In the Tethys, several common faunal elements are added to this circum-hemispheric assemblage, notably: *Eostaffella*, *Valvulinella*, *Vissariotaxis*, and *Forschia*, in addition to the first appearances of *Howchinia*, *Omphalotis*, *Endostaffella*, *Spinothyra*, *Janischewskina*, and *Mediocris*

(Mamet and Skipp, 1970). The last five forms, essentially endemic to the Tethys, occur in the Peratrovich Formation at different horizons. In the Tethys, *Endothyranopsis compressa* normally appears in this zone; it is very rare in the Peratrovich Formation.

The middle Visean Zone 13 is equivalent to the middle part of the Meramecian in the North America midcontinent. It also occurs in the following formations:

1. The lower part of the Yellowpine Limestone of Nevada (Brenckle, 1973).
2. The Loomis Member of the Mount Head Formation and upper part of the Livingstone Formation, southwestern Alberta (Petryk and others, 1970; Mamet, 1976; Bamber and Mamet, 1978).
3. The part of the Hachita Formation that is laterally equivalent to the Rancheria Formation of New Mexico and west Texas (Armstrong and Mamet, 1978b).
4. The Little Flat Formation in the Northern Rocky Mountains of the United States (Sando and others, 1969; Skipp and others, 1979; Lageson and others, 1979).
5. The upper part of the White Knob Limestone, upper part of the Middle Canyon Formation, and lower part of the Scott Peak Formation of Idaho (Skipp and others, 1979).
6. The upper part of the Flett Formation, Mackenzie District of the Northwest Territories (Richards, 1989).
7. The upper part of the Kayak Shale of the Endicott Group in the British Mountains, Yukon Territory (Mamet and Ross in Bamber and Waterhouse, 1971).
8. The basal part of the Kogruk Formation of the Lisburne Group in the western Brooks Range, Alaska (Armstrong, 1975; Armstrong and Mamet, 1977).
9. The Alapah Limestone of the Lisburne Group in Alaska (Armstrong and others, 1970; Mamet and Ross in Bamber and Waterhouse, 1971; Armstrong and Mamet, 1977).

In the Peratrovich Formation, zone 14 (late Visean) has a diverse fauna in the foraminiferal chertified limestones of the upper subunit of the lower cherty limestone member and in the alternations of shale dolomites and limestones of the lower subunit of the lower limestone member. It is characterized by the proliferation of Archaediscidae with open lumen, associated with *Eoforschia* of the *E. moelleri* group (26), *Eoendothyranopsis* of the *E. ermakiensis* group (58), *Endothyranopsis hirosei* (57), and *Endothyranopsis compressa* (56). *Banffella* (48) is a rare form with a short vertical stratigraphic distribution. Except for *Endothyranopsis hirosei*, all these faunal elements are represented in the upper part of the Flett Formation and lower part of the Mattson Formation in the Mackenzie Mountains, as well as in the uppermost part of the Prophet Formation and lower part of the Golata Formation of northeastern British Columbia (Bamber and Mamet, 1978).

Zone 14 is also recognized in the following stratigraphic levels:

1. The middle part of the Yellowpine Limestone of Nevada (Brenckle, 1973).
2. The Marston Member and lower part of the Opal Member of the Mount Head Formation of southwestern Alberta (Petryk and others, 1970; Mamet, 1976; Bamber and Mamet, 1978).
3. The Hachita Formation of the Escabrosa Group of southwestern New Mexico (Armstrong and Mamet, 1978b, 1988).
4. The middle part of the Scott Peak Formation of Idaho and lower part of the Great Blue Limestone of Idaho (Skipp and others, 1979).
5. The Monroe Canyon Limestone of Idaho and Wyoming (Sando and others, 1969; Skipp and others, 1979; Lageson and others, 1979).
6. The upper part of the Kogruk Formation of the Lisburne Group in the western Brooks Range, Alaska (Armstrong, 1975; Armstrong and Mamet, 1977).
7. The Alapah Limestone of the Lisburne Group, Alaska (Armstrong and others, 1970; Mamet and Ross in Bamber and Waterhouse, 1971; Mamet and Armstrong, 1972; Mamet, 1976; Armstrong and Mamet, 1977).
8. The lower part of the Stoddart Group of northeastern British Columbia (Mamet, 1976).

Zone 15 (late Visean) fauna occurs in the Peratrovich Formation in the middle and upper subunits of the lower limestone member and in the lower subunit of the upper cherty limestone member. The microfauna is less abundant than that of Zone 14 and is recognized by the appearance of very large *Globoendothyra* [*G. ishimica* (72) and *Globoendothyra* of the *G. globulus* group (73)] and of *Palaeotextularia* s.s. (*P. longiseptata*) (75).

In the Tethys, several taxa join this cosmopolitan assemblage. Among them are abundant *Howchinia* and *Valvulinella*, accompanied by *Archaediscus karreri, Climacammina* and *Cribrostomum*. For an example of this assemblage, see the microfossils of the Boulonnais in northern France (Mamet, 1973).

In the Peratrovich Formation, the usual fauna of Zone 15 is interrupted by the enigmatic appearance of *Brunsia* in the upper subunit of the lower limestone member. This level, called the "*Brunsia* facies," marks the elimination of most of the preceding fauna, except for some calcispheres (1, 11), *Earlandia* (2, 3, 12, 13), and *Brunsia* of the *B. lenensis* group (21). Specimens of the genus *Planoarchaediscus* (36) sometimes constitute an appreciable percentage of this assemblage.

It is difficult to explain the presence of *Brunsia* within different horizons of the late Visean of the North American Cordillera (Mamet and Armstrong, 1972; Mamet, 1976; Armstrong and Mamet, 1977). The disappearance of most of the plurilocular foraminifers could indicate an important change in temperature and (or) salinity. But it is difficult to explain how these two factors could result in the concomitant disappearance of most of the microflora, which normally is better adapted to such environmental variations.

Zone 15 is also known in the following strata:

1. The upper part of the Yellowpine Limestone and lower part of the Battleship Wash Formation in Nevada (Brenckle, 1973).
2. The Carnarvon Member and the upper part of the Opal Member of the Mount Head Formation of southwestern Alberta (Mamet, 1968a; Petryk and others, 1970; Mamet, 1976, and Bamber and Mamet, 1978).
3. The upper part of the Hachita Formation, Escabrosa Group, Rancheria Formation, and lower part of the Paradise Formation of New Mexico (Armstrong and Mamet, 1978b, 1988).
4. The Monroe Canyon Limestone of the Cordillera in Idaho and Wyoming (Sando and others, 1969; Skipp and others, 1979; Lageson and others, 1979).
5. The Scott Peak Formation and Great Blue Limestone of Idaho (Skipp and others, 1979).
6. The Alapah Limestone of the Lisburne Group of Alaska and the Yukon (Armstrong and others, 1970; Mamet and Armstrong, 1972; Mamet, 1976).
7. Part of the Nuka Formation in the DeLong and Endicott Mountains of the Brooks Range, and the uppermost part of the Kogruk Formation and the lowermost part of the Tupik Formation both of the Lisburne Group, western Brooks Range, Alaska (Armstrong, 1975).

The Zone $15/16_i$ lower boundary (late Visean) in the Peratrovich Formation is at the base of the upper cherty limestone member. It corresponds with the extinction of *Eoforschia* (26) and *Eoendothyranopsis* (71) and their replacement (see fig. 7) by the Eostaffellidae, including *Eostaffella* of the *E. radiata* group (79) and *Zellerinella* (83) and by the Pseudoendothyridae, with *Pseudoendothyra* of the *P. struvei* group (81). The appearance of primitive *Neoarchaediscus* (80) and the local presence of the alga *Ungdarella*, notably *Ungdarella uralica* (82), also mark Zone 16_i which is in the middle part of the *Ungdarella*- and *Koninckopora*-bearing limestones.

This assemblage is comparable to that observed in the Alapah Limestone of the Lisburne Group in the Yukon (Mamet and Ross in Bamber and Waterhouse, 1971). In most of North America, the extinction of the alga *Koninckopora* corresponds with the Zone $15/16_i$ boundary. However, *Koninckopora* ranges above this to the upper boundary of Zone 16_s in the Peratrovich Formation and in the Tethys (see fig. 9).

In the Tethys, endemic forms like *Lituotubella*, *Haplophragmina*, *Forschia*, and *Forchiella* decrease drastically at this level. It should be noted that *Zellerinella* is unknown in the Tethyan fauna but is present in the Peratrovich Formation. There is much taxonomic confusion in the literature, and the genus is regrettably confused with the Tethyan *Endostaffella* (Rich, 1986).

This assemblage is easily correlated with that observed in the Alapah Limestone of the Lisburne Group in the Yukon (Mamet and Ross in Bamber and Waterhouse, 1971).

Zone 16_s (latest Visean) in the Peratrovich Formation is limited to the upper part of the middle subunit of the upper cherty limestone member and contains a fauna dominated by Asteroarchaediscinae including *Neoarchaediscus incertus* (88), *N. parvus* (89) and *N. parvus regularis* (89). In contrast to other formations of the North American Cordillera, *Planospirodiscus* (90) is rather rare (Mamet and Armstrong, 1972; Armstrong and Mamet, 1977). It should be stressed that the Tethyan *Howchinia bradyina* (86) is present in this horizon, (Mamet, 1972a).

Zones 16_i and 16_s are known in the lower part of the Chesterian (Aux Vases Sandstone to Golconda Formation) and the Floyd Formation in the southern Appalachians of southeastern United States in the North America midcontinent (Rich, 1986). They are also recognized in these formations:

1. The lower part of the Etherington Formation of southwestern Alberta (Mamet, 1968a; Petryk and others, 1970; Mamet, (1976).
2. The upper part of the Rancheria Formation and the lower part of the Helms Formation of Texas and New Mexico, and the Paradise Formation of New Mexico and Arizona (Armstrong and Mamet, 1978b, 1988).
3. The Monroe Canyon Limestone of the Cordillera in Idaho, Montana, and Wyoming (Sando and others, 1969; Skipp and others, 1979; Lageson and others, 1979).
4. The Amsden Formation of the Rocky Mountains (Sando and others, 1969; Skipp and others, 1979; Lageson and others, 1979).
5. The uppermost part of the Scott Peak Formation, the South Creek Formation, and the lower part of the Surrett Canyon Formation of Idaho and their lateral equivalents the Big Snowy Formation and the Great Blue Limestone, also in Idaho (Skipp and others, 1979).
6. The lower part of the Nizi Formation in British Columbia (Mamet and Gabrielse, 1969).
7. The Hart River Formation in the Keele Range of the Yukon Territory (Mamet and Ross in Bamber and Waterhouse, 1971).
8. The upper part of the Mattson Formation of the Mackenzie Range and of the Stoddart Group of northeastern British Columbia (Bamber and Mamet, 1978).
9. The middle part of the Alapah Limestone of Alaska and the Yukon (Armstrong and others, 1970; Mamet and Ross in Bamber and Waterhouse, 1971; Mamet and Armstrong, 1972; Mamet, 1972b; Armstrong and Mamet, 1974).

10. The lower part of the Nuka Formation and lower part of the Tupik Formation (Lisburne Group), Brooks Range, Alaska (Armstrong, 1975).

Zone 17, the lower part of the Namurian (basal part of the Serpukhovian), is recognized by the appearance and rapid development of *Asteroarchaediscus baschkiricus* (95) (Mamet and others, 1966; Hallett, 1970; and Mamet, 1975a), accompanied by the first *Endothyranopsis sphaerica intermedia* (99), mixed in the Peratrovich with *Climacammina* sp. (96) and *Cribrostomum* sp. (97).

The bilayered Palaeotextulariidae are a very significant part of the Zone 17 fauna of the upper subunit of the upper cherty limestone member of the Peratrovich Formation but are not present in the Etherington Formation of southwestern Alberta (Mamet, 1968a).

Zone 17 corresponds to the middle part of the Chesterian of the midcontinent (Glen Dean and Menard Limestones) and the Floyd Formation in the southern Appalachians (Rich, 1986). Zone 17 is also known in the following formations:

1. The upper part of the Battleship Wash Formation of Nevada (Brenckle, 1973).
2. The Paradise Formation and the Helms Formation of New Mexico, Arizona, and Texas (Armstrong and Mamet, 1978b, 1988).
3. The Etherington Formation (middle part) of southwestern Alberta (Mamet, 1968a, 1976).
4. The Amsden Formation of the Northern Rocky Mountains of the United States (Sando and others, 1969; Skipp and others, 1979; Lageson and others, 1979).
5. The Hart River Formation in the Keele Range, Yukon Territory (Mamet and Ross in Bamber and Waterhouse, 1971; Mamet, 1976).
6. The Nizi Formation, British Columbia (Mamet and Gabrielse, 1969).
7. The Alapah Limestone (upper part) of the Lisburne Group in the Endicott Mountains of the Brooks Range in Alaska and the Yukon Territory (Armstrong and others, 1970; Mamet and Ross in Bamber and Waterhouse, 1971; Mamet and Armstrong, 1972; Mamet, 1976).
8. The Monroe Canyon Limestone and Big Snowy Formation, Idaho (Sando and others, 1969; Skipp and others, 1979).
9. The Surrett Canyon Formation and the uppermost part of the Great Blue Limestone, Idaho (Skipp and others, 1979).
10. The Kogruk Formation of the Lisburne Group in the DeLong Mountains, Brooks Range, Alaska (Armstrong, 1975).
11. The Nuka Formation (middle part) and Tupik Formation (Lisburne Group) in the DeLong and Endicott Mountains, Brooks Range, Alaska (Armstrong, 1975).

Zone 18 has the first appearance of *Biseriella*, with *Biseriella* of the *B. parva* group (105) and of *Eostaffellina*, notably *E. ovesa* (112) and *E. paraprotvae* (113). In abundance and diversity, this faunule resembles that of Zone 14. Especially marked are the presence of Bradyinidae, with *Bradyina* of the *B. cribrostomata* group (107), and of Palaeotextulariidae, represented by *Climacammina antiqua* (108). In Zone 18, *Archaediscus* (17–19) undergoes a resurgence, as do *Howchinia bradyina* (86), *Zellerinella designata* (91). The same phenomenon occurs for algae like *Fasciella* (27), *Ungdarella uralica* (82), and *Asphaltina cordillerensis* (84). In the Peratrovich Formation, Zone 18 is limited to the lower subunit of the upper limestone member.

The Tethys has many of the same taxa except for *Zellerinella. Eostaffellina* is much more abundant in the Tethys and is an index fossil in the equivalents of the Protva Horizon of the Northern and Canadian Rocky Mountains (Sando and others, 1969; Mamet and Ross in Bamber and Waterhouse, 1971). Spherical *"Pseudoendothyra"* (*Volgella*), unknown in North America, are also used in the Tethys for recognition of Zone 18 (Mamet, 1974, 1975a). Zone 18 is the upper part of the Chesterian, and its foraminiferal assemblages are found in the Clore and Kinkaid Limestones of the midcontinent. Zone 18 is present in the Bangor Limestone and Pennington Formation of the southern Appalachians (Rich, 1986). Zone 18 is also identified in the following sedimentary sequences:

1. The upper part of the Battleship Wash Formation of Nevada (Brenckle, 1973).
2. The upper part of the Monroe Canyon Limestone of the United States Cordillera (Sando and others, 1969; Lageson and others, 1979).
3. The middle part of the Surrett Canyon Formation, Idaho (Mamet and others, 1971; Skipp and others, 1970).
4. The Big Snowy Formation of the northern United States Cordillera (Sando and others, 1969; Skipp and others, 1979).
5. The Amsden Formation of the northern United States Cordillera (Mamet, 1975a; Lageson and others, 1979; Skipp and others, 1979).
6. The basal part of the Ettrain Formation in the Keele Range, Yukon Territory (Mamet and Ross in Bamber and Waterhouse, 1971; Mamet and Mason, 1970).
7. The Nizi Formation (upper part) and an unusual formation in the Atlin Lake region, British Columbia (Mamet and Gabrielse, 1969; Mamet, 1976).
8. The upper part of the Etherington Formation, Alberta (Mamet, 1968a, 1976).
9. The upper part of the Alapah Limestone of the Lisburne Group of northeastern Alaska and the Yukon Territory (Armstrong and others, 1970; Mamet and Ross in Bamber and Waterhouse, 1971; Mamet and Armstrong, 1971; Armstrong and Mamet, 1974, 1977; Mamet, 1976).
10. The Borup Fiord and Otto Fiord Formations, Ellesmere Island, Canada (Davies and Nassichuk, 1980).

Zone ≥18–20 has again a diverse microfauna. In addition to the microfauna of Zone 18 described above, numerous *Janischewskina operculata* (132) and *J. typica* (133) are mixed with gigantic *Omphalotis omphalota* (136). The red alga *Ungdarella peratrovichensis* (137) is abundant at this level, and *U. uralica* (82) has its acme. The age of this horizon is controversial because *Janischewskina* is completely unknown elsewhere in North America. It usually extends through Zone 19 in Eurasia but is known to occur as high as Zone 20 in southern China (Rui, 1987). *Omphalotis* and *Endothyranopsis* range higher in the Peratrovich Formation than in any known sequence in the Tethys.

Zone 19 was originally identified in the Donets Basin in the Ukraine and in the northern hemisphere by the brief acme of *Quasiarchaediscus* and *Eosigmoilina*? (Brazhnikova, 1964; Mamet, 1974; Mamet and Ross in Bamber and Waterhouse, 1971). These two genera were not found in the Peratrovich Formation. This is not due to poor sampling, as the fauna is abundant and the ancestral forms of Archaediscidae are well represented. Micropaleontologic evidence suggests that Zone 19 is missing from the Peratrovich by a hiatus or is replaced by the assemblage of Zone ≥18–20, which is limited to the upper subunit of the upper limestone member.

The absence of Zone 19 in the Peratrovich Formation provides new insight into the problem of the Mississippian-Pennsylvanian boundary. In the midcontinent region, the Pennsylvanian begins with Zone 20 and is often separated from Zone 18 or 19 by a hiatus. In the type Pennsylvanian, the basal part of the system is nonmarine and thus contains no foraminifers. In the type Morrowan, the conglomerate basal part of the group (Zone 20) rests discordantly on the Mississippian, which was eroded (Zone 18 or 19) (Brenckle, 1977; Mamet, 1982). In fact, no section between the Mississippian and Pennsylvanian is continuous in the central part of North America (Groves, 1983).

Zone 19 is considered as very latest Mississippian in age. A latest Chesterian age for the zone is suggested by Sando and others (1969) for the Amsden Formation in the northern Cordillera of the United States and by Armstrong and Mamet (1977) for the Alapah Limestone in Alaska. Other faunal evidence from the Indian Springs Formation and from the basal part of the Bird Spring Formation in Nevada (Brenckle, 1973) supports this hypothesis. Mamet (1975a) recognized Zone 19 in the Amsden Formation of Wyoming. Armstrong and Mamet (1978b) and Mamet (1982) established a Mississippian-Pennsylvanian boundary near Zone 19/20 that corresponds to the contact between the Paradise Formation and the Horquilla Limestone of New Mexico and Arizona. Again a hiatus is present, although it represents a short time interval.

The most continuous section spanning the Mississippian-Pennsylvanian boundary is exposed at Granite Mountain in Nevada. The conodont species *Adetognathus unicornis* (Rexroad et Burton) is in the lower part of Zone 19. The middle part of Zone 19 contains the first occurrence of *Rhachistognathus primus* (Dunn). The first occurrence of *Declinognathodus noduliferus* (Ellison and Graves) occurs near the base of the Pennsylvanian, Zone 20, but there is a hiatus between Zones 19 and 20 (Mamet, 1984; Wardlaw, 1984; Gordon and others, 1985).

Microfacies studies (carbonate sedimentology, foraminifers, and algae) indicate that the Granite Mountain succession (Gordon and others, 1985) is essentially continuous across the Mississippian-Pennsylvanian boundary, without any important sedimentation hiatus (Mamet, 1984). It is thick and not condensed, shows repeated minor oscillation in open-marine facies, and has no carbonate restriction. The boundary is emphasized by two important phyletic changes in the foraminifers: the derivation of *Globivalvulina* from *Biseriella*, and that of *Millerella* from *Eostaffella*.

Reitlinger (1980) has shown that the foraminifers of the *Homoceras* Zone (boundary between the Bogdanovsk and Krasnopoliansk beds), although poorly diagnostic, are above Zone 19 and below the first occurrence of the Bashkirian Zone 20. Again, a small hiatus can be recognized by the first occurrence of a diaphanotheca in *Globivalvulina* (*Globivalvulina* sp. D of Brenckle as proposed by Wagner and others, 1985). Whatever the precise position of the Mississippian-Pennsylvanian boundary (and perhaps also that of the Serpukhovian-Bashkirian), the age of the Zone ≥18–20 *Ungdarella*- and *Komia*-bearing boundstones of the upper subunit of the upper limestone member of the Peratrovich Formation is difficult to assess because (1) at least two paraconformities are present, (2) Zone 19 is absent, (3) the primitive *Globivalvulina* is difficult to recognize, and (4) the Tethyan *Janischewskina* assemblage is unknown in the rest of North America.

Zone 20, observed in the Klawak Formation and Ladrones Limestone, is characterized by the appearance of *Millerella* s.s. (Mamet and Armstrong, 1972), represented by *M. carbonica* (146) and *M. prilukiensis* (147). *Pseudoglomospira gordialiformis* (119) becomes prolific in this horizon. Within the microflora, *Epistacheoides connorensis* and *E. nephroformis* (61), *Asphaltinella horowitzi* (70), and *Asphaltina cordillerensis* (84) are abundant.

In the Tethys realm, the same faunal characteristics are found, with the addition of *Semistaffella* and primitive *Pseudostaffella* (Mamet, 1975a). The first *Pseudostaffella antiqua* marks the Bashkirian deposits of the Russian platform. This marker does not exist in North America except in Alaska (Mamet, 1976) and in the Canadian Arctic. This implies that Bashkirian equivalents in the rest of North America are identified only on the basis of *Millerella*. In North America, the Bradyinidae usually appear for the first time in the Pennsylvanian, with well-evolved forms. In the Tethys, primitive *Bradyina* are already abundant in the uppermost part of the Visean, while in the Peratrovich faunas, they occur in the early Serpukhovian.

Zone 20 corresponds to the Morrowan of the midcontinent of North America (Groves, 1983), with the first true fusulines in the basal part of the Pennsylvanian. This zone is also known in these formations:

1. The Bird Spring Formation and Ely Limestone in Nevada (Brenckle, 1973; Mamet, 1982).
2. The Ettrain Formation in the Keele Range of the Yukon (Mamet and Ross in Bamber and Waterhouse, 1971; Mamet, 1976).
3. The lower part of the Wahoo Limestone of northeastern Alaska (Mamet and Armstrong, 1972; Mamet, 1976; Armstrong and Mamet, 1977).
4. The Amsden Formation (upper part) of Wyoming and Idaho (Mamet, 1975a; Lageson and others, 1979; Skipp and others, 1979).
5. The Spray Lake Group of southwestern Alberta (Mamet, (1976).
6. The La Tuna Formation of western Texas (Lane and others, 1972).
7. The Canyon Fiord, Nansen, and Otto Fiord Formations of Ellesmere Island (Davies and Nassichuk, 1980; Mamet and others, 1987).

Zone 21 was studied only briefly because existence of Waulsortian reefs does not favor the presence of foraminifers. Conodonts reported by Savage and Barkeley (1985) from the same levels are "*Idiognathoides*" *noduliferus*, *I. pacificus*, and *I. delicatus* mixed with *Hindeodus minutus, Neognathodus bothrops,* and *Taphrognathus alaskensis*. The foraminifers that identify this zone are *Globivalvulina* of the *G. bulloides* group (152), and *Pseudostaffella* sp. (154).

Pseudostaffella appears in the Ladrones Limestone one zone later than in the Tethys, and a direct comparison with that domain is difficult. Zone 21 of the Donets Basin in the Ukraine is placed in the Bashkirian. This correlation contradicts the assertion of M.L. Thompson (in Loeblich and others, 1964), who puts the base of the Atokan Series at the same level as the Moscovian, but it is supported by the revision of the Bashkirian by Groves (1988).

Zone 21 is present in the Wapanucka Limestone in the central United States (Mamet, unpub. data). It also appears in the following carbonate sequences:

1. A sequence equivalent to the Atokan of central Idaho (Mamet and others, 1971).
2. The Wahoo Limestone of northeastern Alaska and the Yukon Territory (Armstrong and others, 1970; Mamet and Ross in Bamber and Waterhouse, 1971; Mamet and Armstrong, 1972; Mamet, 1976; Armstrong and Mamet, 1977).
3. The Ettrain Formation in the Keele Range of the Yukon Territory (Mamet and Ross in Bamber and Waterhouse, 1971).
4. The Amsden Formation (upper part) of Wyoming (Mamet, 1975a; Lageson and others, 1979).
5. The Hartville and Minnelusa Formations of Wyoming (Lageson and others, 1979).
6. The Nansen, Otto Fiord, and Canyon Fiord Formations of Ellesmere Island, Canada (Davies and Nassichuk, 1980; Mamet and others, 1987).

PALEOBIOGEOGRAPHIC CONCEPTS

The principle of actualism, that processes of the past can be inferred from those of the present, is not easy to apply to the Carboniferous foraminifers. The Holocene has three kinds of foraminifers: shallow-platform benthic forms, basinal benthic forms, and pelagic forms. In the Paleozoic, only the first forms are known. Despite this fundamental difference, the principle can be applied to shallow-water benthic foraminifers. On a modern carbonate platform, the distribution of benthic Protista is controlled by the water temperature. The temperature distribution of surface waters forms belts that are more or less parallel to the equator. Therefore, the geographic distribution of specific benthic fauna on carbonate platforms is chiefly a function of latitude (Stehli, 1965; Lipina, 1973; Smith, 1989).

The foraminifers that live on carbonate platforms are abundant and show greatest generic and specific diversity in the lower latitude regions and show less generic diversity toward the poles. This gradient in the diversity distribution of platform taxa is synonymous with thermal gradients; it may vary in intensity but not in direction during the course of geologic time. Thus, this gradient provides an adequate tool for estimating the positions of the equator and poles throughout geologic time (Boersma, 1978; Smith, 1989).

These concepts allow us to establish three domains of foraminiferal microfauna and algal microflora for the early Carboniferous (Mamet, 1962, Mamet and Skipp, 1979). The abundant and diverse fauna and flora of the Tethys domain (fig. 5) indicate equatorial to tropical temperature conditions. The Tethys realm includes Ireland, England, Belgium, France, Germany, southern Poland, the Donets Basin of the Ukraine, North Africa, Libya, Egypt, Kazakhstan, Iran, Laos, South China, Vietnam, Malaysia, and part of Australia (Mamet and Skipp, 1979).

The intermediate Kuznets-North American domain is represented by less abundant and less diverse fauna and flora that indicate relatively warm waters. Its realm includes central Siberia and the middle of the North America continent, except for a narrow band along the western Cordillera of North America.

The Taymir-Alaska domain has low diversity and reduced fauna and flora, reflecting temperate water conditions. This Arctic realm includes the Russian Lena, Kolyma, and Pechora River regions and Omolon massif, Novaya Zemlya Islands, northern Alaska, and the Canadian Arctic.

Detailed examination of foraminifers and algae allows us to place the Peratrovich Formation in a general circum-Pacific paleogeographic framework (Ross and Ross, 1981; Monger, 1984; Silberling and Jones, 1984; Howell, 1985).

A critical examination of the microfauna shows that the absolute abundance of a foraminifer population decreases from the Tethys toward the Taymir-Alaska domain. In a 1–cm^3 specimen of a Tethyan grainstone with *Koninckopora*, between 300 and 500 individual foraminifers can be counted. This same facies in the Kuznets-North American domain contains only one-third as many. Finally, in the Taymir-Alaska domain, it is exceptional to obtain more than 50 to 100 individuals, and the dasyclad algae are very scarce (Mamet, 1977).

There has always been a decrease in species diversity toward the poles. The early Carboniferous had at least 800 valid species for the Tethys; this declines to 400 for the intermediate domain and, finally, to 100 for the Arctic. Statistically, the number of endemic species for the Tethys is clearly greater than that for the other two domains combined. The number of genera varies very little within each of the domains. However, the species/genus ratio declines drastically from the abundant and diverse community of the Tethys to its Arctic counterpart (fig. 5).

From a morphological aspect, the variation in test size is not significant from one domain to another. However, certain gigantic forms are limited to the Visean-Namurian Tethys; among them are *Bradyina rotula*, *Archaediscus karreri*, and *Omphalotis omphalota*. In addition, certain forms such as uncoiled types occur only in the tropical waters. These characteristics are less obvious in the Bashkirian and disappear in the Moscovian.

Ordinarily, the first appearance of a cosmopolitan genus occurs almost synchronously in all the domains. A few exceptions are recorded in certain advanced forms among

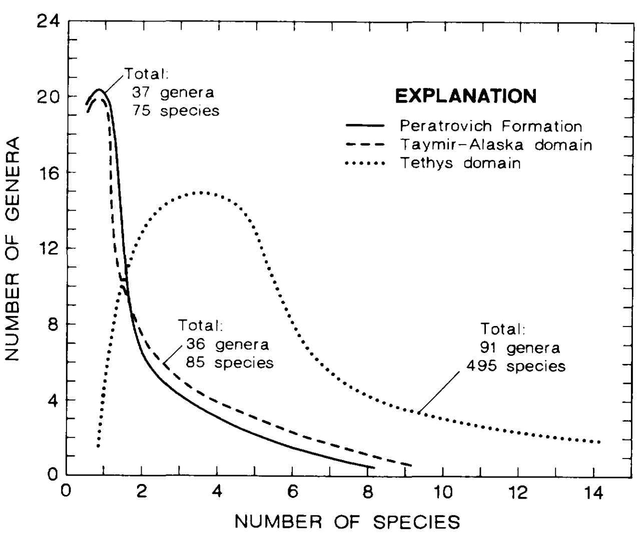


Figure 5. Foraminiferal species/genus ratio of microfauna of the Peratrovich Formation compared to those of the Taymir-Alaska and Tethys domains.

the Bradyinidae and the Palaeotextulariidae (fig. 6). A genus common in the Tethys may appear for the first time a stage later in North America (Mamet and Skipp, 1970). The inverse has never been detected.

The most frequent case of diachronism occurs at the level of the acme zone, even though the first appearances are almost instantaneous on a world-wide scale. The most striking example is that of *Eostaffella*, which proliferated during the Visean in the Tethys. At the same time in North America, the genus *Eoendothyranopsis*, a form morphologically similar to *Eostaffella*, occupied the same ecological niche and proliferated, accompanied by rare *Eostaffella* (see fig. 7). The extinction of the competitive form *Eoendothyranopsis* at the end of the Visean allowed its homologue, *Eostaffella*, to replace it in abundance in North America.

At the species level, interrupted phylogenies are rarely observed in the Tethys. Transitions from one taxon to another, proceeding rapidly or not, form complete sequences. In contrast, North America transitional links are often missing, and taxa of the same sequences seem to have no apparent connection.

As with the foraminifers, most Carboniferous calcareous algae occur in the platform carbonate rocks of shallow bathymetry, less than 50 m deep. It should be emphasized that the type of facies exerts an even greater control on the distribution of chlorophyte microflora than on the foraminifers. These algae are good indicators for shallow environments and surface sea-water temperature (Flügel, 1977).

In the Tethys, the algal proliferation and great specific diversity distinguish this flora from those of the other domains (Mamet, 1990). In these equatorial to tropical waters, several chlorophyte algae take part in building geologic reefs that consist of boundstones, banks, and biostromes (Wray, 1977).

The most abundant algae in the Tethys belong to the Chlorophycophyta, in particular the family Dasycladales. In the Carboniferous, more than 60 genera represent this order,

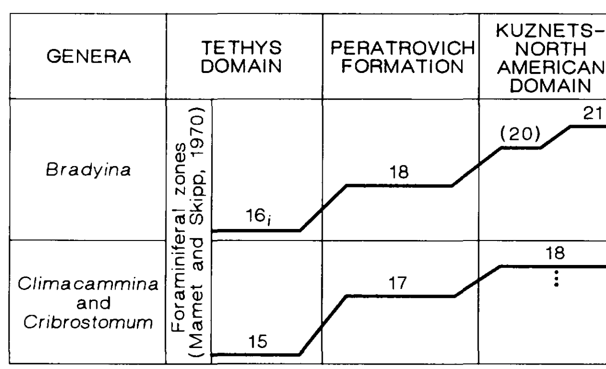


Figure 6. First occurrences of selected microfossils in fora niferal zones (numbers) from three different domains. Pa theses indicate specimens of genus are rare; dots indi possible earlier occurrence.

particularly *Koninckopora*, *Coelosporella*, *Nanopora*, *Atractyliopsis*, and *Anthracoporellopsis*. Although 43 genera are known in the western Tethys, only 12 are known in North America and 11 in the Peratrovich Formation.

The most abundant cyclocrinid, *Koninckopora*, often builds banks in environments that have normal circulation. Unlike most of the algae, this genus effectively contributes to the biostratigraphic zoning of marine carbonate rocks because of its rather limited stratigraphic distribution.

Codiaceae, another family belonging to the Chlorophycophyta, includes *Calcifolium* at the Visean-Namurian boundary. These abundant forms, which are exclusive to the Tethys, also have some stratigraphic value (Mamet and Roux, 1975a, b). Among the other taxa, but much less important and long ranging, are the cosmopolitan *Ortonella*, *Mitcheldeania*, *Garwoodia*, and *Bevocastria*. They occupied lagoonal environments that had either open or restricted circulation. Codiaceae are relatively less important contributors to carbonate sediment than are the Dasycladales. Finally, very few Udoteaceans are known.

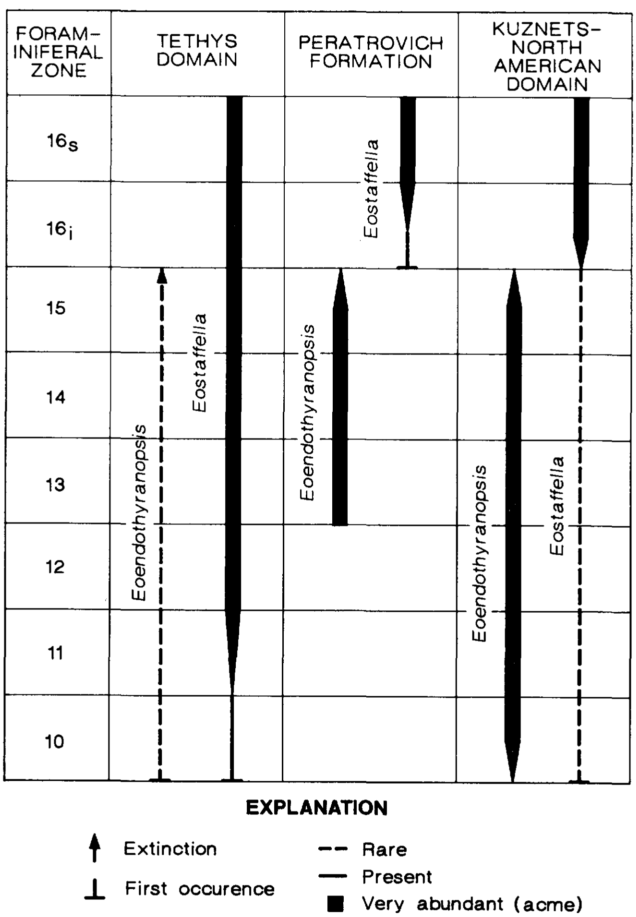


Figure 7. Diachronic acmes of Eostaffellidae in three realms during the Visean. Eostaffellidae are dominant only when *Eoendothyranopsis* is absent or rare. Foraminiferal zones after Mamet and Skipp (1970) and Mamet (1975a).

Blue-green algae, the cyanobacteria, are the second most common algae. Incrustations formed by *Pycnostroma*, *Polymorphocodium*, and *Sphaerocodium* are found in lagoonal facies as well as in turbulent-water facies with Dasycladales. *Girvanella* is always abundant in the photic zone, thus indicating shallow bathymetry.

The Palaeosiphonocladales are less prolific than the preceding algae; nevertheless, they play an appreciable sedimentary role in lagoonal facies. Entangled thalli form more or less solid mats, which filter the sediment and form bafflestones.

Rhodophycophyta are mainly represented by the Ungdarellaceae and Stacheiinae, notably *Fourstonella*, *Stacheia*, *Epistacheoides*, *Stacheoides*, *Ungdarella*, and *Komia*. These extend as far poleward as the temperate waters of the Taymir-Alaska domain.

Passing from the Tethys to the North American domain, species diversity decreases abruptly. The Dasycladales gradually become impoverished, and new forms restricted to this domain arise; among them are *Albertaporella* (Mamet and Roux, 1981), *Sphinctoporella*, and *Windsoporella* (Mamet and Rudloff, 1972). *Koninckopora* banks become fairly rare.

Among the Codiaceae, *Calcifolium* is completely absent in the North American microflora. *Pseudohedstroemia* (Mamet and Roux, 1978) appears sporadically. Palaeosiphonocladales and Solenopores, like most other types of algae, decline in importance in North America. Only the Ungdarellaceae maintain the same productivity as in the Tethys.

As far as endemism in concerned, the Peratrovich flora is unique. Among Carboniferous green algae, 149 species are endemic to the Tethys, 20 species to the North American domain, and none to the Peratrovich Formation, whose flora is completely cosmopolitan (Mamet and Pinard, 1985).

DISCUSSION AND CONCLUSIONS

The micropaleontological study of the Peratrovich Formation shows that the foraminiferal microfauna and the algal microflora belong neither to the Tethyan nor to the Kuznets–North American domains. They are neither Stikinian nor Cache Creekian in the sense of Monger (1984).

We now consider several puzzling anomalies, again beginning with those pertaining to the foraminifers and followed by those of the algae.

In terms of abundance, the high number of individuals in the Peratrovich microfauna denotes a Tethyan character. On the other hand, the moderate number of genera in the microfauna indicates an intermediate position between the two domains. A large number of genera normally not found in North America are abundant in the Peratrovich microfauna. For instance, these taxa include

Janischewskina, *Spinothyra*, *Viseidiscus*, and *Mediocris*. *Banffella* and *Zellerinella*, normally endemic to North America, are well represented. Such a mixture of endemic forms belonging to both domains points to a mixed microfauna.

The Peratrovich species/genus ratio (fig. 5) indicates a microfauna typical of the Taymir-Alaska domain. In the Tethys, many genera are represented by four to six species, and genera with more than ten species are known. In the Taymir-Alaska (Arctic Siberia and North America) domain, most genera are monospecific, and the maximum number of species identified for one genus is about ten; this ratio is also observed in the Peratrovich microfauna.

Omphalotis omphalota among the gigantic forms is usually restricted to the Tethys but occurs in the Peratrovich microfauna. On the other hand, several common forms in the Tethys were not identified in this study. Among them are *Endostaffella*, *Forschia*, *Forschiella*, *Haplophragmina*, *Loeblichia*, "*Permodiscus*", *Propermodiscus*, and *Valvulinella* (Mamet, 1972a, 1974).

The distribution of *Dainella* is perplexing. Common in the North American and Tethys domains, *Dainella* does not appear in the Peratrovich microfauna. This absence cannot be attributed to poor sampling or to observational error.

Three well-documented cases of phylogenetic sequences are compared. First, we consider the Tethyan sequence *Endothyranopsis-Cribrospira-Janischewskina-Bradyina*, presented in order of first appearances. In most of North America the two intermediate genera, *Cribrospira* and *Janischewskina*, are missing. In the Peratrovich Formation, only the absence of *Cribrospira* breaks the continuity of the sequence (Mamet and Skipp, 1970).

Second, in the Tethyan sequence of *Tetrataxis-Howchinia-Monotaxinoides-Eolasiodiscus*, the transitional form *Howchinia* has not been identified elsewhere in North America. The presence of the entire sequence in the Peratrovich Formation indicates a Tethyan affinity.

Third, in the *Brunsia-Viseidiscus*-"*Permodiscus*"-*Propermodiscus-Archaediscus* sequence, only the final form, *Archaediscus*, appears in the North American domain, apparently without any ancestral link from *Brunsia*. The presence of *Viseidiscus* in the Peratrovich provides a partial link between *Brunsia* and *Archaediscus*.

In many places, diachronism of first occurrences is observed. For instance, the first Tethyan *Bradyina* appears in the upper part of Visean Zone 16_i. On most of the North American continent, these forms are known sparsely in Zone 20 and become abundant in the Bashkirian Zone 21. Between these two first appearances there is more than one stage of difference. However, in the Peratrovich Formation, *Bradyina* proliferates in Zone 18, between the zones of the other two domains (fig. 6). This strongly suggests that the Peratrovich served as a bridge between the Tethys and most of North America.

A similar case is observed among double-walled Palaeotextulariidae, for example, *Climacammina* and *Cribrostomum*. They first appear in Zone 15 in the Tethys and Zone 18 in the North American domain. The Peratrovich Formation, again serving as a bridge, contains these forms first in Zone 17 (fig. 6).

Eostaffella is an example of diachronism at the level of the acme zone. This was discussed earlier in the section on paleobiogeography. The acme zones of *Eostaffella* in the Peratrovich Formation and in the rest of North America are nearly identical (fig. 7) but are strongly diachronous with respect to the Tethys.

Another example of diachronism pertains to the upper limits of faunal ranges (fig. 8). *Endothyranopsis*, *Janischewskina*, *Omphalotis*, and *Spinothyra* are usually eliminated at the base of the Bashkirian in the Tethys domain. However, these genera all cross this boundary in the Peratrovich Formation and occur somewhat rarely in the base of Zone 20. This late disappearance gives the Peratrovich microfaunal assemblage a unique character.

The boundary between Zones 15 and 16_i in North America is equivalent to the Meramecian-Chesterian boundary, marked by the extinction of *Eoendothyranopsis* and *Eoforschia*. These same extinctions at that time in the Peratrovich Formation (fig. 8) suggest an American character for the fauna.

The compilation of all these foraminiferal data leads us to conclude that the Peratrovich microfauna is neither typically North American nor obviously Tethyan. It is clearly a mixed microfauna.

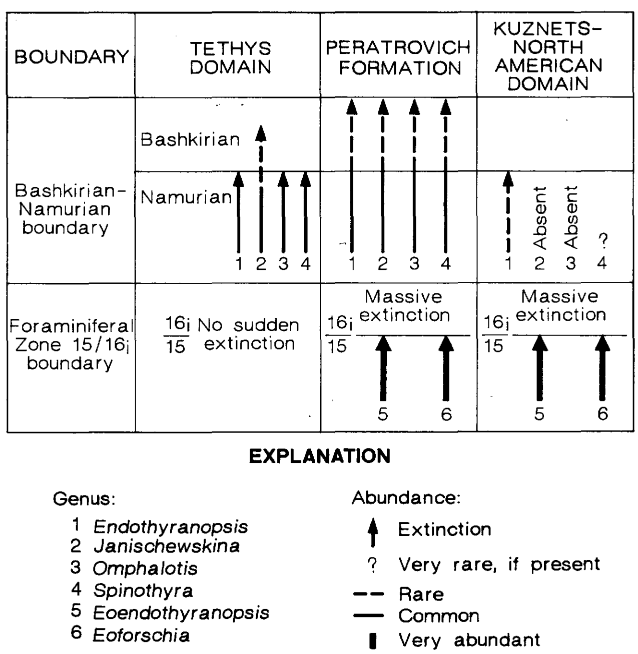


Figure 8. Examples of stage and zone limits of foraminifers in three domains.

When we consider the algal microflora, the total abundance of algae also puts this microflora in a position intermediate between the Tethys and North American realms. The number of genera represented, 28, is more like that of the Tethyan microflora. On the other hand, the 44 species give a rather low species/genus ratio, typically an American character.

In the early Carboniferous around the world, 53 species are very widely dispersed; among them, 29 are observed in the Peratrovich microflora. Moreover, the Peratrovich includes 4 of 20 species normally endemic to North America and 3 of 66 species normally endemic to the western Tethys. Among the Rhodophycophyta, the Ungdarellaceae and the Stacheiinae abound in the Peratrovich and sometimes form organic banks in facies having normal circulation. The Solenoporids constitute only a very small part of the flora, as everywhere else in North America.

Nodular Codiaceans are rare in the Peratrovich, represented by *Ortonella*, *Mitcheldeania*, *Bevocastria* and *Pseudohedstroemia*. The first three are cosmopolitan, and the last is endemic to North America. The absence of *Calcifolium* in the Peratrovich seems very significant and excludes this flora from the Tethyan domain.

On the other hand, Dasycladales are well represented in the Peratrovich by *Koninckopora*, *Anthracoporellopsis*, *Atractyliopsis*, and others; despite their large number, however, they are not very diverse. The microflora has none of the Dasycladales typical of most of North America, such as *Windsoporella*, *Albertaporella*, and *Sphinctoporella*. The cyclocrinid *Koninckopora* is quite abundant (fig. 9) and forms sedimentary banks. This abundance is strikingly different from that in the Yukon and northern Alaska where the genus plays no role in carbonate sedimentation.

Among Schizophyta, Girvanelles are not well represented in the Peratrovich, but they are certainly more abundant than in most of North America. The low abundance of the Spongiostromata characterizes a flora of the North American domain.

Finally, the Kamaenidae are not well represented in the Peratrovich because its carbonate sequence contains few lagoonal facies. In summary, the Peratrovich flora is essentially cosmopolitan and has no more affinities with the rest of North America than with the Tethys domain (Mamet, 1992).

SUMMARY

This study shows that the Peratrovich Formation plays an intriguing role in the distribution of Carboniferous faunas and floras. For the first time, foraminiferal and algal assemblages are defined within the eugeosynclinal carbonate rocks of the North American Cordillera. These new assemblages impose constraints in developing tectonic models. They are inconsistent with models that propose that the Cordilleran terranes are fragments derived from Asia (Wilson, 1968; Danner, 1970). In addition, they are related to the Stikinia terrane but not typically related to the terranes of southwestern United States.

The position of the Peratrovich Formation in the general framework of Carboniferous stratigraphy supports a Tethyan origin for a great part of its microfauna. This hypothesis suggests that the Tethys was the cradle of these foraminifers, which systematically migrated toward North America (Mamet and Skipp, 1970).

Because the only means of locomotion for adult benthic foraminifers are pseudopods, however, it seems reasonable to postulate that strong marine currents provided the means of dispersion for large-scale migrations. As a model, we postulate a warm marine current moving toward the present-day northwest from the southwest along the axis of the Cordilleran geosyncline.

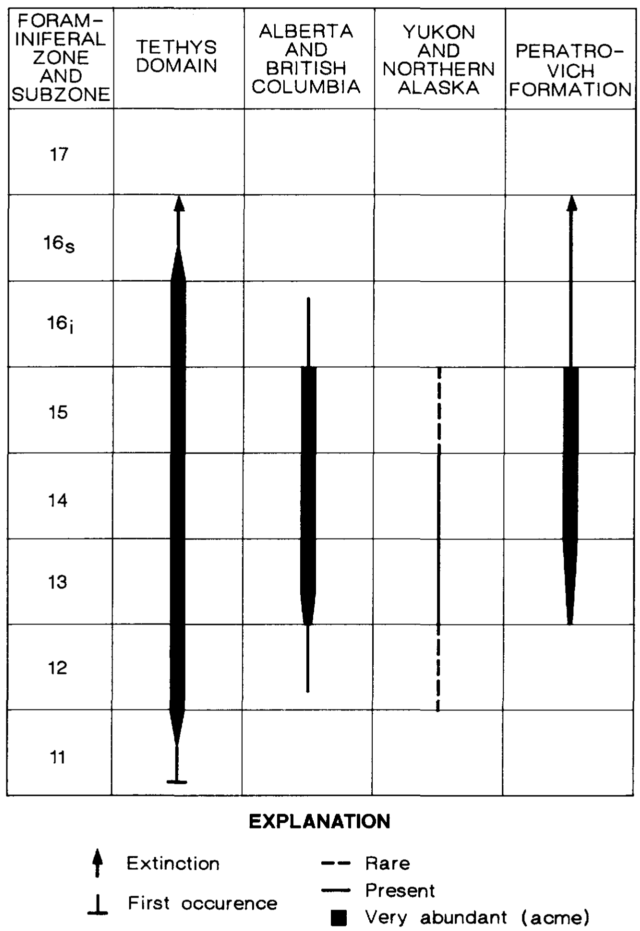


Figure 9. Stratigraphic distribution of the chlorophyte *Koninckopora* in Tethys domain and in three regions of North America. (Genus is still recognized in the Serpukhovian in southern China.) Foraminiferal zones after Mamet and Skipp (1970).

This is precisely the model proposed by Raymond and others (1985, fig. 7.12). This Namurian oceanic circulation pattern was also used by Dutro (1987) to explain brachiopod paleogeographic distributions.

Uniformly distributed sites of carbonate sedimentation between America and northern Asia seem essential for the process of migration. In fact, Churkin (1975) reported that the Paleozoic rocks of the geosyncline at the edge of the Pacific Ocean and the Alaska Range continue and connect with lithologically similar rocks in the Koryak Mountains in the northeastern part of the former Soviet Union. If the area that is now Alaska constituted the route of passage between Asia and North America in the Carboniferous, the paleomagnetic reconstruction by Scotese (1986) does not work.

By accepting the idea of warm marine currents coming from northeast Asia, the presence of the mixed Peratrovich microfauna juxtaposed with an American microfauna farther east is explained by a relatively fixist theory of continental blocks. Bringing in allochthonous terranes by large displacements along transform faults is not necessary to explain these observations. The Peratrovich is not a suspect terrane; it is an intriguing one.

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INDEX

PLATES 1–16

All illustrated specimens are from the Peratrovich Formation, except where noted otherwise (Klawak Formation or Ladrones Limestone). Captions for specimens include the name, University of Montreal Department of Geology number, Armstrong field-note footage (number shows year of collection, section number, and stratigraphic position in feet above base of section), locality, level in the section, foraminiferal zone, stage, and magnification.

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

PLATE 1

FIGURES 1, 2. *Earlandia* of the group *E. elegans* (Rauzer-Chernoussova 1937).
  1. Se 3/16, 66X-1+380 (L.1), Peratrovich Island, 116.3 m above base of section, Zone ≥18–20, Namurian(?), ×62.
  2. Se 2/24, 66X-1+285 (L.6), Peratrovich Island, 87.2 m above base of section, Zone 18, early Namurian, ×97.

3. *Earlandia* of the group *E. clavatula* (Howchin 1888).
  3. Se 25/30, 66X-11+100, Madre de Dios Island, 30.6 m above base of section, Zone 14, late Visean, ×62.

4. *Earlandia* of the group *E. vulgaris* (Rauzer-Chernoussova and Reitlinger 1937).
  4. Ma 366/15, 66X-1+470 (L.1), Peratrovich Island, 143.8 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×97.

5–7. *Pseudoammodiscus volgensis* (Rauzer-Chernoussova 1948).
  5. Ma 507/11, 66X-12+180C, Ladrones Island, 55.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
  6. Ma 508/13, 66X-12+280E, Ladrones Island, 85.7 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×97.
  7. Ma 508/10, 66X-12+280B, same locality as figure 6, ×97.

8, 9, 11. *Brunsia* of the group *B. lenensis* Bogush and Juferev 1966.
  8. Ma 506/28, 66X-12+160D, Ladrones Island, 49.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
  9. Se 22/4, 66X-6+60, Toti Island, 18.4 m above base of section, Zone 13, middle Visean, ×97.
  11. Se 3/17, 66X-1+380 (L.1), same locality as figure 1, ×62.

10, 18. *Pseudoammodiscus mameti* Rich 1980.
  10. Ma 371/7, 66X-11+110 (L.3), Madre de Dios Island, 33.6 m above base of section, Zone 14, late Visean, ×97.
  18. Ma 369/37, 66X-11+110 (L.23), same locality as figure 10, ×97.

12, 13. *Septatournayella*? *kennedyi* Skipp 1966.
  12. Ma 370/8, 66X-11+110 (L.28), same locality as figure 10, ×97.
  13. Ma 372/4, 66X-11+110, same locality as figure 10, ×118.

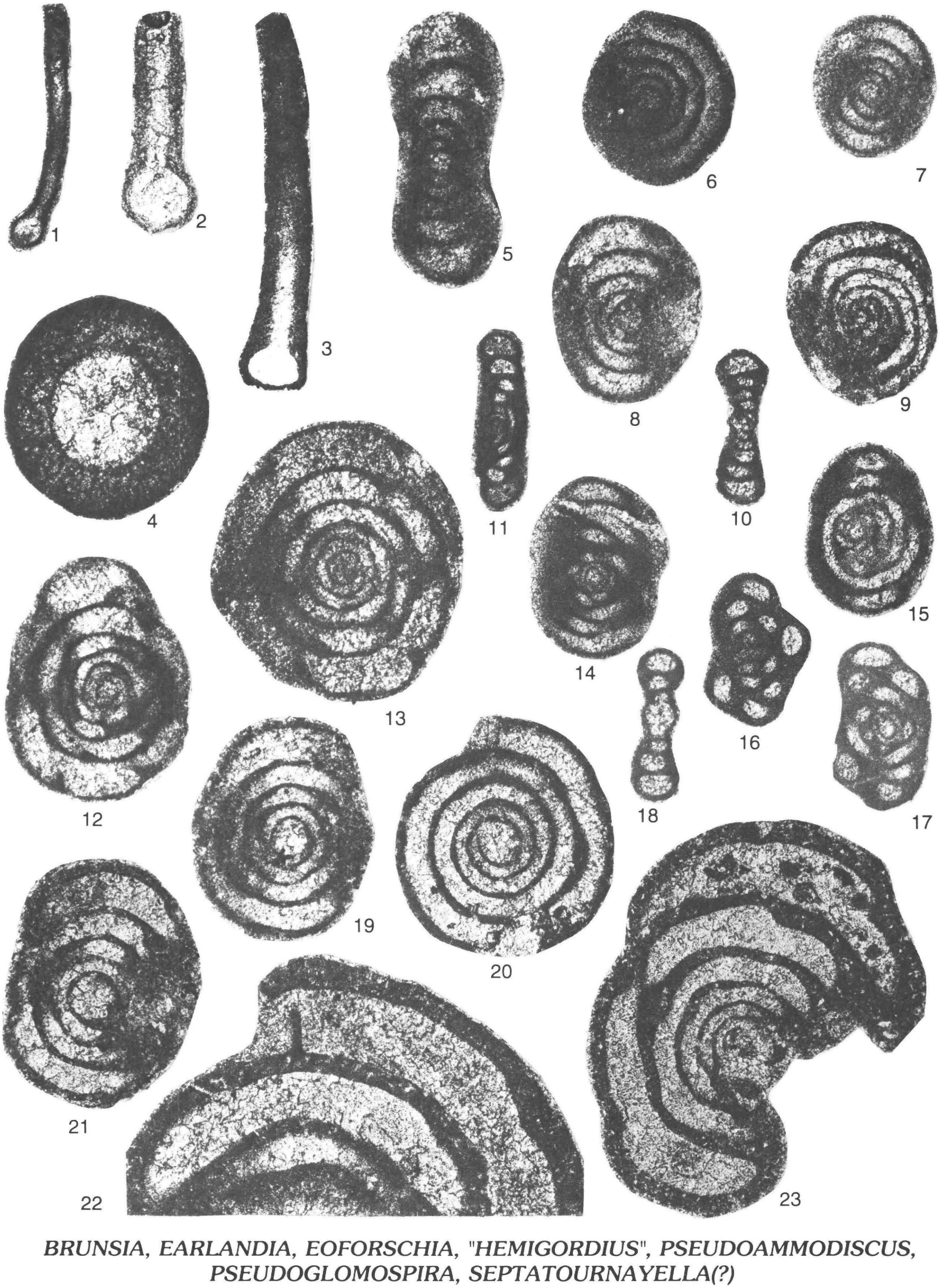
14, 15. "*Hemigordius*" sp.
  14. Ma 506/31, 66X-12+170A, Ladrones Island, 52.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
  15. Ma 506/17, 66X-12+160A, same locality as figure 8, ×97.

16, 17. *Pseudoglomospira irregularis* (Rauzer-Chernoussova 1948).
  16. Se 15/33, 66X-12+50 (L.22), Ladrones Island, 15.3 m above base of section, Zone ≥18–20, Namurian(?), ×97.
  17. Ma 367/30, 66X-1+380 (L.2), same locality as figure 1, ×97.

19–21. *Eoforschia* of the group *E. moelleri* (juvenile) (Malakhova in Dain 1953).
  19. Ma 371/34, 66X-11+110 (L.2), same locality as figure 10, ×97.
  20. Ma 370/3, 66X-11+110 (L.28), same locality as figure 10, ×97.
  21. Se 11/28, 66X-11+150 (L.46), Madre de Dios Island, 45.9 m above base of section, Zone 14, late Visean, ×121.

22. Secondary deposit (hook) of *Eoforschia* of the group *E. moelleri* (Malakhova in Dain 1953).
  22. Ma 371/28, 66X-11+150 (L.49), same locality as figure 21, ×121.

23. *Eoforschia* of the group *E. moelleri* (mature) (Malakhova in Dain 1953).
  23. Se 11/26, 66X-11+150 (L.46), same locality as figure 21, ×62.



BRUNSIA, EARLANDIA, EOFORSCHIA, "HEMIGORDIUS", PSEUDOAMMODISCUS, PSEUDOGLOMOSPIRA, SEPTATOURNAYELLA(?)

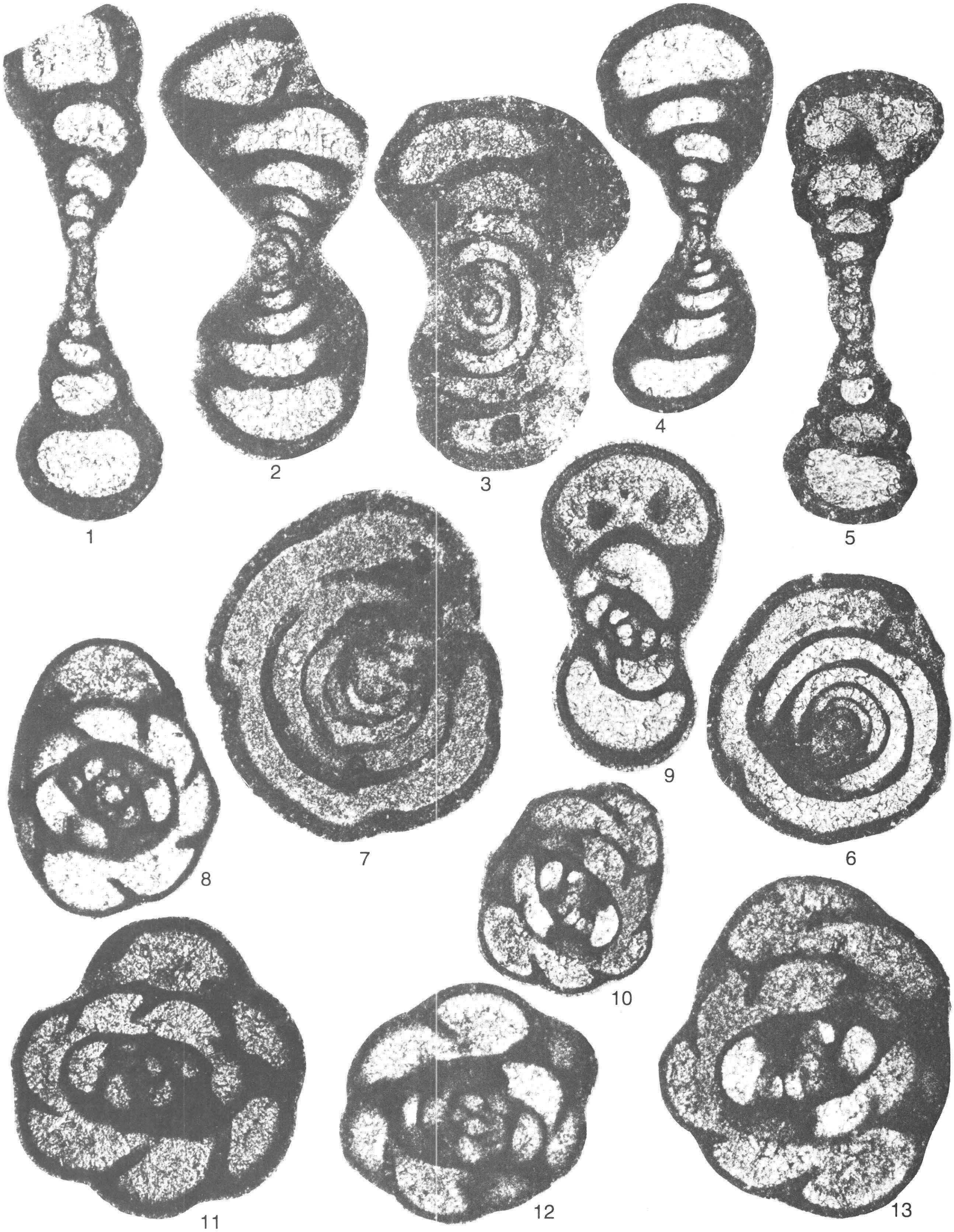
PLATE 2

FIGURES 1–7. *Eoforschia* of the group *E. moelleri* (Malakhova in Dain 1953).

1. Ma 371/30, 66X-11+150 (L.50), Madre de Dios Island, 45.9 m above base of section, Zone 14, late Visean, ×97.
2. Ma 371/2, 66X-11+110 (L.39), Madre de Dios Island, 33.6 m above base of section, Zone 14, late Visean, ×78.
3. Ma 371/36, 66X-11+150 (L.52), same locality as figure 1, ×78.
4. Se 9/11, 66X-11+90 (L.10), Madre de Dios Island, 27.5 m above base of section, Zone 14, late Visean, ×62.
5. Ma 368/34, 66X-11+90 (L.10), same locality as figure 4, ×62.
6. Ma 370/37, 66X-11+110 (L.38), same locality as figure 2, ×62.
7. Se 11/6, 66X-11+110 (L.35), same locality as figure 2, ×62.

8–13. *Endothyra torquida* (Zeller 1957).

8. Ma 371/3, 66X-11+140 (L.54), Madre de Dios Island, 42.8 m above base of section, Zone 14, late Visean, ×78.
9. Se 10/24, 66X-11+110 (L.31), same locality as figure 2, ×97.
10. Se 10/17, 66X-11+110 (L.38), same locality as figure 2, ×97.
11. Ma 370/5, 66X-11+110 (L.28), same locality as figure 2, ×97.
12. Ma 370/6, 66X-11+110 (L.28), same locality as figure 2, ×97.
13. Ma 370/13, 66X-11+110 (L.28), same locality as figure 2, ×97.



ENDOTHYRA, EOFORSCHIA

PLATE 3

FIGURES 1–5. *Endothyra* of the group *E. obsoleta* Rauzer-Chernoussova 1948.

1. Ma 371/26, 66X-11+150 (L.49), Madre de Dios Island, 45.9 m above base of section, Zone 14, late Visean, ×97.
2. Ma 369/39, 66X-11+110 (L.23), Madre de Dios Island, 33.6 m above base of section, Zone 14, late Visean, ×97.
3. Ma 370/36, 66X-11+110 (L.38), same locality as figure 2, ×97.
4. Ma 370/26, 66X-11+110 (L.33), same locality as figure 2, ×97.
5. Ma 370/12, 66X-11+110 (L.31), same locality as figure 2, ×97.

6–12, 17. *Endothyra* of the group *E. bowmani* Phillips 1846 emend. Brady 1876.

6–12. *Endothyra excentralis* Cooper 1947.

6. Ma 370/30, 66X-11+110 (L.34), same locality as figure 2, ×97.
7. Ma 371/24, 66X-11+110 (L.49), same locality as figure 2, ×97.
8. Ma 370/34, 66X-11+110 (L.34), same locality as figure 2, ×97.
9. Ma 371/25, 66X-11+150 (L.49), same locality as figure 1, ×97.
10. Ma 370/5, 66X-11+110 (L.28), same locality as figure 2, ×97.
11. Ma 370/18, 66X-11+110 (L.31), same locality as figure 2, ×97.
12. Ma 370/17, 66X-11+110 (L.31), same locality as figure 2, ×97.

17. *Endothyra bowmani* Phillips 1846 emend. Brady 1876.

17. Ma 371/27, 66X-11+150 (L.49), same locality as figure 1, ×97.

13. *Endothyra* of the group *E. similis* Rauzer-Chernoussova and Reitlinger 1936. *Endothyra excellens* (Nodine-Zeller 1953).

13. Ma 370/15, 66X-11+110 (L.31), same locality as figure 2, ×97.

14-16. *Endothyra hortonensis* Rich 1980.

14. Se 10/19, 66X-11+110 (L.28), same locality as figure 2, ×62.
15. Se 12/1, 66X-11+150 (L.48), same locality as figure 1, ×62.
16. Se 10/15, 66X-11+110 (L.28), same locality as figure 2, ×62.

18. *Planoendothyra aljutovica* (Reitlinger 1950).

18. Ma 506/26, 66X-12+160C, Ladrones Island, 49.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.

19–21. *Priscella* of the group *P. prisca* (Rauzer-Chernoussova 1936).

19. Juvenile form.

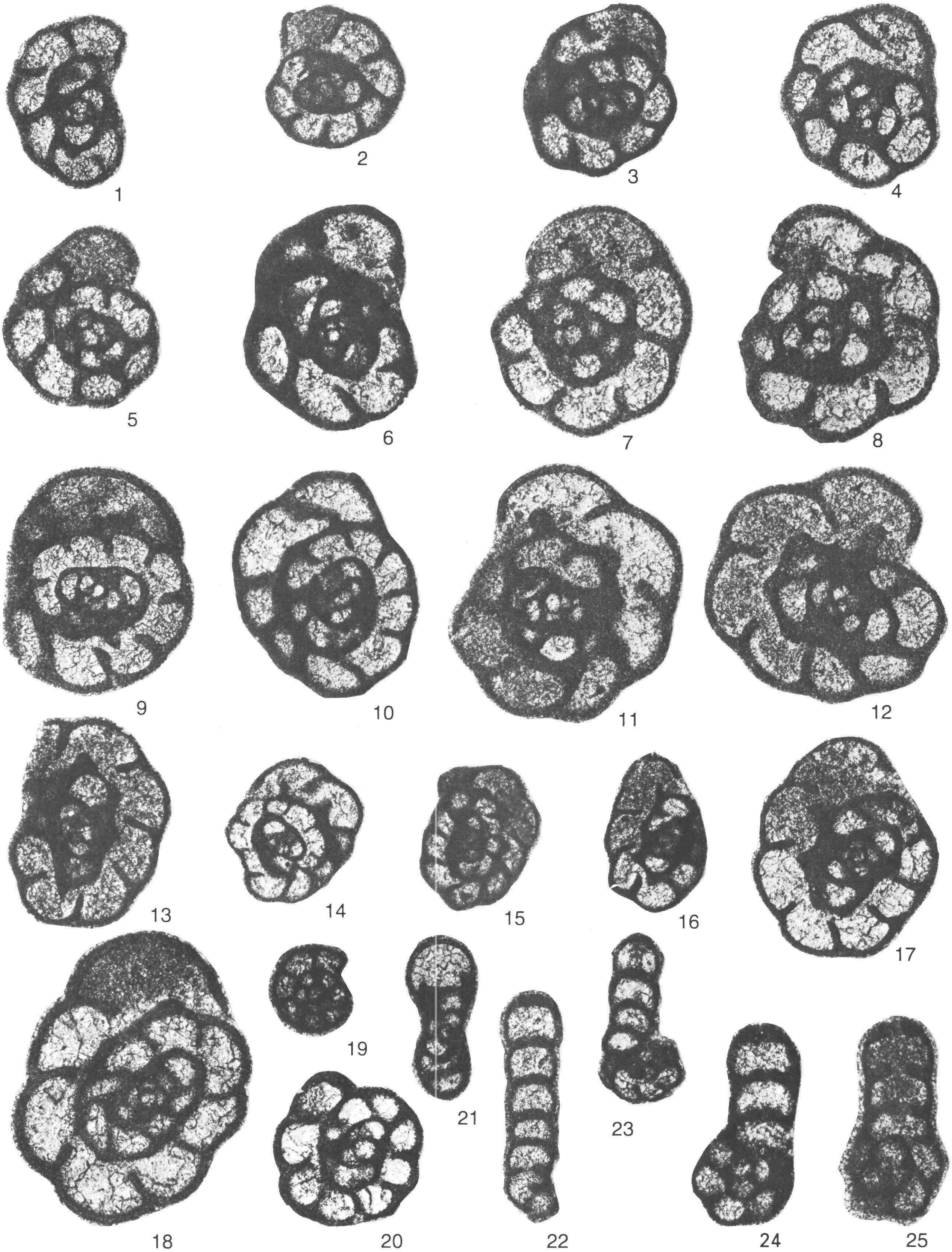
19. Se 14/17, 66X-8+620, Shelikof Island, 189.7 m above base of section, Zone 17, early Namurian, ×97.

20, 21. *Priscella prisca* (Rauzer-Chernoussova 1936).

20. Ma 275/34, 66X-8+300, Shelikof Island, 91.8 m above base of section, Zone 15, late Visean, ×97.
21. Ma 275/33, 66X-8+300, same locality as figure 20, ×97.

22–25. *Endothyranella recta* (Brady 1876).

22. Se 11/1 66X-11+110 (L.32), same locality as figure 2, ×97.
23. Se 11/11 66X-11+110 (L.37), same locality as figure 2, ×62.
24. Ma 369/28 66X-11+110 (L.22), same locality as figure 2, ×97.
25. Se 11/17 66X-11+110 (L.39), same locality as figure 2, ×97.



ENDOTHYRA, ENDOTHYRANELLA, PLANOENDOTHYRA, PRISCELLA

PLATE 4

FIGURES 1–3. *Omphalotis omphalota* (Rauzer-Chernoussova 1936).

1. Se 6/24, 66X-1+440 (L.19), Peratrovich Island, 134.6 m above base of section, Zone ≥18–20, Namurian(?), ×78.
2. Se 8/26, 66X-1+470 (L.7), Peratrovich Island, 143.8 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×62.
3. Ma 366/12, 66X-1+455, Peratrovich Island, 139.2 m above base of section, Zone ≥18–20, Namurian(?), ×62.

4, 9. *Globoendothyra* of the group *G. globulus* (d'Eichwald 1860).

4. Ma 368/24, 66X-8+540, Shelikof Island, 165.2 m above base of section, Zone 16_i, late Visean, ×62.
9. Ma 367/13, 66X-1+366 (L.7), Peratrovich Island, 112.0 m above base of section, Zone ≥18–20, Namurian(?), ×62.

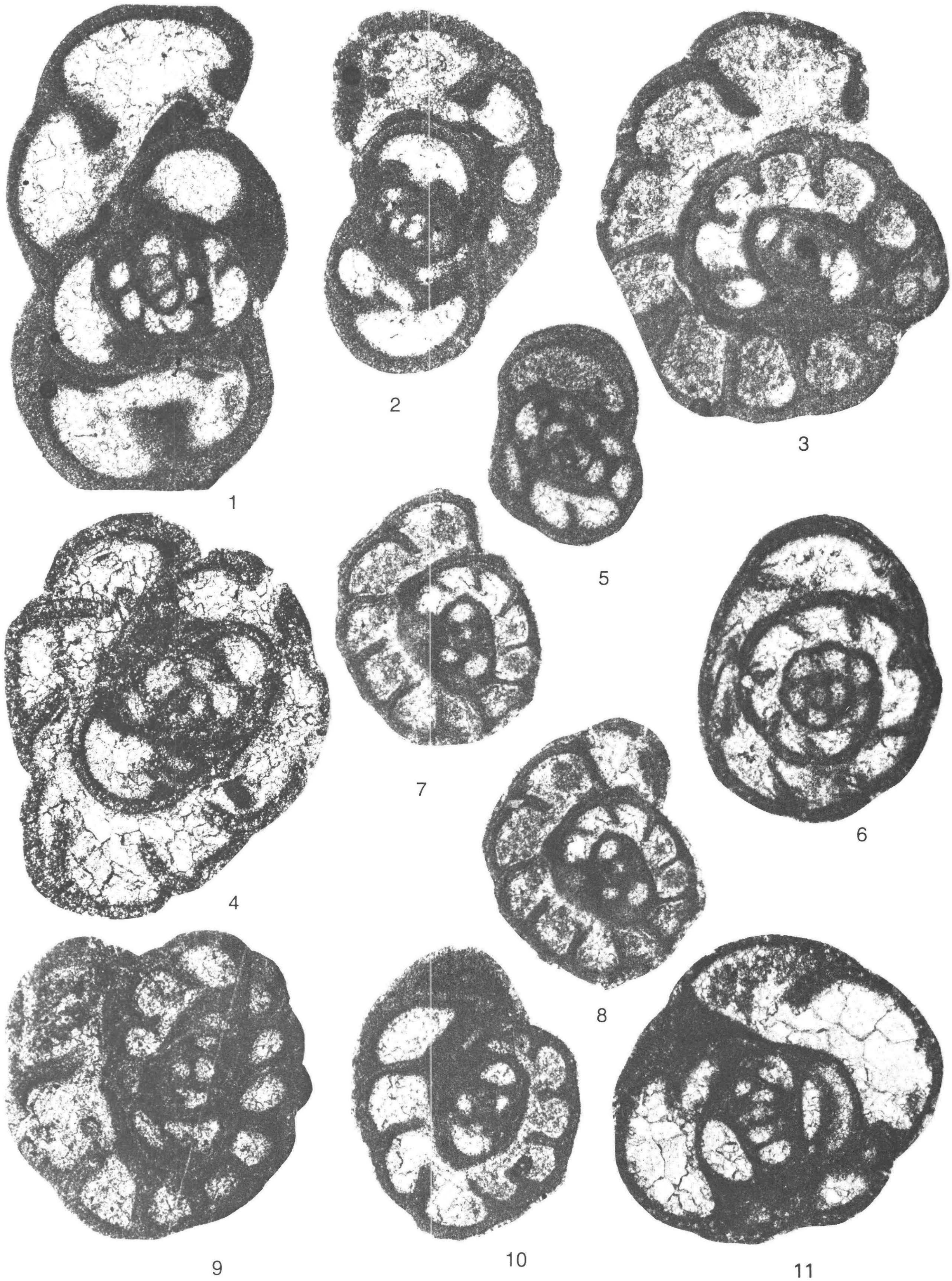
5–8, 10, 11. *Globoendothyra* of the group *G. tomiliensis* (Grozdilova and Lebedeva 1954).

5–8, 10. *Globoendothyra ishimica* (Rauzer-Chernoussova 1948).

5. Ma 506/32, 66X-12+170A, Ladrones Island, 52.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×62.
6. Se 15/17, 66X-12+40, Ladrones Island, 12.2 m above base of section, Zone ≥18–20, Namurian(?), ×62.
7. Se 4/26, 66X-1+415, Peratrovich Island, 127.0 m above base of section, Zone ≥18–20, Namurian(?), ×62.
8. Se 4/26, 66X-1+415, same locality as figure 7, ×62.
10. Se 8/22, 66X-1+470, Peratrovich Island, 143.8 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×62.

11. *Globoendothyra paula* (Vissarionova 1948).

11. Ma 403/1, 66X-6+260, Toti Island, 79 m above base of section, Zone 14, late Visean, ×62.



GLOBOENDOTHYRA, OMPHALOTIS

PLATE 5

FIGURES 1–6, 9. *Eoendothyranopsis* of the group *E. pressa-rara* (Grozdilova in Lebedeva 1954).

1. Ma 370/25, 66X-11+110 (L.23), Madre de Dios, 33.6 m above base of section, Zone 14, late Visean, ×62.
2. Ma 368/36, 66X-11+90 (L.11), Madre de Dios Island, 27.5 m above base of section, Zone 14, late Visean, ×78.
3. Ma 371/35, 66X-11+150 (L.52), Madre de Dios Island, 45.9 m above base of section, Zone 14, late Visean, ×78.
4. Ma 371/18, 66X-11+150 (L.47), same locality as figure 3, ×78.
5. Ma 360/27, 66X-11+100 (L.22), Madre de Dios Island, 30.6 m above base of section, Zone 14, late Visean, ×62.
6. Ma 372/3, 66X-11+110 (L.23), same locality as figure 1, ×78.
9. Se 11/4, 66X-11+110 (L.33), same locality as figure 1, ×97.

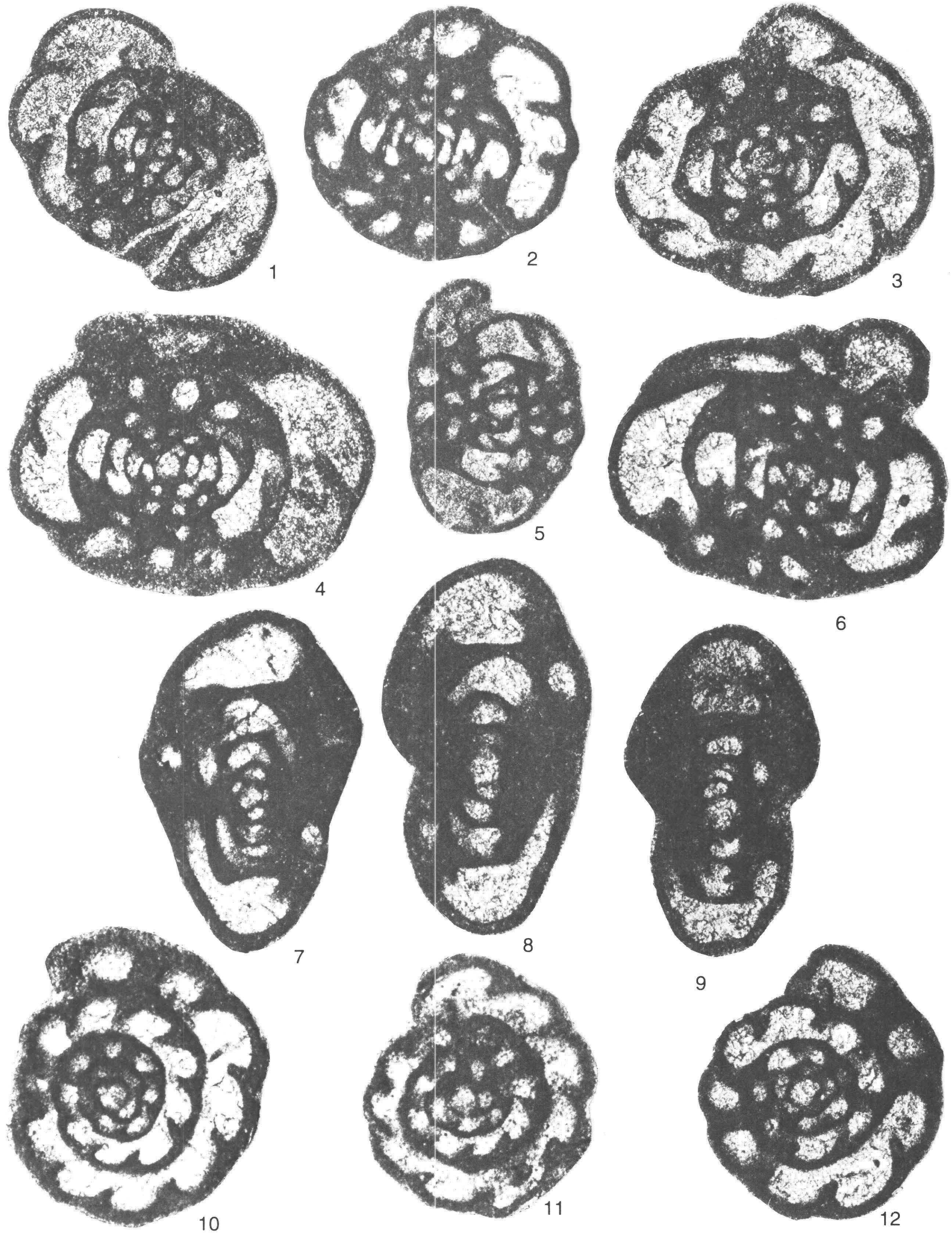
7, 8. *Eoendothyranopsis* of the group *E. ermakiensis* (Lebedeva 1954).

7, 8. *Eoendothyranopsis ermakiensis* (Lebedeva 1954).

7. Ma 370/33, 66X-11+110 (L.37), same locality as figure 1, ×97.
8. Se 10/5, 66X-11+110 (L.23), same locality as figure 1, ×97.

10–12. *Eoendothyranopsis*? sp.

10. Se 25/8, 66X-11+100, same locality as figure 5, ×97.
11. Se 25/29, 66X-11+100, same locality as figure 5, ×97.
12. Ma 370/20, 66X-11+110 (L.31), same locality as figure 1, ×97.



EOENDOTHYRANOPSIS

PLATE 6

FIGURES 1–5. *Endothyranopsis* of the group *E. sphaerica* (Rauzer-Chernoussova and Reitlinger 1936).

1–5. *Endothyranopsis sphaerica intermedia* (Rauzer-Chernoussova 1948).

1. Ma 368/12, 66X-1+415 (L.5), Peratrovich Island, 127.0 m above base of section, Zone ≥18–20, Namurian(?), ×30.
2. Ma 368/22, 66X-1+430 (L.11), Peratrovich Island, 131.6 m above base of section, Zone ≥18–20, Namurian(?), ×30.
3. Ma 506/27, 66X-12+160D, Ladrones Island, 49.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×30.
4. Ma 368/20, 66X-1+470 (L.8), Peratrovich Island, 143.8 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×30.
5. Ma 176/25, 66X-1+440 (L.38), Peratrovich Island, 134.6 m above base of section, Zone ≥18–20, Namurian(?), ×25.

6–8, 10, 11. *Eoendothyranopsis* of group *E. pressa-rara* (Grozdilova in Lebedeva 1954).

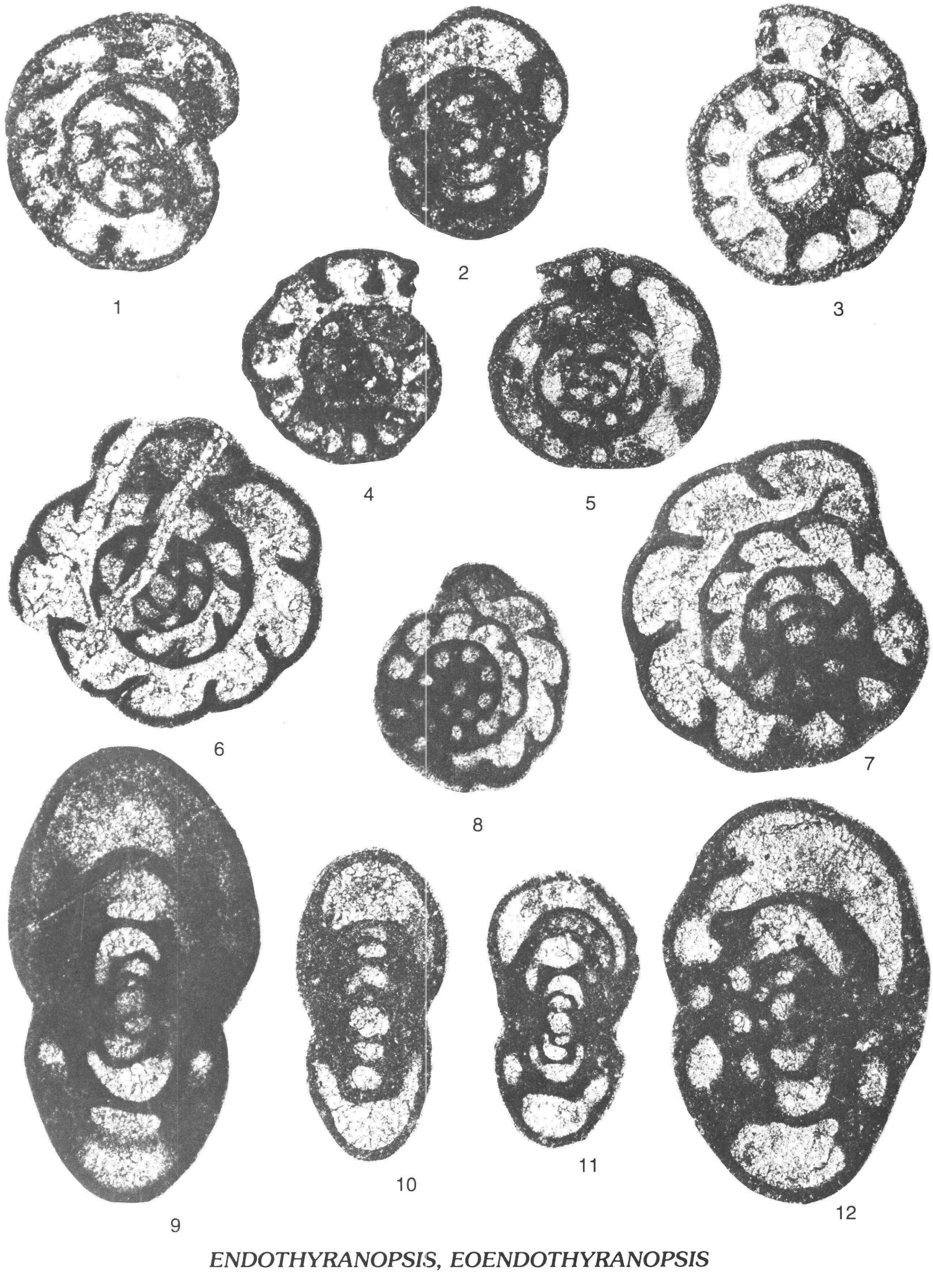
11. Se 10/30, 66X-11+110 (L.32), Madre de Dios Island, 33.6 m above base of section, Zone 14, late Visean, ×62.

6–8, 10. *Eoendothyranopsis scitula* (Toomey 1961).

6. Ma 370/35, 66X-11+110 (L.38), same locality as figure 11, ×78.
7. Ma 317/5, 66X-11+110 (L.39), same locality as figure 11, ×97.
8. Se 12/8, 66X-11+150 (L.54), Madre de Dios Island, 45.9 m above base of section, Zone 14, late Visean, ×62.
10. Ma 3 70/29, 66X-11+110 (L.33), same locality as figure 11, ×97.

9, 12. *Eoendothyranopsis* of group *E. ermakiensis* (Lebedeva 1956).

9. Ma 369/20, 66X-11+110 (L.22), same locality as figure 11, ×97.
12. Ma 370/32, 66X-11+110 (L.28), same locality as figure 11, ×97.



ENDOTHYRANOPSIS, EOENDOTHYRANOPSIS

PLATE 7

FIGURES 1, 2. *Endothyranopsis compressa* (Rauzer-Chernoussova and Reitlinger 1936).

1. Se 3/29, 66X-1+380 (L.4), Peratrovich Island, 116.3 m above base of section, Zone ≥18–20, Namurian(?), ×25.
2. Se 10/6, 66X-11+110 (L.23), Madre de Dios Island, 33.6 m above base of section, Zone 14, late Visean, ×62.

3, 4. Transition between *Endothyranopsis compressa* (Rauzer-Chernoussova and Reitlinger 1936) and *E. hirosei* Okimura 1965.

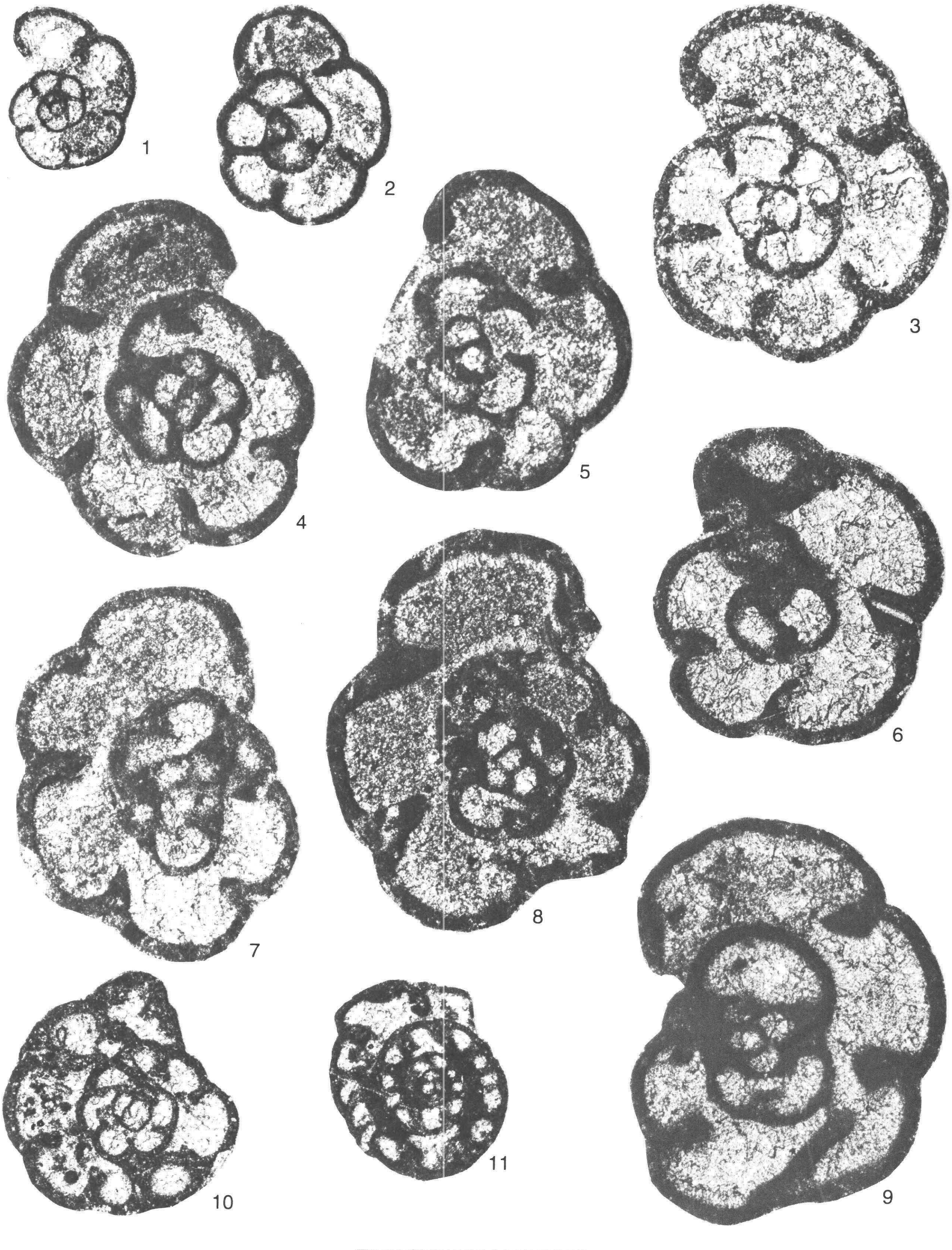
3. Ma 371/18, 66X-11+120 (L.42), Madre de Dios Island, 36.7 m above base of section, Zone 14, late Visean, ×97.
4. Ma 370/11, 66X-11+110 (L.31), same locality as figure 2, ×97.

5–9. *Endothyranopsis hirosei* Okimura 1965.

5. Ma 371/3, 66X-11+110 (L.29), same locality as figure 2, ×97.
6. Ma 370/13, 66X-11+110 (L.31), same locality as figure 2, ×97.
7. Ma 371/21, 66X-11+150 (L.48), Madre de Dios Island, 45.9 m above base of section, Zone 14, late Visean, ×97.
8. Ma 370/21, 66X-11+110 (L.34), same locality as figure 2, ×97.
9. Ma 369/35, 66X-11+110 (L.23), same locality as figure 2, ×97.

10, 11. *Endothyranopsis* of the group *E. sphaerica* (Rauzer-Chernoussova and Reitlinger 1936).

10. Se 6/25, 66X-1+440 (L.18), Peratrovich Island, 134.6 m above base of section, Zone ≥18–20, Namurian(?), ×25.
11. *Endothyranopsis sphaerica intermedia* (Rauzer-Chernoussova 1948).
    11. Se 6/24, 66X-1+440 (L.17), same locality as figure 10, ×25.



ENDOTHYRANOPSIS

PLATE 8

FIGURES 1–4, 6–12. *Janischewskina typica* Mikhailov 1939.

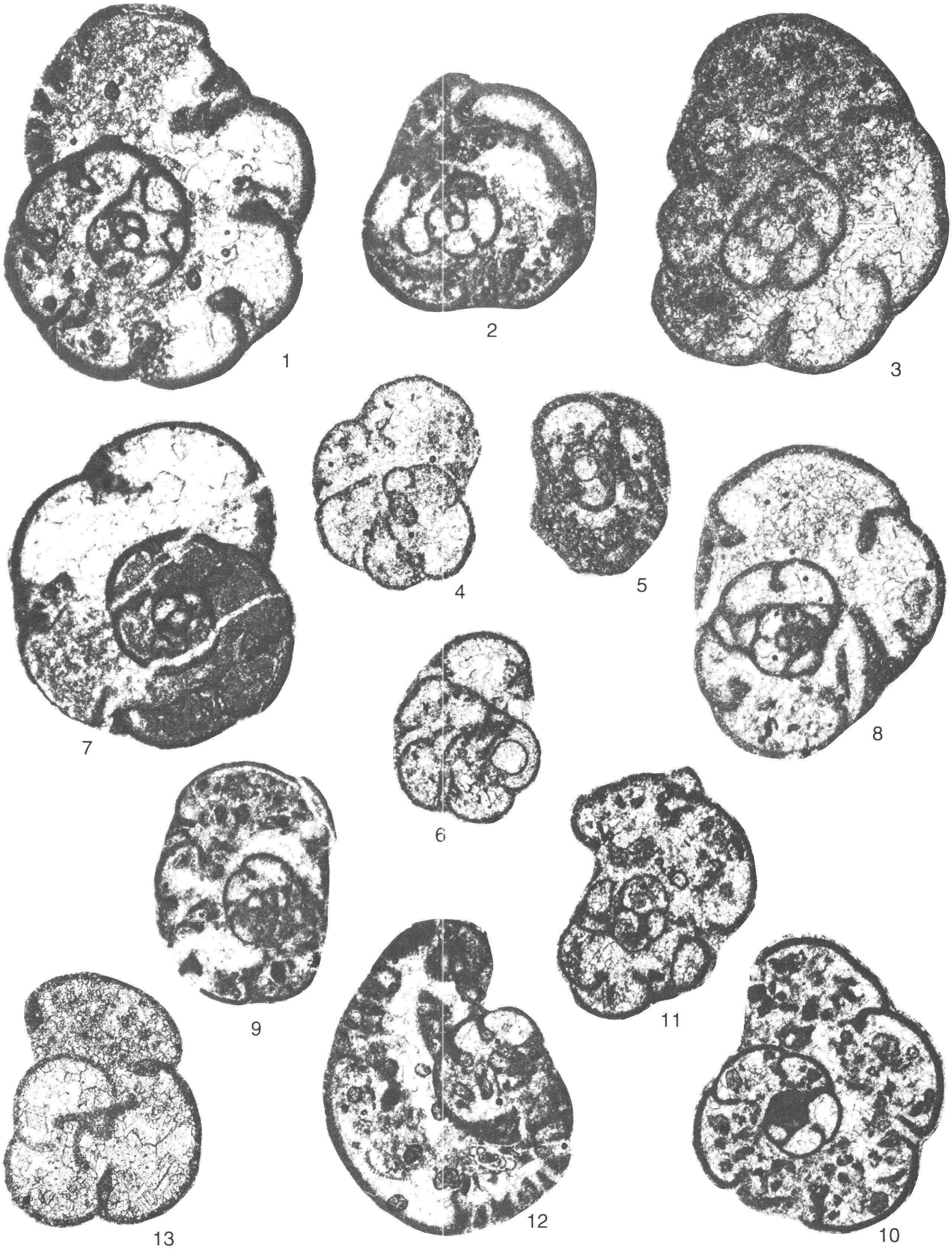
1. Ma 366/19, 66X-1+470 (L.3), Peratrovich Island, 143.8 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×30.
2. Ma 366/13, 66X-1+470 (L.1), same locality as figure 1, ×30.
3. Ma 366/5, 66X-1+461 (L.5), Peratrovich Island, 141.0 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×25.
4. Se 4/7 66X-1+366 (L.9), Peratrovich Island, 112.0 m above base of section, Zone ≥18–20, Namurian(?), ×25.
6. Se 3/8, 66X-1+366 (L.6), same locality as figure 4, ×25.
7. Se 6/8, 66X-1+366 (L.6), same locality as figure 4, ×25.
8. Ma 366/17, 66X-1+470 (L.2), same locality as figure 1, ×30.
9. Se 17/8, 66X-12+110 (L.45), Ladrones Island, 33.6 m above base of section, Zone ≥18–20, Namurian(?), ×25.
10. Se 16/7, 66X-12+70 (L.29), Ladrones Island, 21.4 m above base of section, Zone ≥18–20, Namurian(?), ×25.
11. Ma 367/3, 66X-1+366 (L.1), same locality as figure 4, ×30.
12. Se 4/35, 66X-1+415 (L.8), Peratrovich Island, 127.0 m above base of section, Zone ≥18–20, Namurian(?), ×25.

5. *Bradyina potanini* Venukoff 1889.

5. Se 6/26, 66X-1+440 (L.10), Peratrovich Island, 134.6 m above base of section, Zone ≥18–20, Namurian(?), ×25.

13. *Spinothyra pauciseptata* (Rauzer-Chernoussova 1948).

13. Ma 376/3, 66X-1+470, same locality as figure 1, ×25.



BRADYINA, JANISCHEWSKINA, SPINOTHYRA

PLATE 9

FIGURES 1–3. *Janischewskina typica* Mikhailov 1939.

1. Se 8/18, 66X-1+470 (L.1), Peratrovich Island, 143.8 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×25.
2. Se 6/15, 66X-1+440 (L.23), Peratrovich Island, 134.6 m above base of section, Zone ≥18–20, Namurian(?), ×25.
3. Se 7/15, 66X-1+445 (L.3), Peratrovich Island, 136.2 m above base of section, Zone ≥18–20, Namurian(?), ×25.

4–6, 10. *Bradyina potanini* Venukoff 1889.

4. Se 6/2, 66X-1+440 (L.22), same locality as figure 2, ×25.
5. Ma 173/25, 66X-1+430, Peratrovich Island, 131.6 m above base of section, Zone ≥18–20, Namurian(?), ×25.
6. Se 4/8, 66X-1+380 (L.2), Peratrovich Island, 116.3 m above base of section, Zone ≥18–20, Namurian(?), ×25.
10. Ma 366/22, 66X-1+470 (L.5), same locality as figure 1, ×30.

7–9, 11. *Bradyina concinna* Reitlinger 1950.

7. Se 5/28, 66X-1+415 (L.2), Peratrovich Island, 127.0 m above base of section, Zone ≥18–20, Namurian(?), ×25.
8. Se 4/34, 66X-1+415 (L.7), same locality as figure 7, ×25.
9. Ma 506/35, 66X-12+170A, Ladrones Island, 52.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×25.
11. Ma 506/14, 66X-12+150E, Ladrones Island, 45.9 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×62.

BRADYINA, JANISCHEWSKINA

PLATE 10

FIGURES 1–12, 15. *Eostaffella* of the group *E. radiata* (Brady 1876) (=*Eostaffella mosquensis* Vissarionova 1948).

1–5. *Eostaffella chesterensis* (Cooper 1947).

1. Ma 368/13, 66X-1+415 (L.5), Peratrovich Island, 127.0 m above base of section, Zone ≥18–20, Namurian(?), ×97.
2. Ma 508/19, 66X-12+280C, Ladrones Island, 85.7 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×97.
3. Ma 366/16, 66X-1+470 (L.1), Peratrovich Island, 143.8 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×97.
4. Se 18/5, 66X-12+150A, Ladrones Island, 45.9 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
5. Ma 508/16, 66X-12+280E, same locality as figure 2, ×97.

6–12, 15. *Eostaffella radiata* (Brady 1876).

6. Se 8/9, 66X-1+470 (L.10), same locality as figure 3, ×62.
7. Ma 366/26, 66X-1+470 (L.6), same locality as figure 3, ×97.
8. Ma 508/9, 66X-12+260B, Ladrones Island, 79.6 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×97.
9. Se 19/11, 66X-12+260C, same locality as figure 8, ×97.
10. Se 18/2, 66X-12+150B, same locality as figure 4, ×62.
11. Ma 508/15, 66X-12+260D, same locality as figure 8, ×97.
12. Ma 367/29, 66X-1+366 (L.11), Peratrovich Island, 112.2 m above base of section, Zone ≥18–20, Namurian(?), ×97.
15. Ma 366/18, 66X-1+470 (L.2), same locality as figure 3, ×97.

13, 14, 16. *Eostaffella inflecta* (Thompson, 1945).

13. Ma 367/18, 66X-1+366 (L.10), Peratrovich Island, 112.0 m above base of section, Zone ≥18–20, Namurian(?), ×97.
14. Se 2/12, 66X-1+163 (L.11), Peratrovich Island, 49.8 m above base of section, Zone 17, early Namurian, ×97.
16. Se 8/22, 66X-1+470 (L.10), same locality as figure 3, ×62.

17. *Millerella prilukiensis* Vakarchuk in Brazhnikova et al. 1967.

17. Ma 506/19, 66X-12+260A, same locality as figure 8, ×97.

18. *Eostaffella advena* (Thompson 1944).

18. Ma 366/9, 66X-1+461 (L.10), Peratrovich Island, 141.0 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×97.

19–22. *Mediocris breviscula* (Ganelina 1951).

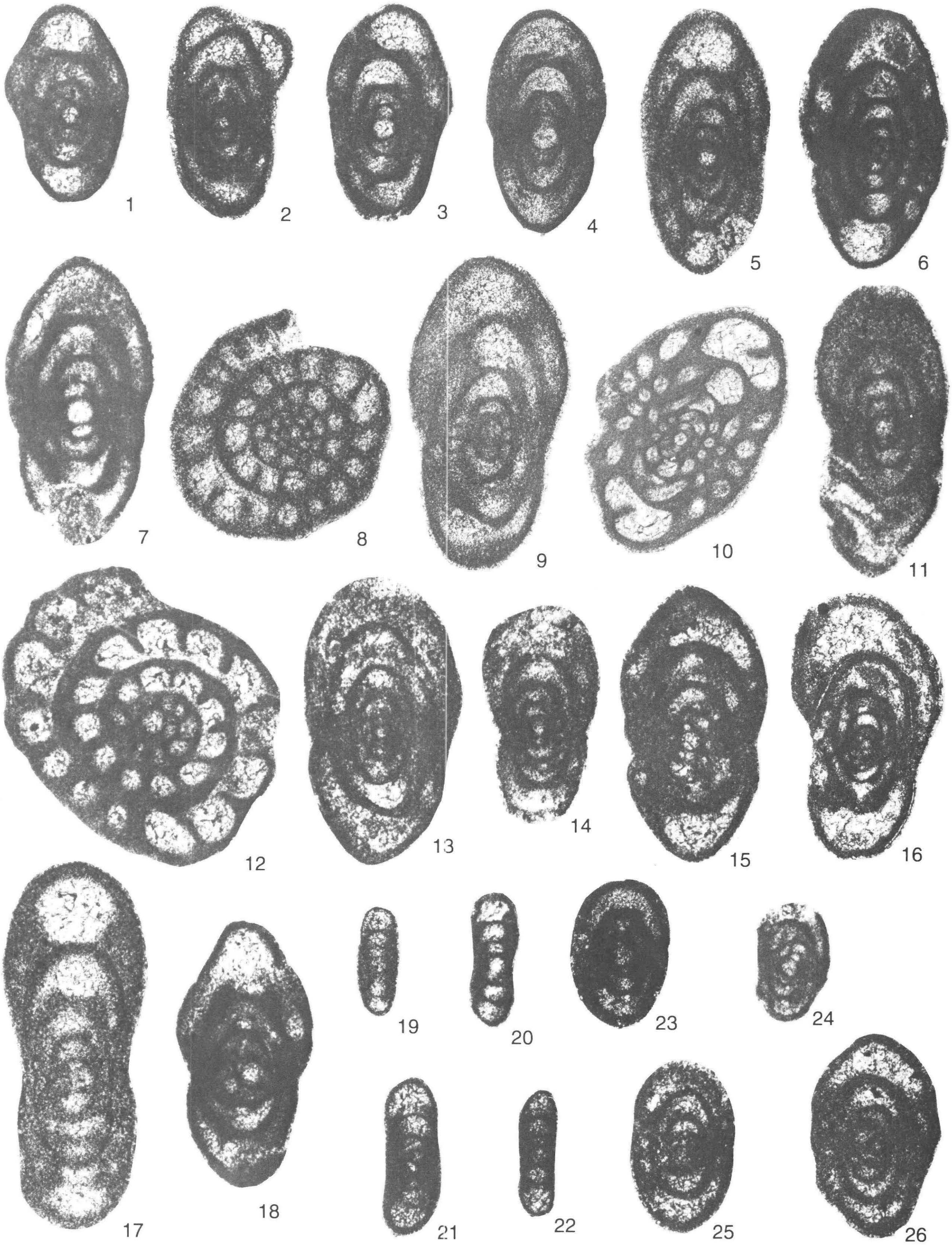
19. Ma 367/17, 66X-1+366 (L.11), same locality as figure 13, ×97.
20. Se 2/9, 66X-1+163 (L.8), same locality as figure 14, ×97
21. Ma 368/25, 66X-8+620, Shelikof Island, 189.7 m above base of section, Zone 17, early Namurian, ×97.
22. Ma 367/4, 66X-1+366 (L.1), same locality as figure 13, ×97.

23–25. *Eostaffellina ovesa* (Ganelina 1956).

23. Ma 505/33, 66X-12+150A, same locality as figure 4,x97.
24. Ma 366/35, 66X-1+290 (L.3), Peratrovich Island, 88.7 m above base of section, Zone 18, early Namurian, ×97.
25. Ma 367/17, 66X-1+366 (L.11), same locality as figure 13, ×97.

26. *Eostaffellina paraprotvae* (Rauzer-Chernoussova 1948).

26. Ma 367/8, 66X-1+366 (L.4), same locality as figure 13, ×97.



EOSTAFFELLA, EOSTAFFELLINA, MEDIOCRIS, MILLERELLA

PLATE 11

FIGURES 1–3. *Zellerinella designata* (Zeller 1953).

1. Ma 506/22, 66X-12+160B, Ladrones Island, 49.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
2. Se 3/6, 66X-1+366 (L.4), Peratrovich Island, 112.0 m above base of section, Zone ≥18–20, Namurian(?), ×97.
3. Ma 366/36, 66X-1+305 (L.7), Peratrovich Island, 93.3 m above base of section, Zone ≥18–20, Namurian(?), ×97.

4–10. *Zellerinella discoidea* (Girty 1915).

4. Ma 507/9, 66X-12+180C, Ladrones Island, 55.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
5. Ma 506/23, 66X-12+160B, same locality as figure 1, ×97.
6. Se 18/12, 66X-12+160B, same locality as figure 1, ×62.
7. Se 5/29, 66X-1+420 (L.2), Peratrovich Island, 128.5 m above base of section, Zone ≥18–20, Namurian(?), ×62.
8. Se 3/29, 66X-1+380 (L.5), Peratrovich Island, 116.2 m above base of section, Zone ≥18–20, Namurian(?), ×97.
9. Ma 505/32, 66X-12+150A, Ladrones Island, 45.9 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
10. Ma 173/19, 66X-1+420, same locality as figure 7, ×97.

11. *Millerella* aff. *M. carbonica* Grozdilova and Lebedeva 1950.

11. Ma 472/11, 66X-12+250, Ladrones Island, 76.5 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×62.

12. *Eostaffella* sp.

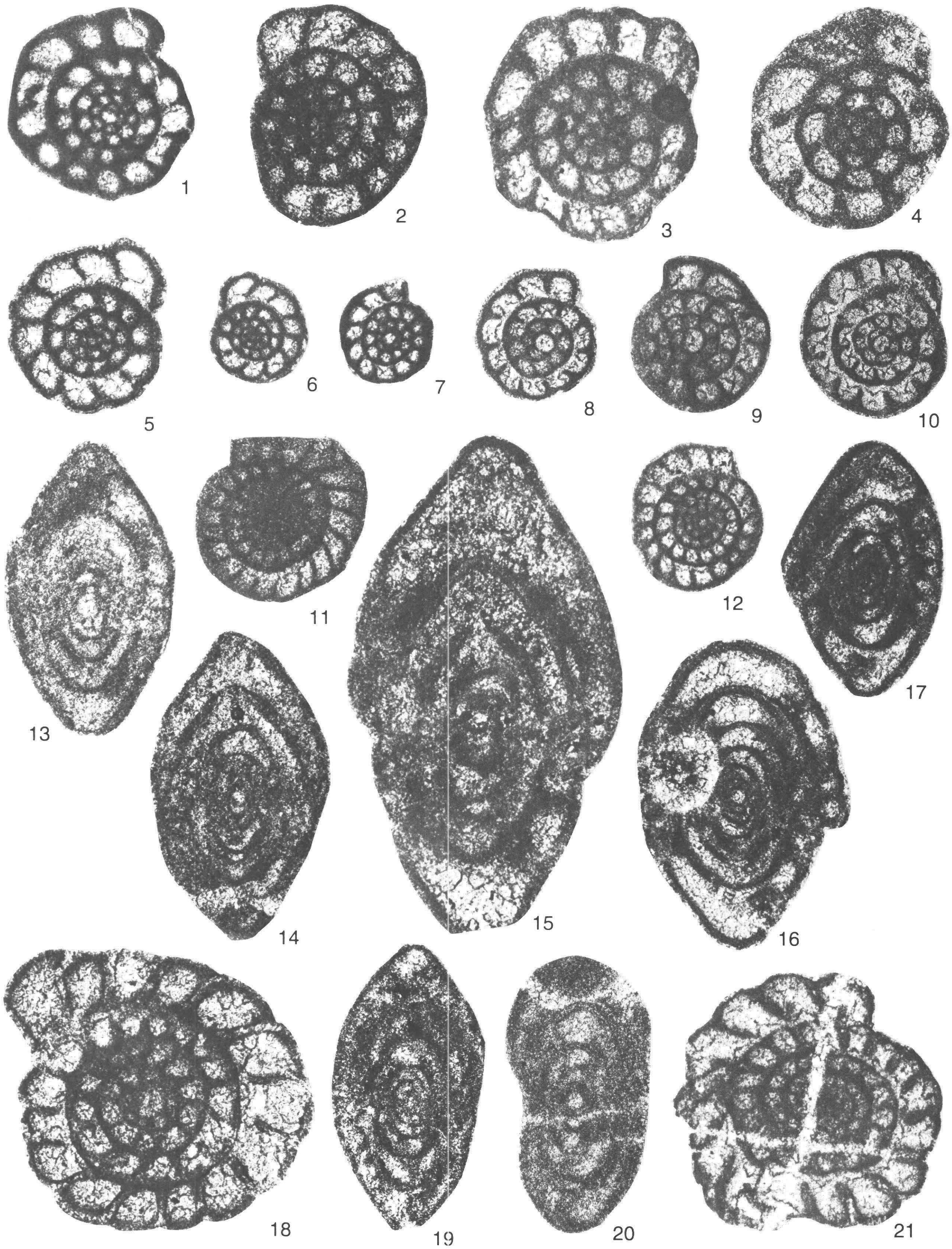
12. Se 19/4, 66X-12+250, same locality as figure 11, ×62.

13-19, 21. *Pseudoendothyra densa* (Rozovskaya 1963).

13. Se 8/3, 66X-12+470 (L.7), Ladrones Island, 143.8 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×62.
14. Se 3/3, 66X-1+366 (L.3), same locality as figure 2, ×62.
15. Ma 367/5, 66X-1+366 (L.2), same locality as figure 2, ×97.
16. Se 3/13, 66X-1+366 (L.11), same locality as figure 2, ×62.
17. Se 3/5, 66X-1+366 (L.4), same locality as figure 2, ×62.
18. Ma 366/38, 66X-1+366 (L.1), same locality as figure 2, ×97.
19. Se 17/3, 66X-12+110 (L.46), Ladrones Island, 33.6 m above base of section, Zone ≥18–20, Namurian(?), ×62.
21. Ma 366/30, 66X-1+245 (L.4), Peratrovich Island, 74.9 m above base of section, Zone 18, early Namurian, ×78.

20. *Pseudoendothyra* of the group *P. ornata* (Brady, 1876) [=*Pseudoendothyra* of the group *P. struvei* (von Möller 1880)].

20. Ma 507/3, 66X-12+180A, same locality as figure 4, ×97.



EOSTAFFELLA, MILLERELLA, PSEUDOENDOTHYRA, ZELLERINELLA

PLATE 12

FIGURES 1–3, 5. *Tetrataxis* of the group *T. angusta* Vissarionova 1948.

1–3, 5. *Tetrataxis angusta* Vissarionova 1948.

1. Ma 372/9, 66X-7+340, Shelikof Island, 104.0 m above base of section, Zone 10 or slightly younger, early Visean, ×97.
2. Ma 372/8, 66X-7+110, Shelikof Island, 33.6 m above base of section, Zone 9 or slightly younger, late Tournaisian, ×97.
3. Ma 366/11, 66X-1+461, Peratrovich Island, 141.0 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×78.
5. Ma 372/10, 66X-7+340, same locality as figure 1, ×97.

4. *Tetrataxis* of the group *T. paraminima* Vissarionova 1948.

4. *Tetrataxis paraminima* Vissarionova 1948.

4. Se 16/24, 66X-12+90 (L.37), Ladrones Island, 27.5 m above base of section, Zone ≥18–20, Namurian(?), ×62.

6–8. *Tetrataxis* of the group *T. conica* Ehrenberg emend. von Möller 1879.

6–8. *Tetrataxis parviconica* Lee and Chen 1930.

6. Se 19/26, 66X-1+470 (L.7), Peratrovich Island, 143.8 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×62.
7. Ma 366/10, 66X-1+461, same locality as figure 3, ×78.
8. Ma 366/10, 66X-1+461, same locality as figure 3, ×78.

9–11. *Howchinia bradyina* Howchin 1888.

9. Ma 394/21, 66X-1+0, Peratrovich Island, base of section, Zone 16_s, latest Visean, ×97.
10. Ma 394/7, 66X-1+0, same locality as figure 9, ×97.
11. Ma 394/20, 66X-1+0, same locality as figure 9, ×97.

12, 13. *Monotaxinoides* sp.

12. Ma 507/23, 66X-12+230, Ladrones Island, 70.4 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×97.
13. Ma 366/14, 66X-1+470 (L.1), same locality as figure 6, ×97.

14. *Eolasiodiscus donbassicus* (Reitlinger 1958).

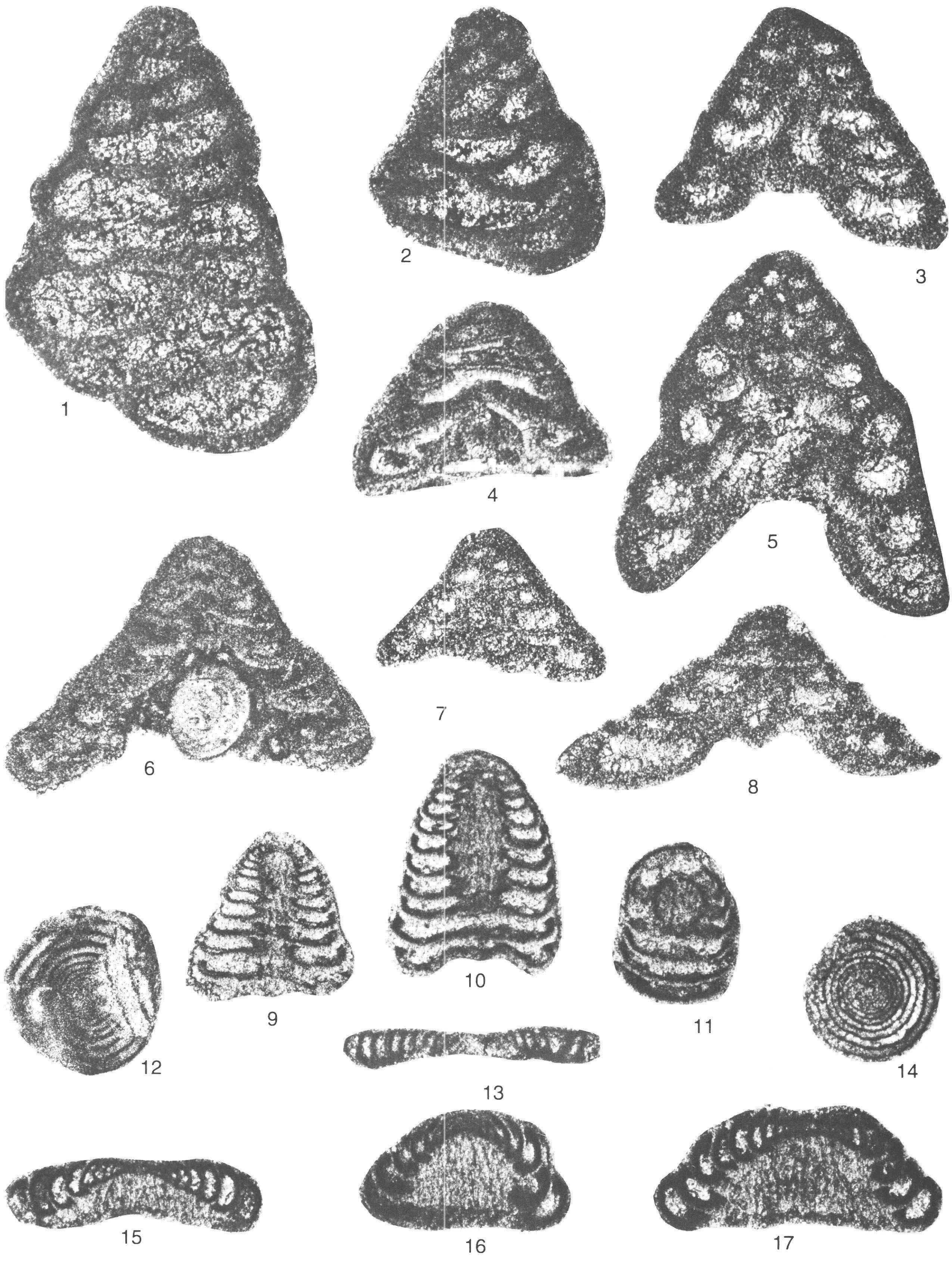
14. Se 1/3, 66X-12+430, Ladrones Island, 131.2 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×97.

15. *Monotaxinoides transitorius* Brazhnikova and Yartseva 1956.

15. Se 5/32, 66X-1+420 (L.2), Peratrovich Island, 128.5 m above base of section, Zone ≥18–20, Namurian(?), ×97.

16, 17. *Monotaxinoides*? *subconicus* (Brazhnikova and Yartseva 1956) (transition between *Monotaxinoides* and *Howchinia*).

16. Ma 173/36, 66X-1+440, Peratrovich Island, 134.6 m above base of section, Zone ≥18–20, Namurian(?), ×97.
17. Ma 173/15, 66X-1+420, same locality as figure 15, ×97.



EOLASIODISCUS, HOWCHINIA, MONOTAXINOIDES, TETRATAXIS

PLATE 13

FIGURES 1–3, 5, 6. *Biseriella* of the group *B. parva* (Chernysheva 1948).

1. Se 3/18, 66X-1+380 (L.1), Peratrovich Island, 116.2 m above base of section, Zone ≥18–20, Namurian(?), ×62.
2. Se 1/6, 66X-12+740, Ladrones Island, 226.4 m above base of section, Ladrones Limestone, Zone 22, late Bashkirian, ×78.
3. Se 26/13, 66X-1+380 (L.4), same locality as figure 1, ×97.
5. Se 26/9, 66X-1+380 (L.1), same locality as figure 1, ×97.
6. Se 26/1, 66X-1+380 (L.4), same locality as figure 1, ×97.

4, 7. *Globivalvulina* of the group *G. moderata* Reitlinger 1949 (primitive *Globivalvulina* with poorly developed diaphanoca).

4. Ma 506/3, 66X-12+150B, Ladrones Island, 45.9 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
7. Ma 367/9, 66X-1+380 (L.4), same locality as figure 1, ×97.

8, 9. *Palaeotextularia longiseptata* Lipina 1948.

8. Ma 507/15, 66X-12+180E, Ladrones Island, 55.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×62.
9. Ma 367/35, 66X-1+380 (L.4), same locality as figure 1, ×78.

10. *Cribrostomum bradyi* (von Möller 1879)

10. Ma 19/15, 66X-12+260, Ladrones Island, 79.6 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×25.

11. *Climacammina padunensis* Ganelina 1956.

11. Se 26/33 and 34, 66X-1+440 (L.20), Peratrovich Island, 134.6 m above base of section, Zone ≥18–20, Namurian(?), ×62.

12. *Climacammina antiqua* Brady 1871.

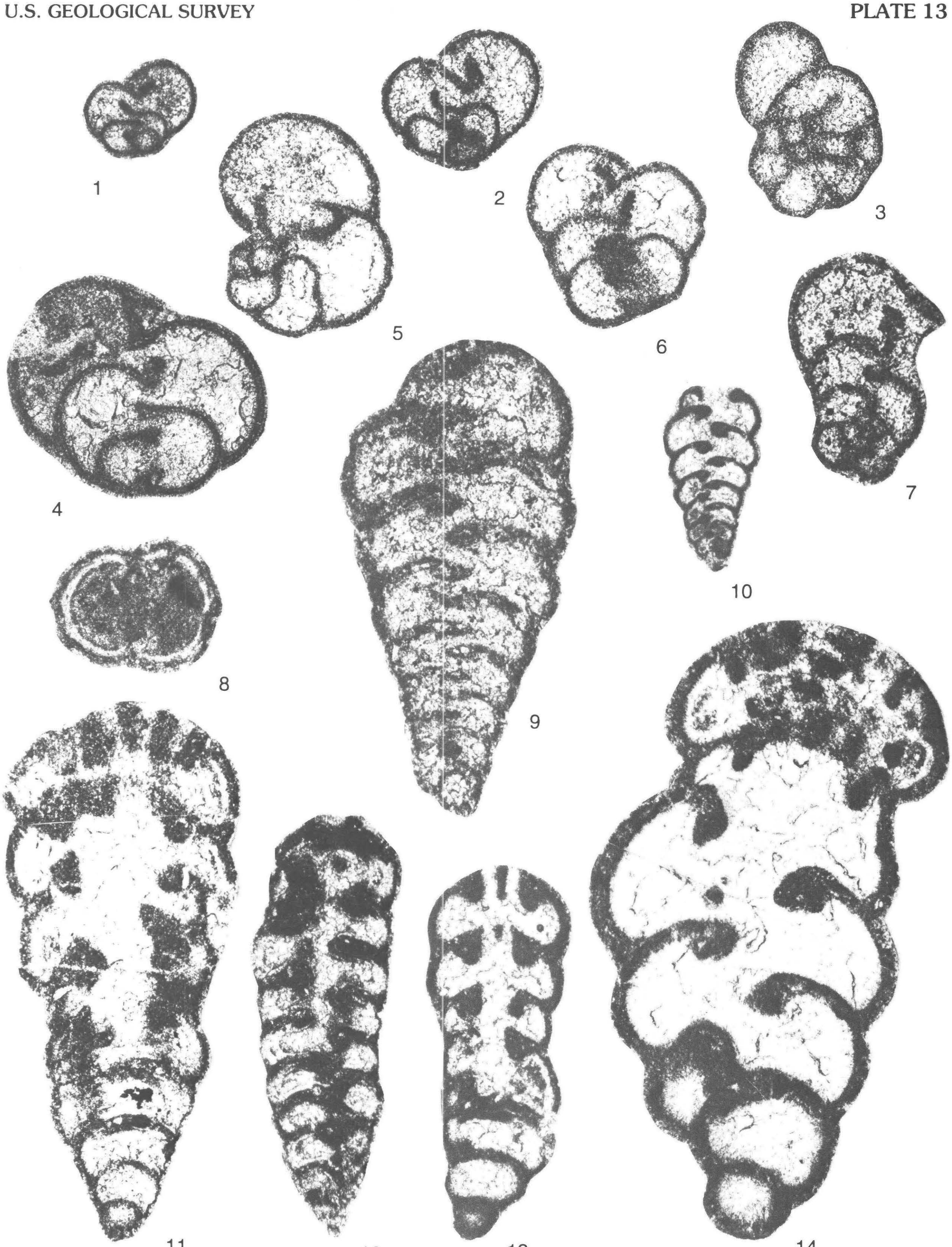
12. Ma 507/14, 66X-12+180E, same locality as figure 8, ×41.

13. *Deckerella laheei* Cushman and Waters 1928.

13. Ma 366/20, 66X-1+470 (L.4), Peratrovich Island, 143.8 above base of section, Klawak Formation, Zone 20, early Bashkirian, ×30.

14. *Cribrostomum paraeximium* Lipina 1948.

14. Se 26/31 and 32, 66X-12+70 (L.20), Ladrones Island, 21.4 m above base of section, Zone ≥18–20, Namurian(?), ×62.



BISERIELLA, CLIMACAMMINA, CRIBROSTOMUM, DECKERELLA, GLOBIVALVULINA, PALAEOTEXTULARIA

PLATE 14

FIGURE 1. *Viseidiscus transitus* (Reitlinger, 1969) (="*Planodiscus*" of authors and *Ammarchaediscus* of authors).
1. Se 9/32, 66X-11+100 (L.17), Madre de Dios Island, 30.6 m above base of section, Zone 14, late Visean, ×97.

2–31. *Archaediscus* of the group *A. krestovnikovi* Rauzer-Chernoussova 1948.
26. Se 6/5, 66X-1+420 (L.2), Peratrovich Island, 128.5 m above base of section, Zone ≥18–20, Namurian(?), ×97.
27. Se 8/16, 66X-12+160C, Ladrones Island, 49.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
31. Se 3/19, 66X-1+380 (L.1), Peratrovich Island, 116.2 m above base of section, Zone ≥18–20, Namurian(?), ×97.

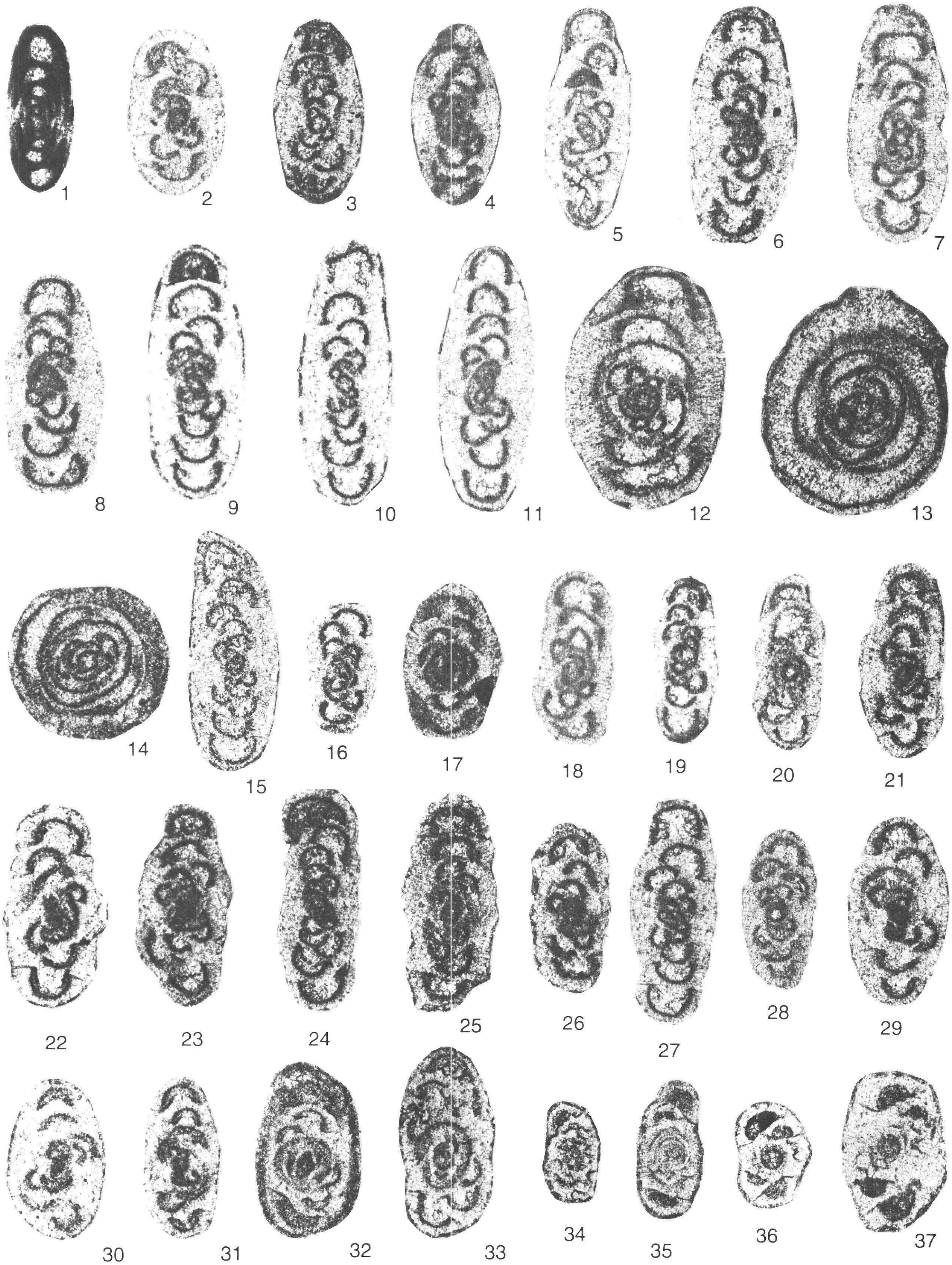
2–12, 15, 29, 30. *Archaediscus koktjubensis* Rauzer-Chernoussova 1948.
2. Ma 505/12, 66X-12+140B, Ladrones Island, 42.8 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
3. Ma 369/17, 66X-11+100 (L.16), same locality as figure 1, ×97.
4. Ma 369/4, 66X-11+90 (L.11), Madre de Dios Island, 27.5 m above base of section, Zone 14, late Visean, ×97.
5. Ma 369/8, 66X-11+90 (L.12), same locality as figure 4, ×97.
6. Se 11/13, 66X-11+110 (L.37), Madre de Dios Island, 33.6 m above base of section, Zone 14, late Visean, ×97.
7. Ma 369/6, 66X-11+100 (L.19), same locality as figure 1, ×97.
8. Ma 370/4, 66X-11+110 (L.38), same locality as figure 6, ×97.
9. Se 25/20, 66X-11+100, same locality as figure 1, ×97.
10. Se 25/27, 66X-11+110 (L.16), same locality as figure 6, ×97.
11. Ma 369/22, 66X-11+100 (L.19), same locality as figure 1, ×97.
12. Ma 369/9, 66X-11+90 (L.13), same locality as figure 4, ×97.
15. Se 9/18, 66X-11+90 (L.10), same locality as figure 4, ×97.
29. Se 6/23, 66X-1+440 (L.20), Peratrovich Island, 134.6 m above base of section, Zone ≥18–20, Namurian(?), ×97.
30. Se 8/21, 66X-1+470 (L.10), Peratrovich Island, 143.8 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×97.

13, 14, 16-25, 28. *Archaediscus krestovnikovi* Rauzer-Chernoussova 1948. [Including "*Nodosarchaediscus*" *demaneti* (Conil and Lys 1969)].
13. Se 11/27, 66X-11+150 (L.46), Madre de Dios Island, 45.9 m above base of section, Zone 14, late Visean, ×97.
14. Se 23/9, 66X-6+320 (L.10), Toti Island, 98.2 m above base of section, Zone 14, late Visean, ×97.
16. Se 9/22, 66X-11+90 (L.12), same locality as figure 4, ×97.
17. Se 4/3, 66X-1+380 (L.6), same locality as figure 31, ×97.
18. Ma 369/5, 66X-11+90 (L.12), same locality as figure 4, ×97.
19. Ma 369/11, 66X-11+90 (L.14), same locality as figure 4, ×97.
20. Ma 366/8, 66X-1+461 (L.10), Peratrovich Island, 141.0 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×97.
21. Se 6/32, 66X-12+90 (L.40), Ladrones Island, 27.5 m above base of section, Zone ≥18–20, Namurian(?), ×97.
22. Se 16/32, 66X-12+90 (L.40), same locality as figure 21, ×97.
23. Ma 173/8, 66X-1+420, same locality as figure 26, ×97.
24. Se 11/8, 66X-11+110 (L.35), same locality as figure 6, ×97.
25. Se 9/5, 66X-11+130, Madre de Dios Island, 39.6 m above base of section, Zone 14, late Visean, ×97.
28. Se 11/4, 66X-11+110 (L.37), same locality as figure 6, ×97.

32, 33. "*Nodosarchaediscus*" sp.
32. Ma 507/13, 66X-12+180D, Ladrones Island, 55.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
33. Se 16/18, 66X-12+90 (L.36), same locality as figure 21, ×97.

34, 35. *Neoarchaediscus parvus* (Rauzer-Chernoussova 1948).
34. Se 14/33, 66X-12+0 (L.4), Ladrones Island, base of section, Zone 18, early Namurian, ×97.
35. Ma 508/7, 66X-12+260A, Ladrones Island, 79.6 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×97.

36, 37. *Neoarchaediscus* sp.
36. Se 16/30, 66X-12+90 (L.40), same locality as figure 21, ×97.
37. Se 3/32, 66X-1+380 (L.5), same locality as figure 31, ×97.



ARCHAEDISCUS, NEOARCHAEDISCUS, "NODOSARCHAEDISCUS", VISEIDISCUS

PLATE 15

FIGURE 1. *Archaediscus* of the group *A. moelleri* Rauzer-Chernoussova 1948.

1. *Archaediscus approximatus* Ganelina 1956.
   1. Se 9/32, 66X-11+100 (L.17), Madre de Dios Island, 30.6 m above base of section, Zone 14, late Visean, ×97.

2–4. *Planospirodiscus gregorii* (Dain in Dain and Grozdilova 1953).

2. Ma 368/19, 66X-1+470 (L.9), Peratrovich Island, 143.8 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×97.
3. Se 7/13, 66X-1+445 (L.1), Peratrovich Island, 136.2 m above base of section, Zone ≥18–20, Namurian(?), ×78.
4. Se 2/20, 66X-1+275, Peratrovich Island, 84.2 m above base of section, Zone 18, early Namurian, ×97.

5, 6. *Neoarchaediscus incertus* (Grozdilova and Lebedeva 1954).

5. Se 15/29, 66X-12+50 (L.23), Ladrones Island, 15.3 m above base of section, Zone ≥18–20, Namurian(?), ×97.
6. Se 16/26, 66X-12+90 (L.38), Ladrones Island, 27.5 m above base of section, Zone ≥18–20, Namurian(?), ×97.

7–14. *Neoarchaediscus subbaschkiricus* (Reitlinger 1949).

7. Se 3/24, 66X-1+380 (L.3), Peratrovich Island, 116.2 m above base of section, Zone ≥18–20, Namurian(?), ×78.
8. Ma 507/7, 66X-12+180B, Ladrones Island, 55.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
9. Ma 173/32, 66X-12+432, Ladrones Island, 134.2 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×97.
10. Se 3/24, 66X-1+380 (L.4), same locality as figure 7, ×97.
11. Se 3/33, 66X-1+380 (L.6), same locality as figure 7, ×97.
12. Ma 173/21, 66X-1+420, Peratrovich Island, 128.5 m above base of section, Zone ≥18–20, Namurian(?), ×97.
13. Ma 173/31, 66X-12+432, same locality as figure 9, ×97.
14. Ma 505/27, 66X-12+150A, Ladrones Island, 45.9 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.

15–18. *Neoarchaediscus subbaschkiricus grandis* (Reitlinger 1950).

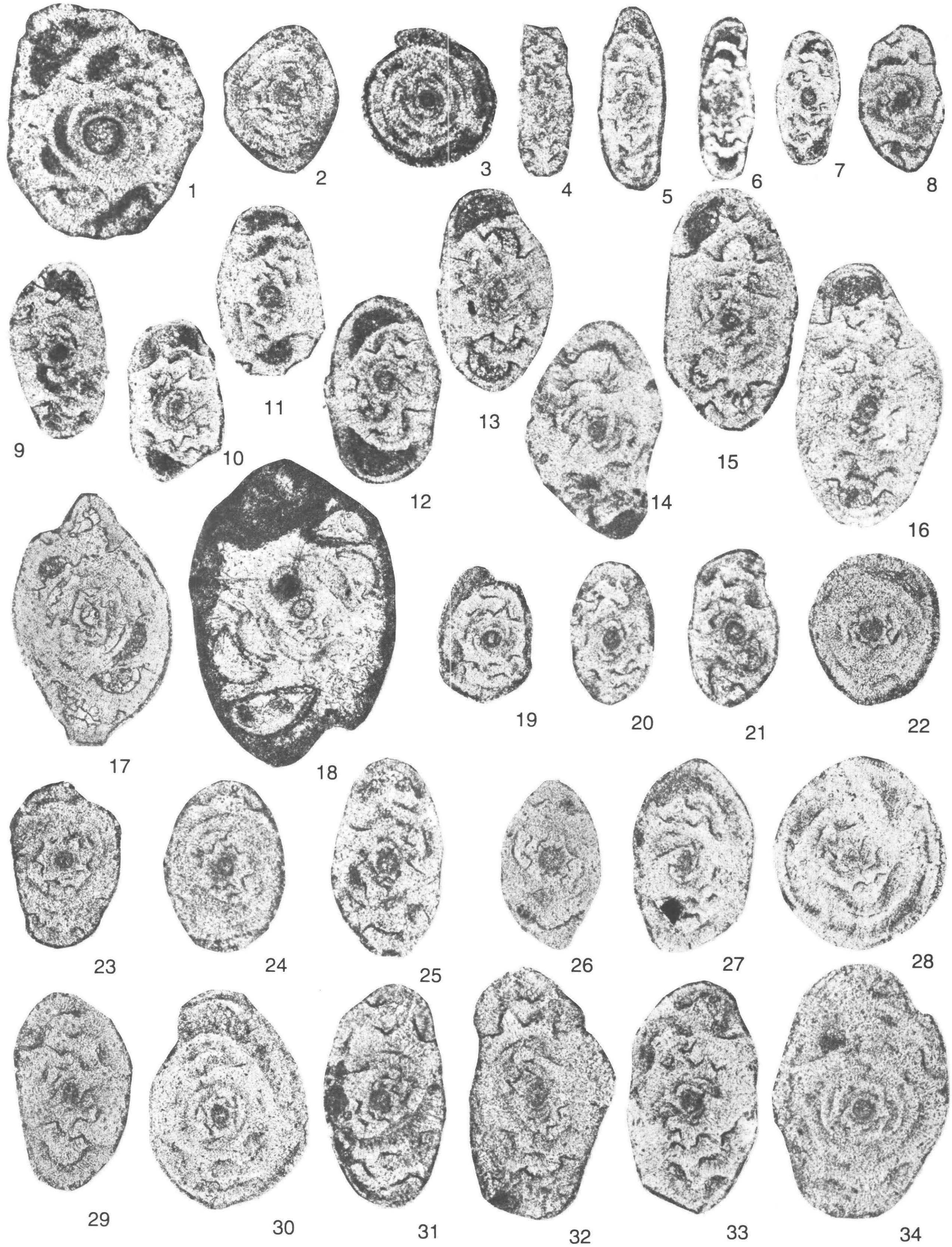
15. Ma 173/22, 66X-1+420, same locality as figure 12, ×97.
16. Ma 366/1, 66X-1+457 (L.5), Peratrovich Island, 139.8 m above base of section, Zone ≥18–20, Namurian(?), ×97.
17. Se 18/10, 66X-12+150A, same locality as figure 14, ×78.
18. Se 15/27, 66X-12+50 (L.24), same locality as figure 5, ×78.

19–27, 29. *Asteroarchaediscus baschkiricus* (Krestovnikov and Teodorovitch 1936).

19. Se 4/31, 66X-1+415 (L.3), Peratrovich Island, 127.0 m above base of section, Zone ≥18–20, Namurian(?), ×97.
20. Ma 505/5, 66X-12+140A, Ladrones Island, 42.8 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
21. Ma 173/7, 66X-1+420, same locality as figure 12, ×97.
22. Ma 506/10, 66X-12+150D, same locality as figure 14, ×97.
23. Ma 506/5, 66X-12+150C, same locality as figure 14, ×97.
24. Ma 506/38, 66X-12+170B, Ladrones Island, 52.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
25. Ma 366/3, 66X-1+461 (L.4), Peratrovich Island, 141.0 m above base of section, Klawak Formation, Zone 20, early Bashkirian, ×97.
26. Ma 505/24, 66X-12+140E, same locality as figure 20, ×97.
27. Ma 505/22, 66X-12+140E, same locality as figure 20, ×97.
29. Se 18/8, 66X-12+150A, same locality as figure 14, ×97.

28, 30–34. *Asteroarchaediscus ovoides* (Rauzer-Chernoussova 1948).

28. Se 17/11, 66X-12+120 (L.48), Ladrones Island, 36.7 m above base of section, Zone ≥18–20, Namurian(?), ×78.
30. Ma 507/22, 66X-12+230, Ladrones Island, 70.4 m above base of formation, Ladrones Limestone, Zone 21, middle Bashkirian, ×97.
31. Ma 173/9, 66X-1+420, same locality as figure 12, ×97.
32. Ma 506/33, 66X-12+170A, same locality as figure 24, ×97.
33. Se 16/15, 66X-12+80 (L.39), Ladrones Island, 24.5 m above base of section, Zone ≥18–20, Namurian(?), ×97.
34. Ma 505/15, 66X-12+140C, same locality as figure 20, ×97.



ARCHAEDISCUS, ASTEROARCHAEDISCUS, NEOARCHAEDISCUS, PLANOSPIRODISCUS

PLATE 16

FIGURES 1–4. *Pseudoglomospira gordialiformis* Rich 1980.

1. Se 15/10, 66X-12+30 (L.13), Ladrones Island, 9.2 m above base of section, Zone ≥18–20, Namurian(?), ×97.
2. Se 15/18, 66X-12+40 (L.19), Ladrones Island, 12.2 m above base of section, Zone ≥18–20, Namurian(?), ×97.
3. Ma 372/37, 66X-12+5 (L.6), Ladrones Island, 1.5 m above base of section, Zone 18, early Namurian, ×97.
4. Se 15/12, 66X-12+40 (L.17), same locality as figure 2, ×97

5, 6. Calcisphere in an *Earlandia* simulating a *Quasipolyderma* or an *Eovolutina*.

5. Se 16/4, 66X-6+60 (L.26), Toti Island, 18.4 m above base of section, Zone 13, middle Visean, ×97.
6. Se 11/7, 66X-11+110 (L.35), Madre de Dios Island, 33.6 m above base of section, Zone 14, late Visean, ×97.

7–9, 14. *Glomospiroides mikhailovi* (Reitlinger 1950).

7. Ma 506/26, 66X-12+170B, Ladrones Island, 52.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
8. Ma 507/1, 66X-12+170E, same locality as figure 7, ×78.
9. Ma 506/11, 66X-12+150D, Ladrones Island, 45.9 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
14. Ma 507/5, 66X-12+180B, Ladrones Island, 55.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.

10, 15. Wall of *Glomospiroides*? sp.

10. Ma 367/25, 66X-1+380 (L.9), Peratrovich Island, 116.2 m above base of section, Zone ≥18–20, Namurian(?), ×78.
15. Ma 367/37, 66X-1+380 (L.2), same locality as figure 10, ×97.

11. *Diplosphaerina mastophora* (Derville 1950).

11. Se 11/18, 66X-11+110 (L.39), same locality as figure 6, ×97.

12. *Diplosphaerina ovoidea* (Derville 1950).

12. Se 4/9, 66X-1+380 (L.2), same locality as figure 10, ×97.

13. *Bituberitina* sp.

13. Se 16/25, 66X-12+180B, same locality as figure 14, ×97.

16. *Insolentitheca horrida* (Brazhnikova 1967).

16. Ma 368/1, 66X-1+380 (L.5), same locality as figure 10, ×62. Note agglutination of two different genera, refuting a syzygial origin.

17, 18. *Glomospiroides*? sp.

17. Ma 506/20, 66X-12+160A, Ladrones Island, 49.0 m above base of section, Ladrones Limestone, Zone 20, early Bashkirian, ×97.
18. Ma 508/14, 66X-12+280D, Ladrones Island, 85.7 m above base of section, Ladrones Limestone, Zone 21, middle Bashkirian, ×97.

19. *Volvotextularia* sp. (=*Trepeilopsis* of the literature).

19. Se 18/28, 66X-12+180C, same locality as figure 14, ×97.

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BITUBERITINA, DIPLOSPHAERINA, EARLANDIA, GLOMOSPIROIDES, INSOLENTITHECA, PSEUDOGLOMOSPIRA, VOLVOTEXTULARIA