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SMALLER MISSISSIPPIAN AND LOWER PENNSYLVANIAN CALCAREOUS FORAMINIFERS FROM NEVADA

BY

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SMALLER MISSISSIPPIAN AND LOWER PENNSYLVANIAN CALCAREOUS FORAMINIFERS FROM NEVADA

PAUL LOUIS BRENCKLE[1]

ABSTRACT

Seventy-seven species of smaller calcareous foraminifers belonging to thirty-two genera and fourteen families, and two groups of uncertain affinity are distinguished in Mississippian and Lower Pennsylvanian strata from four localities in southern and eastern Nevada. Most belong to the Superfamily Endothyraceae, a group characterized by skew, planispiral, or erect growth, a simple or cribrate aperture, and a layered wall of secreted calcite. Five new species are named.

The Mississippian foraminifers permit recognition of assemblage zones based on the global zonation scheme of Bernard Mamet. The Pennsylvanian strata are not zoned.

Formations studied in the Arrow Canyon Range, north-central Clark County, include the Crystal Pass Limestone, Dawn Limestone, Anchor Limestone, Bullion Limestone, Yellowpine Limestone, Battleship Wash Formation, Indian Springs Formation, and the lower part of the Bird Spring Formation. The Joana Limestone was studied southwest of Ely, Nevada, at Ward Mountain in the Egan Range, and the lower part of the exposed Ely Limestone was studied northwest of Ely in the vicinity of the Moorman Ranch and in the Butte Mountains.

The upper part of the Crystal Pass Limestone in the Arrow Canyon Range contains foraminifers that appear to be late Kinderhook in age, but the lower beds lack stratigraphically useful foraminifers. The entire formation has been previously assigned to the Late Devonian on the basis of conodont assemblages. The Dawn Limestone which disconformably overlies the Crystal Pass Limestone is early and middle, and, possibly, late Osage in age. The successively overlying Anchor and Bullion Limestones contain only sparse, nondiagnostic foraminifers, but, based on their stratigraphic position, they are late Osage to middle Meramec. The overlying Yellowpine Limestone and the lower beds of the Battleship Wash Formation contain a well developed middle and late Meramec fauna; however, the upper part of the Battleship Wash is middle to late Chester with no evidence of an intervening early Chester fauna. The Indiana Springs Formation and the lowest part of the overlying Bird Spring Formation are late Chester. The remainder of the Bird Spring that was measured was deposited in Morrow time.

At Ward Mountain the lower member of the Joana Limestone has a late Kinderhook fauna. The upper member is Osage in age.

Foraminifers are scarce in the lower part of the exposed Ely Limestone at the Moorman Ranch and Butte Mountains sections. The microfaunal associations suggest a Morrow age for these rocks.

ACKNOWLEDGMENTS

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INTRODUCTION

Until recently, Mississippian calcareous foraminifers were little studied in North America. The pioneering American works on these organisms in the 1950's and early 1960's, although useful, described a fauna of only limited diversity and did not utilize the wealth of taxonomic and stratigraphic information available from foreign sources in Europe and Asia where Carboniferous foraminifers have been intensively studied for many years. The publications of Mamet, Skipp and other workers in the last few years, however, have provided an awareness of the variety of North American microfaunas and of their similarity to foreign assemblages.

In the western United States Mississippian foraminifers have been studied at scattered locations in the Cordilleran region (E. J. Zeller, 1957), in eastern Nevada-central Utah (Chilingar and Bissell, 1957; Woodland, 1958), New Mexico (Armstrong, 1958, 1967), Idaho (Skipp, 1961; Skipp and Mamet, 1970; Mamet *et al.*, 1971), northern Arizona (Skipp *et al.*, 1966; Skipp, 1969) and the northern Cordillera (Sando *et al.*, 1969). Previously, the precise ages of Mississippian strata in southern and eastern Nevada were not well defined because of limited faunal studies. The present investigation, therefore, was undertaken in areas of known stratigraphy to describe systematically the foraminifers, to zone the sediments on the basis of the microfaunal assemblages, and to compare the age of the strata as defined

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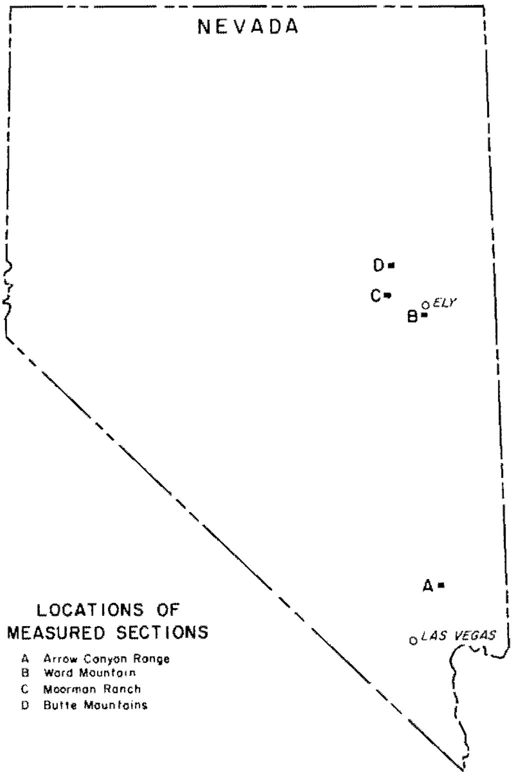

FIGURE 1

Index map of measured sections.

by the foraminifers with that indicated by other faunal groups.

Seventy-seven species, thirty-two genera and three subgenera of smaller calcareous foraminifers from fourteen families, and two groups of uncertain affinity are distinguished in four measured sections; five new species are named. Most belong to the Superfamily Endothyracea, but others represent the Parathuramminacea, Fusulinacea, Ammodiscacea and Miliolacea. The age of the specimens ranges from late Kinderhook, or possibly older, to Morrow.

METHODS OF STUDY

In the field, four sections (see index map, figure 1) were measured with Brunton compass and Jacob's staff during the summer of 1966 and the winter of 1969. Approximately two hundred and twenty samples were collected at intervals of twenty feet except for closer spacing where lithologies changed. An acetate peel was made from each limestone sample. The peels were examined for multilocular foraminifers. Fifty-eight samples contained specimens. Three unoriented thin sections were cut from each of these samples, and they provide most of the data for the study. Measurements and identifications were made by microscopic examination or from photomicrographs. The shale samples from the Indian Springs Formation were broken down in Stoddard solution, washed and sieved. Whole specimens were picked from the residue.

LOCALITIES

Arrow Canyon Range

A composite section of Lower Mississippian through Lower Pennsylvanian strata was assembled in the Arrow Canyon Range, north-central Clark County, Nevada. The two oldest formations, the Crystal Pass and Dawn Limestones, were measured on the west side of the range in the SE ¼, Sec. 10, and NE ¼, Sec. 15, T. 16 S., R. 63 E. (figure 2). The lower two members of the Anchor Limestone were measured at the west end of Battleship Wash in or near the SW ¼ Sec. 14, T. 14 S., R. 64 E. (unsurveyed, figure 3, c, d). The upper member of the Anchor Limestone, the Bullion Limestone, Yellowpine Limestone, Battleship Wash Formation, Indian Springs Formation and lower part of the Bird Spring Formation were measured in Arrow Canyon at the northeastern end of the range in approximately the east half of Sec. 11 and west half of Sec. 12, T. 14 S., R. 64 E. (unsurveyed, figure 3, e, f, g).

Ward Mountain

The Lower Mississippian Joana Limestone section was measured on the west side of Ward Mountain in the Egan Range a few miles southwest of Ely, Nevada, in the SW ¼, Sec. 25, T. 15 N., R. 62 E. (figure 4).

Moorman Ranch and Butte Mountains

The lower part (Lower Pennsylvanian) of the Ely Limestone was measured in two areas. The Moorman Ranch (Illipah) section is located about thirty-five miles west of Ely, Nevada, at the south end of the Butte Mountains along U. S. Highway 50 in the south half of Sec. 12, T. 17 N., R. 58 E. (figure 5). The other section is in the NW ¼, T. 21 N., R. 59 E. (sections unsurveyed) in the Butte Mountains (figure 6) about twenty-five miles north of the Moorman Ranch section.

STRATIGRAPHY

Previous Work

Carboniferous rocks in the Arrow Canyon Range were first mentioned by Spurr (1903) and Longwell (1928) and later shown on reconnaissance maps of Clark County, Nevada, by Bowyer

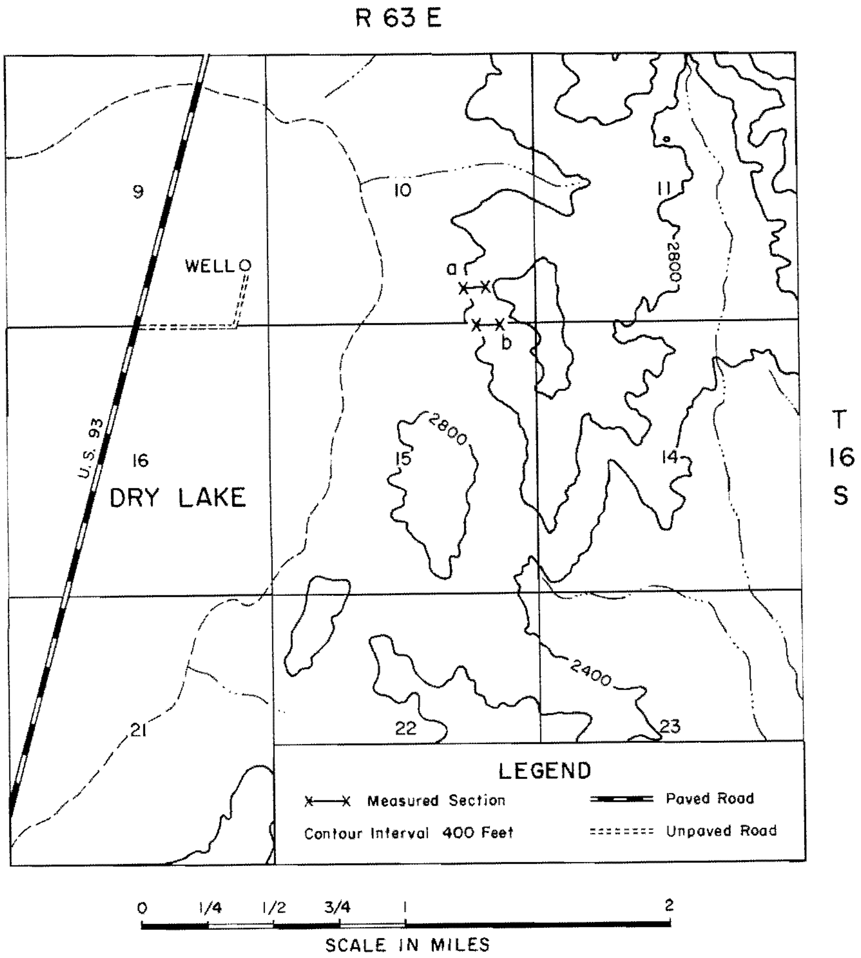

FIGURE 2

Arrow Canyon Range: a, Crystal Pass Ls.; b, Dawn Ls.; base map—Arrow Canyon, Nevada, Quad., 1:62,500, ed. 1958, U. S. Geological Survey.

et al. (1958) and Longwell *et al.* (1965). Langenheim *et al.* (1962) published the first detailed rock descriptions. The stratigraphy and rock nomenclature were further developed in articles by Langenheim and Langenheim (1965), Webster and Lane (1967) and Webster (1969). The paleontology, age, and/or petrology were discussed by Langenheim and Collinson (1963), Coogan (1964), Langenheim and Langenheim (1965), Carss and Carozzi (1965), Cassity and Langenheim (1966), Heath *et al.* (1967), Webster and Lane (1967) and Webster (1969).

Spencer (1917) named the Joana Limestone for strata outcropping just west of Ely, Nevada. The formation has been mapped and studied in the Ward Mountain area by Chilingar and Bissell (1957), Woodland (1958), Langenheim (1960, 1962), Stensaas and Langenheim (1960) and Brew (1971).

Lawson (1906) named the Ely Limestone for exposures in the Robinson Mining District west of Ely, Nevada. The unit was redefined by Spencer (1917), Pennebaker (1932), Dott (1955) and Steele (1960) who designated a reference section west of the Moorman Ranch (Illipah) near U.S. Highway 50.

Steele's reference section, one of the localities where the lower part of the Ely Limestone was studied for this report, was mapped by Humphrey (1960), and measured and described by Lane (1960), Mollazal (1961) and Bissell (1964) among others. The other section of the lower Ely Limestone in the central Butte Mountains was measured north of the area mapped by Douglass

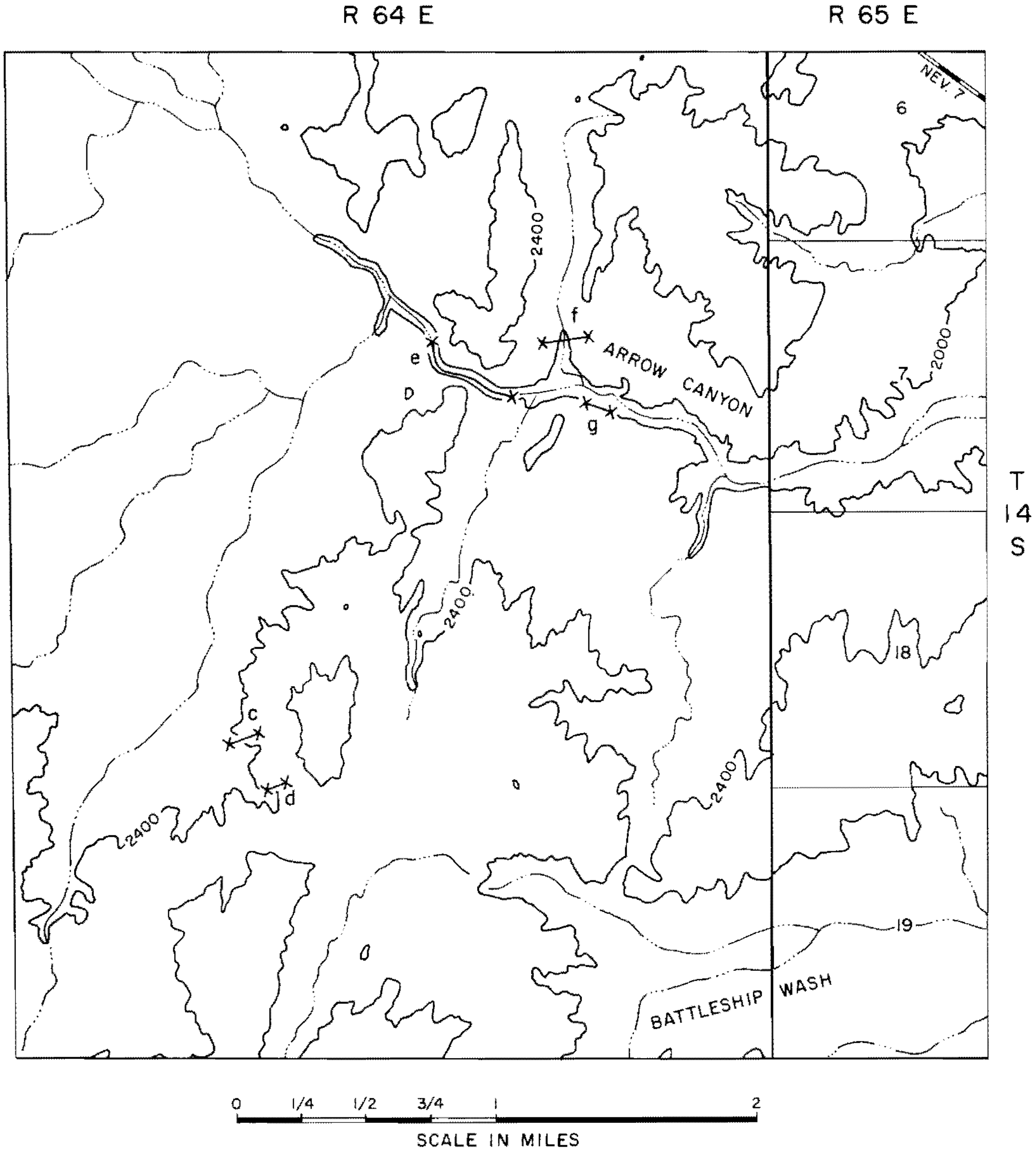

FIGURE 3

Arrow Canyon Range: c, lower member Anchor Ls.; d, middle member Anchor Ls.; e, upper member Anchor Ls., Bullion Ls., Yellowpine Ls., lower part Battleship Wash Fm.; f, upper part Battleship Wash Fm., Indian Springs Fm., lower part Bird Spring Fm.; g, lower part Bird Spring Fm.; base map and symbols same as figure 2.

(1960) and in approximately the same location as section 33 of Bissell (1964, pp. 566–567).

The age of the lower Ely Limestone in the vicinity of Moorman Ranch has been discussed by Steele (1960), Humphrey (1960), Lane (1960, 1962), Mollazal (1961), Bissell (1964), Coogan (1964), Rich (1967) and Dunn (1970).

A quite complete history of work on the Ely Limestone was presented by Bissell (1964).

ARROW CANYON RANGE

The Crystal Pass Limestone (258 feet thick) is composed of light gray to white weathering, fine grained, non-cherty limestone beds one to two

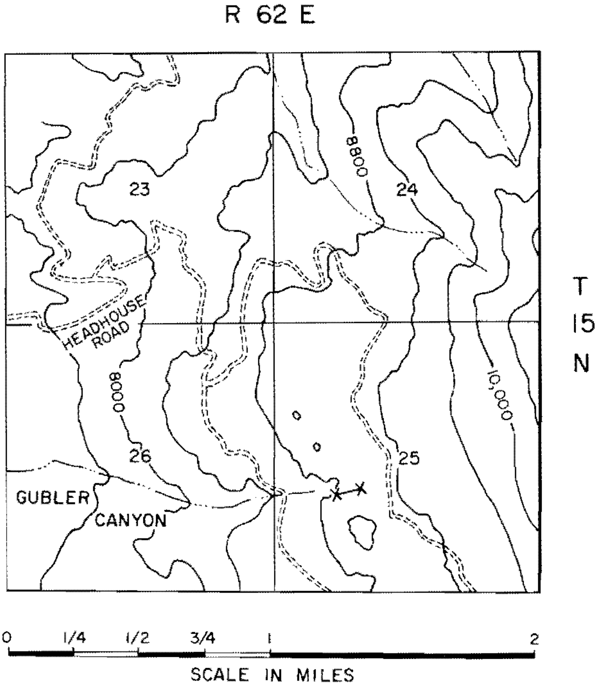

FIGURE 4

Ward Mountain: Joana Ls.; base map—Ely, Nevada, Quad., 1:62,500, ed. 1958, U. S. Geological Survey; see figure 2 for explanation of symbols.

feet thick. The base is placed at the top of a pair of dark gray weathering limestone bands belonging to the underlying Arrow Canyon Formation. The uppermost Crystal Pass beds exhibit the "worm borings" described by Langenheim *et al.* (1962, p. 601). Macrofossils are scarce. In thin section, the lithology is dominantly recrystallized biopelmicrite and biointramicrite. Multilocular foraminifers occur in only one sample (CP 5). Simple, unilocular or bilocular forms (*e.g.* calcisphaerids, radiosphaerids, *Earlandia*), however, appear in all samples.

The Dawn Limestone (214 feet thick) rests disconformably on the Crystal Pass. It is dark gray or black, thin bedded and medium grained. Chert is sparse but becomes more abundant near the top of the formation. Crinoidal debris and other fossil material are common. Complex foraminifers occur in recrystallized biopelmicrite and biointrasparite.

The contact between the Dawn and the overlying Anchor Limestone is gradational and is placed at the base of the first continuously bedded chert unit. The Anchor (668 feet thick) can be divided into a lower and upper member containing abundant, closely spaced chert beds and a middle relatively chert free member whose flint content, however, is highly variable laterally. The limestone is light to dark gray, fine to coarse grained, partially recrystallized and contains a high percentage of crinoidal and bryozoan debris along with some dolomite rhombs and authigenic silica. Only simple microfossils (calcisphaerids and *Earlandia*) are found.

The Bullion Limestone (266 feet thick) directly overlies a thick, cherty sequence belonging to the upper member of the Anchor Limestone. Scattered chert nodules appear throughout the Bullion, but consistently well developed bedded chert units are lacking. The limestone weathers medium to dark gray, is fine to coarse grained and is generally massive. Most thin sections are composed of recrystallized crinoidal biomicrite. Bryozoan fragments are common; dolomite rhombs and authigenic silica are also present. Multilocular foraminifers were found in two samples only. Sample B 6, a crinoidal-bryozoan biomicrite, contains a single specimen, and sample B 3, a biomicrite with less crinoidal debris, contains numerous specimens.

The Arrowhead Limestone, which lies between the Bullion and Yellowpine Limestones in the type Goodsprings area (Hewett, 1931, p. 18), is absent in the Arrow Canyon Range (Langenheim

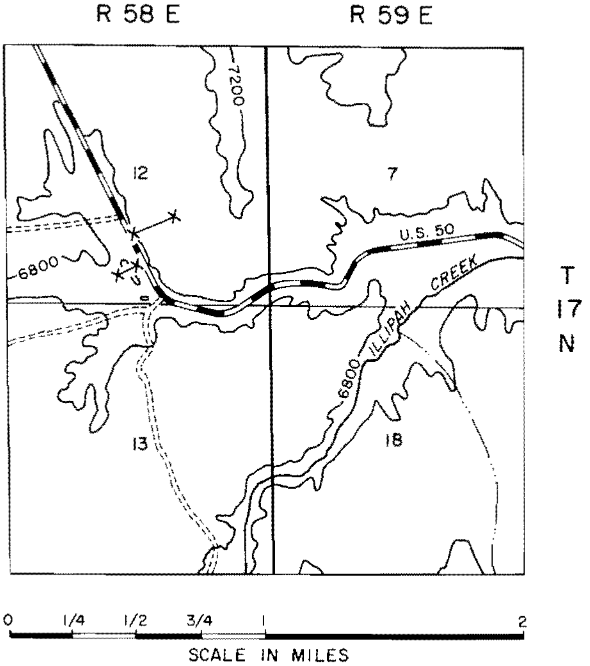

FIGURE 5

Moorman Ranch (Illipah): Ely Limestone; base map—Illipah, Nevada, Quad., 1:62,500, ed. 1951, U. S. Geological Survey; see figure 2 for explanation of symbols.

et al., 1962, p. 602). Without the intervening Arrowhead, the basal Yellowpine beds are not readily distinguishable from those of the Bullion whose upper contact is arbitrarily placed at the top of a whitish weathering limestone bed approximately two feet thick. In general the Yellowpine (178 feet thick) is more thinly bedded than the Bullion and contains abundant rugose corals. A few sandy limestone beds occur in the upper 40 feet of the formation. Numerous foraminifers are found in partially recrystallized biopelmicrite, crinoid rich biosparite and biomicrite.

The base of the Battleship Wash Formation (98 feet thick) is composed of a tan weathering, sandy unit approximately 3 feet thick overlying a prominent bench of Yellowpine Limestone. Nodular limestones, calcareous sandstones, sandy limestones and chert layers are scattered throughout the lower part of the formation. Most of the remaining strata consists of thick bedded, dark, blocky fractured limestone. Megafossils including plant fragments are abundant at the top of the formation. Foraminifers occur in recrystallized biomicrite, crinoidal biosparite and also in a sample of sandy biopelmicrite (BW 3).

The Indian Springs Formation (211 feet thick) lies conformably over the Battleship Wash Formation and is composed predominantly of varicolored shale which erodes into a prominent strike valley. The lower third of the formation is covered, but exposures become progressively better farther up the section. Sandstone layers and lenses and beds of reddish colored, terrigenous and fossiliferous limestone are common and become more numerous toward the top. The ferruginous "marker" conglomerate of Webster and Lane (1967, p. 510) outcrops approximately 81 feet above the base on the north wall of Arrow Canyon and is one foot thick. Calcareous foraminifers were identified in two limy shale samples.

The Bird Spring Formation lies conformably on the Indian Springs. Only the lower part (261 feet thick) was measured. It is composed of gray, thin to thick bedded, fine to coarse grained limestones interlayered with calcareous shales, arenaceous and argillaceous limestones and some closely to widely spaced chert beds. Foraminifers are found in crinoid biosparite, biomicrite and sandy biomicrite. Some recrystallization is apparent in the limestones.

WARD MOUNTAIN

The Joana (408 feet exposed) is a light to dark gray weathering limestone, divided into two mem-

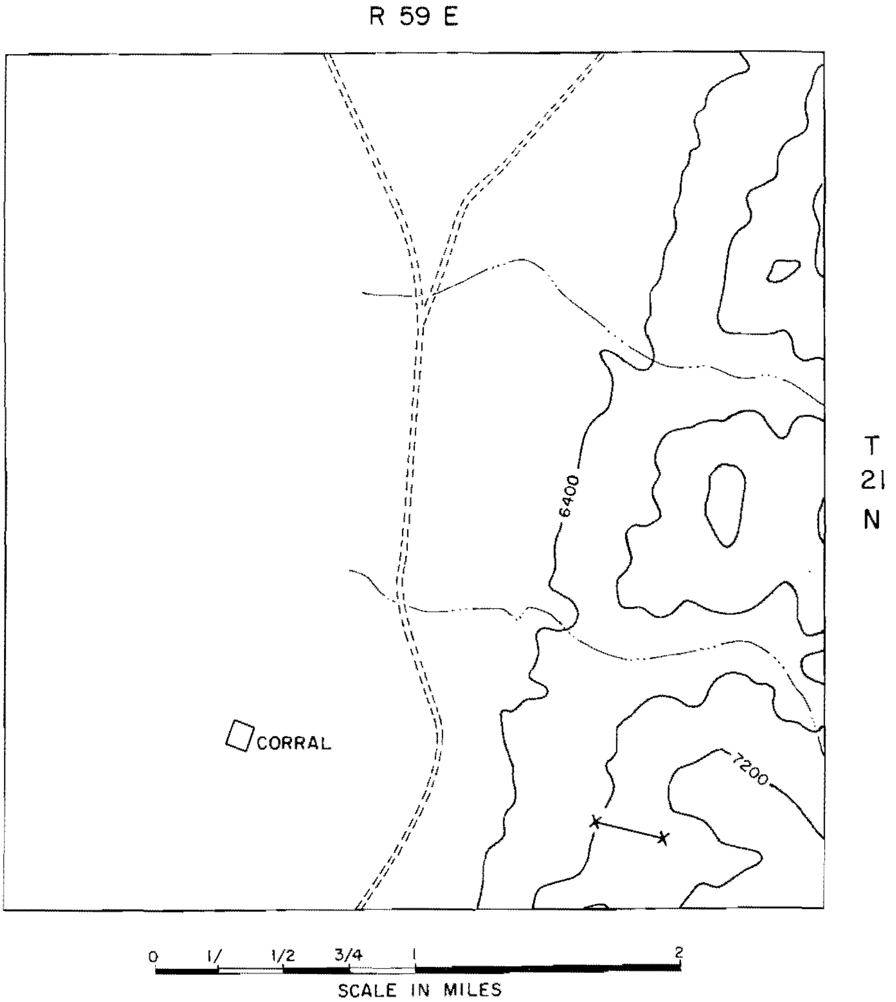

FIGURE 6

Butte Mountains: Ely Limestone; base map—Ely, Nevada; Utah, 1:250,000, ed. 1963, U. S. Geological Survey; see figure 2 for explanation of symbols.

bers at Ward Mountain. Both the lower and upper contacts are covered. The lower member is a massive, thick bedded, fine to coarse grained, cliff-forming limestone, and has abundant nodular chert at the base. The upper member is a platy, thin bedded, fine to coarse grained limestone which erodes as a steep slope. Thin, argillaceous limestones and calcareous, shaly partings are common. Chert appears as intermittent layers and scattered nodules. Foraminifers are found in only a few samples. Those from the lower member are deposited in recrystallized biomicrite, intrasparite and oosparite in which the foraminifers are commonly located at the center of the ooliths. Foraminifers from the upper member appear in recrystallized biopelmicrite and recrystallized crinoidal biopelsparite. Some thin sections show silification.

Moorman Ranch (Illipah)

The lower 530 feet of exposed Ely Limestone were measured above the covered base at this location. Approximately the bottom third of the section consists of thin bedded, platy, tan or yellow to light gray weathering, fine grained, argillaceous limestone with closely spaced banded chert although some beds are thicker, more coarse grained and have more widely spaced chert layers. A large segment in the middle of the bottom third is hidden by U. S. Highway 50 and surrounding alluvium. The remainder of the section is composed of more thickly bedded, tan to gray weathering, mostly fine grained limestone. Some beds are arenaceous or argillaceous. Nodular and banded chert is closely to widely spaced. The more resistant units are exposed as ridges separated by talus covered slopes. Foraminifers appear in biomicrite although few samples contain them.

BUTTE MOUNTAINS

The lower 490 feet of exposed Ely Limestone were measured here. The base lies within a 55 foot thick, covered slope above the sandy, fossiliferous limestone beds of the underlying Jensen Member of the Chainman Formation (terminology of Arnold and Sadlick, 1962, p. 250; also called Illipah Formation by Spivey, 1954, p. 1). Much of the limestone is fine to medium grained, tan or yellow to dark gray weathering and argillaceous or arenaceous. Crossbedding is common. Outcrops are discontinuous as the less resistant units form rubble strewn slopes. Bedding is mostly thin and platy although thicker, non-platy units occur toward the top of the measured section. Banded and nodular chert is locally abundant in the lower beds but is more widely distributed in the younger strata. As at the Moorman Ranch section, foraminifers occur in only a few samples which are composed of recrystallized biomicrite and sandy biomicrite.

FORAMINIFERAL ZONATION

The foraminiferal zonation used in this paper is the global scheme presented by Bernard Mamet *in* Sando, Mamet and Dutro, 1969 and Mamet and Skipp, 1970. The Mississippian is divided into fifteen zones based on concurrent ranges and peaks (acmes) of diverse cosmopolitan taxa. Other publications using this zonal scheme in North America include those of Mamet (1968a, 1968b, 1970), Mamet and Mason (1968), Mamet and Gabrielse (1969), Mamet *et al.* (1971), Skipp and Mamet (1970), Armstrong *et al.* (1970) and Petryk *et al.* (1970). The relationship of these foraminiferal zones to North American and European time-stratigraphic units and to Carboniferous foraminiferal zones of the type Belgian sections is illustrated in figure 7.

Other efforts to determine the age of Mississippian strata on the basis of foraminifers have been published by E. J. Zeller (1950, 1957), Chilingar and Bissell (1957), Woodland (1958), Armstrong (1958, 1967), Skipp (1961, 1969), McKay and Green (1963) and Skipp, Holcomb, and Gutschick (1966). These age determinations are based almost exclusively on members of the Families Endothyridae or Tournayellidae and do not include the more varied fauna used in Mamet's scheme.

EUROPE		BELGIAN CARBONIFEROUS FORAMINIFERAL ZONES	GLOBAL FORAMINIFERAL ZONES	NORTH AMERICA	
SYSTEM	STAGE			SERIES	SYSTEM
UPPER CARBONIFEROUS	NAMURIAN			MORROW	PENNSYLVANIAN
		H	19	CHESTER	MISSISSIPPIAN
		E_2	18		
		E_1	17		
LOWER CARBONIFEROUS	VISEAN	$V3c_s$	16s		
		$V3c_i$	16i		
		V3B	15	MERAMEC	
		V3A	14		
		V2B	13		
		V2A	12		
		V1B	11		
		V1A	10		
	TOURNAISIAN	TN3C (B)	9	OSAGE	
		TN3A	8		
		$TN2^{C}_{B}$	7		
		TN2A $TN1^{B}_{A}$	6	KINDERHOOK	
DEVONIAN	FAMENNIAN				DEVONIAN

FIGURE 7

Correlation of global foraminiferal zones with North American and European time-stratigraphic units and with the foraminiferal zones of the type Belgian Carboniferous (from Sando *et al.*, 1969 and Mamet and Skipp, 1970).

The following zonal determinations are based on the foraminiferal occurrences listed in Tables 1 through 4. Figure 8 shows the actual location of samples within the measured sections and also the division of the formations into foraminiferal zones and series. Morrow rocks are not zoned.

Zone 7, of late Kinderhook-early Osage age, is the oldest recognizable zone in this study. It is characterized by the appearance of *Palaeospiroplectammina* and *Chernyshinella* with the species *P. tchernyshinensis* and *C. glomiformis* being important zonal markers. *Septaglomospiranella* [dominantly *S. primaeva* (Rauzer-Chernousova)] is abundant, and *Septabrunsiina* is found locally. Rare *Tuberendothyra* and *Endothyra*? appear in the upper part of the zone. Other faunal elements include the simple organisms *Bisphaera*, *Earlandia*, *Paracaligella*, *Eovolutina*, calcisphaerids

TABLE 1

Foraminiferal occurrences at Arrow Canyon Range. For limestone samples R represents average of ≤ 2 specimens per thin section, C represents average of > 2 ≤ 5 specimens per thin section, A represents average of > 5 specimens per thin section. For shale samples of the Indian Springs Fm., R and C are arbitrary designations based on time needed to find specimens.

FORMATIONS	CRYSTAL PASS						DAWN							ANCHOR						BULLION								YELLOWPINE					BATTLESHIP WASH					INDIAN SPRGS.		BIRD SPRING								
FORAM ZONES	?				7				8					? 9 THROUGH 12														13	15							17-18		19			MORROW							
SAMPLE NUMBERS	CP 1	CP 2	CP 3	CP 4	CP 5	CP 6	D 1	D 2	D 3	D 4	D 5	D 6	D 7	A 1	A 2	A 3	A 4	A 5	A 6	B 1	B 2	B 3	B 4	B 5	B 6	B 7	B 8	Y 1	Y 2	Y 3	Y 4	Y 5	BW 1	BW 2	BW 3	BW 4	BW 5	IS 1	IS 2	BS 1	BS 2	BS 3	BS 4	BS 5	BS 6	BS 7	BS 8	BS 9
calcisphaerids	A	A	A	A	A	A	A	A	A	A	A	A	A					A	A	A	C	A	?R	C	C	C	?R	A	A	A	A	A	A	A	A	R	R				C	C					A	
radiosphaerids	C		R	C	C	R		R																							R	R	R															
Bisphaera	R	R	R	R		R						?R																																				
Eovolutina	R						R		R				R																																			
Earlandia				R			C	?R		?R	R		R					A				R						R	A	A	C			R														
E. elegans				R			R						R					A				R								R	R																	
E. sp. A																		R																														
E. sp. B																													R					R														
Paracaligella					R																																											
Parathurammina					A	C	C					R	R																					R														
Septaglomospiranella					A		A		R		R	R	C									?R																										
S. primaeva (Rauz.-Chern.)					C		R						?R																																			
S. primaeva (Chernysheva)					R		R				R		?R																																			
Chernyshinella					C		C	R	R		R	R	R																																			
C. glomiformis					R																																											
C. cf. C. disputabilis					R			?R																																								
C. tumulosa					R		R	?R	R		R	R																																				
Palaeospiroplectammina					R		C																																									
P. parva					R																																											
P. tchernyshinensis							C																																									
Septabrunsiina							C	R	R		C																				R		R															
S. krainica											C																																					
S. cf. S. mckeei																															R		R															
S. sp. A																																	R															
Endothyra (Tuberendothyra)							R		R		C																																					
T. safonovae							R				R																																					
T. tuberculata									R		R																																					
Septatournayella									R		R																				R																	
S. tumula									R		R																																					
S. praesegmentata																															R																	
Tournayella												R																	R	A	R																	
T. discoidea												R																	R	C	R																	
Eotuberitina												C	R																	C				C							R							
Endothyra (Endothyra)							?R						?R									C			R			A	A	A	A	R	R	R		A	R	C	C		R	A		R		C	R	R
E.? cf. E.? tumida							R						R																																			
E. bowmani																													C	R	C							C	C									
E. apposita																													R	R																		
E. rugosa																														R	R																	
E. torquida																															R																	
E. introjectans																															R																	
E. excellens																																							C									
E. sp. A																																										R						R
E. planiformis n. sp.																																										R						
Eoendothyranopsis																												R	A	A	A	A	A	C	R													
E. aff. E. scitula																												R	C	R	C	R	C	R	R													
E. utahensis																													C	C	C	C	C	R														
E. redwallensis																														R	R	R		R														
E. cf. E. spiroides																																R																
E. aff. E. macra																																	R															
Endothyranopsis																												R	A	R	C	R	R		R													
E. eocompressa																													A		R																	
E. cf. E. crassa																													R		R		R															
E. cf. E. compressa																															R		R															
Endothyra (Globoendothyra)																						?R							C	C	A	A	A	C	R													
G. sp. A																													R	R	R																	
G. cf. G. gutschicki																																R	R															
G. aequiparvus n.n.																																A	R	R														
G.? sp. B.																																R																
Tetrataxis																													A												R	C	R			R		
T. aff. T. acutus																													R																			
T. media																													R																			
T. cf. T. obtusus																													R																			
T. vulgaris																													R																			
T. sp. A																													R																			
T. aff. T. parviconica																																									R							
T. parviconica																																										R						
T. sp. B																																										R						
T. sp. C																																										R						
Archaediscus																													R	R						R												
A. sp. A																													R	R																		
A. cf. A. pauxillus																																				R												
Eoforschia																													?R	C	R	R	C	R														
E. cf. E. nonconstricta																														R		R	R	R														
Uviella																														R																		
U. sp. A																														R																		

(Table 1 Continued)

FORMATIONS	CRYSTAL PASS						DAWN							ANCHOR						BULLION								YELLOWPINE					BATTLESHIP WASH					INDIAN SPRGS.		BIRD SPRING								
FORAM ZONES	?				7				8					? 9 THROUGH 12														13	15							17-18		19			MORROW							
SAMPLE NUMBERS	CP 1	CP 2	CP 3	CP 4	CP 5	CP 6	D 1	D 2	D 3	D 4	D 5	D 6	D 7	A 1	A 2	A 3	A 4	A 5	A 6	B 1	B 2	B 3	B 4	B 5	B 6	B 7	B 8	Y 1	Y 2	Y 3	Y 4	Y 5	BW 1	BW 2	BW 3	BW 4	BW 5	IS 1	IS 2	BS 1	BS 2	BS 3	BS 4	BS 5	BS 6	BS 7	BS 8	BS 9
Plectogyrina																																		R														
P. aff. *P. nevskiensis*																																		R														
Brunsia																																		R	R											R		
Asteroarchaediscus																																				C	C			R	R	R			?R			
A. *gnomellus* n. sp.																																				C	R											
A. *rugosimilis* n. sp.																																				R	R			R		R						
Neoarchaediscus																																				C	C			R	C	A	R					
N. incertus																																				R	R				R	A						
N. cf. *N. parvus*																																				R					R	R						
Planospirodiscus																																				A	C					A						
P. sulculus n. sp.																																				R	C											
P. cf. *P. minimus*																																										C						
P. ? *altiluminis* n. sp.																																										R						
Ozawainellidae																																				R			R		A		R		R	C		
Eostaffella																																							R		R				R	C		
E. cf. *E. tortula*																																									R				R	R		
E. sp. A																																													R			
Millerella																																									R							
M. cf. *M. designata*																																									R							
M. sp. A																																									R							
Eosigmoilina																																						R	R	R								
Quasiarchaediscus																																								?R								
Q. ? sp. A																																								R								
Globivalvulina																																									C		R	C	C	A		
G. sp. A																																									R							
G. sp. B																																									R					R		
G. sp. C																																											R					
G. sp. D																																												R		R		
G. sp. E																																													R			
G. sp. F																																														R		
Planoendothyra																																										C						
P. aljutovica																																										C						
Turrispiroides																																										R	R			R		

and radiosphaerids. Samples CP 5 and CP 6 from the Crystal Pass Limestone, D 1 and D 2 from the Dawn Limestone and J 1 through J 3 from the Joana Limestone are assigned to this zone.

The lower samples in the Crystal Pass (CP 1-CP 4) have an assemblage of simple, unilocular or bilocular forms similar to those of zone 7, but without multilocular foraminifers their zonal position cannot be ascertained. No foraminifers were recovered beneath sample J 1 of the Joana, but the age of these lowermost Joana rocks is most certainly Kinderhook since Early Mississippian fossils have been recovered both from the upper part of the underlying Pilot Shale in the Confusion Range to the east (Hose, 1966) and from the basal Joana beds in the Pahranagat Range to the south (Sandberg and Poole, 1970).

The Crystal Pass Limestone in the Arrow Canyon Range has, until now, been placed in the Upper Devonian for two reasons. First, because the formation lacks useful macrofossils and lies conformably upon known Upper Devonian strata and disconformably beneath the Mississippian Dawn Limestone, its stratigraphic position is apparently Devonian (Langenheim, 1961, p. 127; Langenheim *et al.*, 1962, p. 601). Second, Langenheim and Collinson (1963) have found a conodont assemblage which appears to be Late Devonian in age.

Only a single Crystal Pass sample (CP 5), located approximately fifty-five feet below the top contact, has complex foraminifers, but the assemblage definitely appears to be of Early Mississippian, probably late Kinderhook, age. This suggests that at least the upper portion of the Crystal Pass is Mississippian and that the conodonts from this level may be reworked. No foraminiferal evidence was found concerning the age of the formation beneath sample CP 5, but these lower beds are probably no older than Fammenian since Waines (1962) has found late Frasnian foraminifers from strata beneath the Crystal Pass in the Arrow Canyon Range.

The disconformity at the base of the Dawn probably represents a relatively short erosional interval during earliest Osage time. It separates the late Kinderhook strata of the upper Crystal Pass from the early Osage beds of the lower Dawn.

Zone 8 is of middle Osage age. Important zonal markers include the appearance of *Septatournayella tumula*, the appearance and acme of *Septabrunsiina krainica* and the acme of *Tuberendothyra*. *Septaglomospiranella* and *Chernyshinella* are found throughout most of the zone. Other faunal elements are calcisphaerids, *Parathurammina*, *Earlandia*, *Bisphaera*, *Eovolutina*, *Eotuberitina*, *Tournayella* and *Endothyra*?. Samples D 3 through D 5 from the Dawn Limestone and J 4 and J 5

TABLE 2

Foraminiferal occurrences at Ward Mountain. See Table 1 for explanation of letter symbols.

FORMATION	JOANA					
FORAM ZONES	7			8		
SAMPLE NUMBERS	J 1	J 2	J 3	J 4	J 5	J 6
calcisphaerids	?C	A	?C	C	A	C
Eovolutina	R				R	
Septaglomospiranella	A	A	?R	R	R	R
S. primaeva (Rauz.-Chern.)	R	R				
S. primaeva (Chernysheva)					R	
Palaeospiroplectammina	R					
P. sp. A	R					
Chernyshinella		R			R	
C. paucicamerata		R				
C. tumulosa					R	
Parathurammina		R				
Septabrunsiina			R	R	C	
S. krainica					C	
Earlandia			A	A		C
E. elegans				R		
Endothyra (*Tuberendothyra*)				C	R	R
T. safonovae				R		
Septatournayella					R	
S. tumula					R	
Tournayella					R	
T. discoidea					R	
Eotuberitina					C	
Bisphaera					R	
Endothyra (*Endothyra*)						?C

from the Joana Limestone are definitely placed in this zone. Dawn samples D 6 and D 7 and Joana sample J 6 show neither a distinctive zone 8 *Septatournayella-Septabrunsiina-Tuberendothyra* assemblage nor a distinctive zone 9 (late Osage) fauna characterized by *Spinoendothyra* Lipina (acme), *Carbonella* Dain (acme), specimens of the group *Endothyra prisca* Rauzer-Chernousova and Reitlinger (first appearance) and the first appearance of *Calcisphaera pachisphaerica* (Pronia). In this study the three samples are tentatively placed in the older zone although they may belong to the younger.

Using both macro- and microfossil evidence Chilingar and Bissell (1957) assign a late Kinderhook-early Osage age to the Joana Limestone near Ward Mountain. Woodland (1958) considers these same rocks to be Osage on the basis of foraminiferal evidence only. At Ward Mountain, Huddle (*in* Brew, 1970, p. 36) recognizes a late Kinderhook *Siphonodella* conodont assemblage zone at the top of the lower Joana member, and Duncan (*in* Brew, 1970, p. 36) dates the coral and brachiopod faunas of the upper member as Osage in age. Stensaas and Langenheim (1960) assign a tentative late Osage-Meramec age to the upper member in the same area on the basis of rugose corals. Langenheim (1960, p. 79) points out that the sections of Chilingar, Bissell and Woodland are mostly limited to the lower member

TABLE 3

Foraminiferal occurrences at Moorman Ranch. See Table 1 for explanation of letter symbols.

FORMATION	ELY		
SERIES	MORROW		
SAMPLE NUMBERS	E 1	E 2	E 3
Turrispiroides	R		R
Endothyra (*Endothyra*)	R	R	
Parathurammina		R	
Eotuberitina		C	A
Ozawainellidae		R	A
Eostaffella		R	C
E. sp. A.			R
Millerella			C
M cf. *M. bigemmicula*			R
M. sp A			R
calcisphaerids			A
Globivalvulina			A
G. sp. B			R
G. sp. C			R
G. sp. D			R
G. sp. F			R

TABLE 4

Foraminiferal occurrences at Butte Mountains. See Table 1 for explanation of letter symbols.

FORMATION	ELY		
SERIES	MORROW		
SAMPLE NUMBERS	Bu 1	Bu 2	Bu 3
Endothyra (*Endothyra*)	C	R	R
E. sp. A	R		
E.? sp. B	R		
E. planiformis n. sp.		?R	
Neoarchaediscus	R		
Planospirodiscus	R		
Ozawainellidae	R		
Eostaffella	R		
E. cf. *E. pinguis*	R		
Globivalvulina	R		
calcisphaerids		?C	
Glomospira			A

and the ages do not conflict with those determined by the corals.

The foraminiferal evidence at Ward Mountain is too sparse to delineate precisely the ages of the Joana members. My data coupled with Huddle's conodont assemblage suggests a late Kinderhook age for the lower member although the foraminiferally barren strata below sample J 1 may be of an earlier Kinderhook age. The upper member appears to be middle Osage and, near the top of the formation, possibly late Osage, but no Meramecian microfaunas were seen. The lower beds of the upper member beneath sample J 4, however, lack foraminifers, and, from their stratigraphic position above the lower member, they may be partly of early Osage age.

Zones 9 through 12 (late Osage to middle Meramec) are represented by the Anchor and Bullion Limestones in the Arrow Canyon Range section. However, these zones are not readily distinguishable because of a lack of stratigraphically useful microfossils. Calcisphaerids and *Earlandia* are found in both formations, but only one sample (B 3) from the Bullion has numerous multilocular foraminifers. However, the only diagnostic forms found in B 3 are a pair of questionable *Globoendothyra*, indicative of zone 10 or younger. From its stratigraphic position sample B 3 is possibly in zone 12. The base of the Anchor is considered to be in zone 9 since the top of the Dawn Limestone cannot be placed unequivocably above zone 8. Yet without the appropriate faunas the age assignment of the basal Anchor can only be tentative.

The Anchor and Bullion Limestones are composed predominantly of coarse crinoidal debris. In thin section the samples do not appear highly abraded or well sorted, as smaller bryozoan fragments and mud fill the interstices, and the sediment evidently suffered little transport. This depositional environment seems generally unfavorable to foraminiferal accumulation, probably because of foraminiferal intolerance of the crinoidal biota. Significantly, sample B 3, a biomicrite, has less crinoidal material than seen in other thin sections. Skipp (1969, pp. 192–194) notes that the distribution of some contemporaneous endothyrid species in the Redwall Limestone is apparently related to the amount of encrinitic material. Also, in Armstrong's work (1967) on the Arroyo Peñasco Formation, foraminiferal assemblages appear reduced in crinoid rich rocks. On the other hand, Woodland (1958, p. 808) finds that foraminifers are in greatest relative abundance in encrinal rocks.

Sample Y 1 of the Yellowpine Limestone is

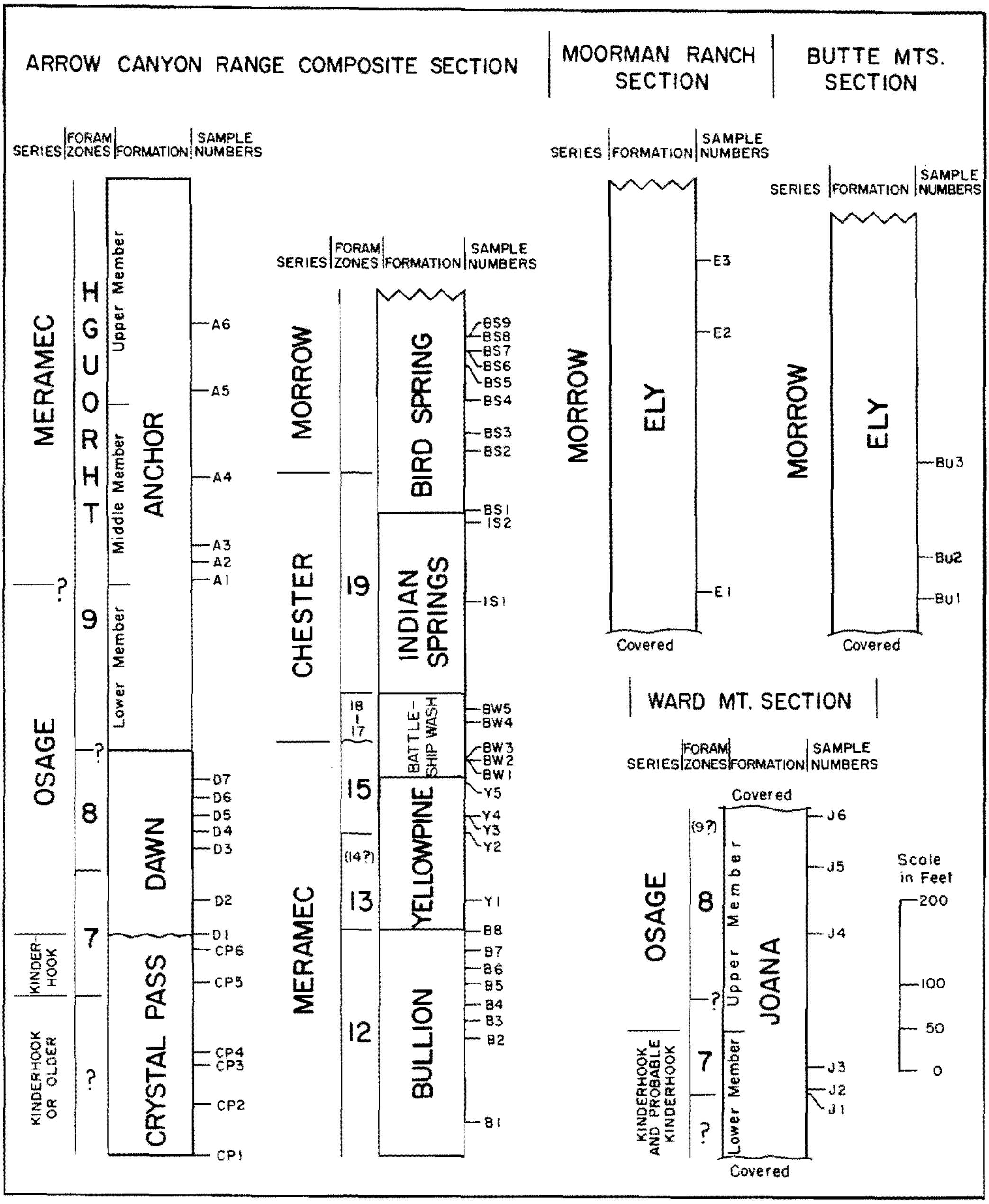

FIGURE 8

Division of measured sections into foraminiferal zones and series, based on data gathered from samples listed on right side of each column.

assigned to zone 13 (middle Meramec) on the basis of the appearance of *Eoendothyranopsis* aff. *E. scitula* and *Endothyranopsis*. Calcisphaerids, *Earlandia* and *Endothyra* are also present. Zone 14 (late Meramec) has a fauna similar to zone 13, but with the important addition of *Eoendothyranopsis utahensis*. Because this species is missing in Y 1, the sample is assigned to the older zone. No foraminifers were recovered from the 80 feet of strata between sample Y 1 and the base of zone 15 (sample Y 2). However, since the sampling interval is great, foraminifer-bearing rocks may have been missed, and a zone 14 assemblage might be found upon closer examination of this interval.

Zone 15 (late Meramec) is the most easily recognizable zone in the Arrow Canyon Range section. The base of the zone (sample Y 2) is marked by the appearance of *Endothyranopsis crassa*. *Eoendothyranopsis*, *Endothyranopsis* and *Globoendothyra* are at their acmes. Other important faunal elements include numerous *Eoforschia* and *Endothyra* (mostly of the group *E. bowmani*). *Tetrataxis* and *Tournayella* are abundant in some samples. Calcisphaerids, radiosphaerids, *Brunsia*, *Parathurammina*, *Eotuberitina*, *Earlandia*, *Septatournayella*, *Septabrunsiina*, *Uviella*, *Plectogyrina* and *Archaediscus* are scattered throughout the zone. Samples Y 2 through Y 5 of the Yellowpine Limestone and samples BW 1 through BW 3 of the Battleship Wash Formation are placed in this zone. Langenheim and Langenheim (1965, p. 232) consider the contact between the Yellowpine and Battleship Wash to be a disconformable surface representing a long stratal hiatus. However, in view of the present microfaunal evidence, the erosional interval, if any, must have been of very short duration.

Zone 16i (early Chester), characterized by the first appearance of *Neoarchaediscus*, diminution of *Endothyranopsis* and the extinction of *Eoendothyranopsis* and the Tournayellidae, and zone 16s (early Chester), characterized by the coexistence of *Neoarchaediscus*, *Planospirodiscus*, *Archaediscus* and *Pseudoendothyra*, are apparently missing in Arrow Canyon. Approximately 40 feet of foraminiferally barren strata separate sample BW 3 (zone 15) from sample BW 4 (zone 17–18). As in the case of zone 14, intensive sampling of this forty foot interval may reveal a zone 16 fauna, but all available evidence points to a faunal hiatus in about the middle third of the Battleship Wash Formation.

Zone 17 (middle Chester) is marked by the appearance of numerous *Asteroarchaediscus* intermingled with *Neoarchaediscus* and *Planospirodiscus*. *Endothyra* is also numerous, and rarer elements include *Archaediscus*, Ozawainellidae (undetermined *Millerella* or *Eostaffella*), and calcisphaerids. Zone 18 (late Chester) differs from zone 17 only in having an outburst of *Globivalvulina* and the first appearance of *Eostaffellina*. Because of the similarity of the two zonal faunas and lack of the diagnostic zone 18 taxa in Arrow Canyon, I have grouped samples BW 4 and BW 5 from the upper part of the Battleship Wash Formation into zone 17–18 undifferentiated.

Zone 19 (late Chester), characterized by the appearance of *Eosigmoilina* and possible *Quasiarchaediscus* (*Q.*? sp. A), includes the Indian Springs (samples IS 1 and IS 2) and lower part of the Bird Spring (sample BS 1) Formations. Other foraminifers belong to *Endothyra* of the group *E. bowmani*, *Asteroarchaediscus*, *Neoarchaediscus* and *Eostaffella*. The abundance and diversity of the Endothyracea are generally low, and, in the case of the Indian Springs Formation, the sparsity of these foraminifers is no doubt attributable to the unfavorable terrigenous depositional environment.

Previously, zone 19 was questionably assigned a latest Mississippian age because it does not appear in the Midcontinent area where an apparent hiatus separates Chester from Pennsylvanian strata (Sando *et al.*, 1969, pp. E16–E17, E21). However, more recent work by Armstrong *et al.* (1970) in Alaska and Mamet *et al.* (1971) in Idaho confirms a latest Chester age for the zone. Other faunal evidence at Arrow Canyon supports a similar age assignment. Webster and Lane (1967) and Webster (1969) in their study of the macrofauna and conodonts in Arrow Canyon place the Mississippian-Pennsylvanian boundary at the top of the *Rhipidomella nevadensis* brachiopod zone and the contemporaneous *Gnathodus girtyi simplex* conodont zone. These zones range from the base of the Indian Springs Formation up through approximately the lower 47 feet of the Bird Spring Formation (up through stratigraphic unit 28, Webster, 1969, p. 68). Zone 19 faunas are confined to the same strata.

The foraminiferal faunas found in sample BS 2 through BS 9 of the Bird Spring Formation are considered Morrow in age and lie within the lower half of the *Streptognathodus noduliferus-Idiognathoides convexus* conodont assemblage zone of Webster (1969, pp. 22–23). The important foraminiferal taxa in these samples include *Endothyra*, *Planoendothyra*, *Globivalvulina*, *Planospirodiscus* (most prevalent, *P.* cf. *P. minimus*), *Neoarchaediscus* (especially *N. incertus*), *Tetrataxis*, *Turrispiroides* and the Ozawainellidae (*Millerella* and *Eostaffella*). *Asteroarchaediscus*, *Eotuberitina*, *Brunsia* and calcisphaerids are also present. The alga *Girvanella* is locally abundant.

Some Morrow faunas are also found in the lower Ely limestone at the Moorman Ranch and Butte Mountains sections. The Ely was studied to compare the foraminifers with those found in the Bird Spring Formation at Arrow Canyon.

The conodont assemblages of Dunn (1970) strongly support a Morrow age for the basal Ely strata in the vicinity of the Moorman Ranch. Most other workers (Steele, 1960; Humphrey, 1960; Mollazal, 1961; Coogan, 1964; Bissell, 1964; Rich, 1967) also favor a Morrow age assignment at the Moorman Ranch and Butte Mountains although Humphrey (1960) and Coogan (1964) say that the lower beds may be Late Mississippian as is true in other areas (Hose and Repenning, 1959; Kellogg, 1960, 1963; Drewes, 1967; Brew, 1971).

Foraminifers are scarce throughout the measured sections. Of the three microfossiliferous samples found at the Moorman Ranch section, only E 3 has numerous foraminifers including *Globivalvulina*. Ozawainellidae (*Millerella* and *Eostaffella*), *Turrispiroides*, *Eotuberitina* and calcisphaerids. This fauna resembles the Morrow assemblages of the Bird Spring Formation. The other samples have no well developed Morrow faunas although E 1 (located approximately 48 feet above the exposed base) contains *Turrispiroides* which first appears in the Pennsylvanian at Arrow Canyon.

Only three foraminifer-bearing samples were found at the Butte Mountains section. Sample Bu 1 (about 40 feet above the exposed base) has an apparent Morrow fauna of *Neoarchaediscus, Planospirodiscus, Globivalvulina, Eostaffella* and *Endothyra*. Sample Bu 2 has a possible specimen of *Endothyra planiformis* which also occurs in sample BS 3 (Morrow) of the Bird Spring Formation. Sample Bu 3 has abundant *Glomospira*.

SUMMARY

A well developed microfauna consisting dominantly of members of the Superfamily Endothyracea but containing important elements of other groups permits recognition of Mississippian foraminiferal biozones in southern and eastern Nevada. Morrow strata are also recognized but are not zoned.

The upper beds of the Crystal Pass Limestone in the Arrow Canyon Range have late Kinderhook (zone 7) foraminifers. The lower beds, however, have no stratigraphically useful foraminifers and may be as old as Fammenian. A short erosional interval, probably during earliest Osage time, preceded the deposition of the overlying Dawn Limestone which is early (zone 7) and middle (zone 8) and possibly late (zone 9) Osage in age. Foraminifers become scarce in the successively overlying Anchor and Bullion Limestones because of the unfavorable depositional environment of crinoidal debris. But, based on their stratigraphic position, the two formations range possibly from late Osage (zone 9) into middle Meramec (zone 12) time. The overlying Yellowpine Limestone and the lower beds of the Battleship Wash Formation are middle (zone 13) to latest Meramec (zone 15) in age although a zone 14 fauna was not found in the Yellowpine. Early Chester foraminifers (zone 16) were not seen in the Battleship Wash, but middle and late Chester species (zones 17–18) occur in the upper part. The overlying Indian Springs Formation and the lowest part of the Bird Spring Formation have latest Chester faunas (zone 19), and the remainder of the Bird Spring that was measured is Morrow in age.

At Ward Mountain the foraminifers in the lower Joana Limestone member appear to be late Kinderhook (zone 7); however, no foraminifers were recovered from the basal beds which may be older. The upper member contains definite middle Osage (zone 8) and possible late Osage (zone 9) faunas. Early Osage strata are probably represented by the beds directly above the lower member, but no foraminifers were recovered from these rocks.

The lower part of the exposed Ely Limestone at the Moorman Ranch and Butte Mountains sections has sparse foraminiferal assemblages which appear Morrow in age.

In this study, members of the family Tournayellidae and *Tuberendothyra* are most useful in identifying Kinderhook and Osage strata. The Endothyridae and primitive Bradyinidae (*Endothyranopsis*) are most useful in identifying Meramec strata, and the Archaediscidae along with the miliolid genus *Eosigmoilina* are most useful in zoning Chester rocks. The potential of nonfusulinid calcareous foraminifers in defining Lower Pennsylvanian strata has not been widely explored. Certain taxa encountered in this investigation such as *Endothyra planiformis, Planospirodiscus? altiluminis, Turrispiroides, Planoendothyra* and species of *Globivalvulina* may prove useful for zoning Morrow sediments.

SYSTEMATIC PALEONTOLOGY

Unless stated otherwise, the following genus and species descriptions are based upon material recovered only in this investigation. Family and subfamily descriptions in some cases are based upon characteristics reported by others since all features are not represented in the present specimens.

Identifications were based almost entirely on thin sections. Important identifying characteristics of complex foraminifers include the diameter or length, width, number of volutions, number of chambers per volution, peripheral shape, secondary deposits and manner of coiling. These parameters are most easily determined in sagittal and axial thin sections. Sagittal sections cut through the proloculus perpendicular to the axis of coiling of the final volution so that all the chambers of the whorl are typically visible. Axial sections slice through the proloculus in the axis of coiling of the final volution. Other useful, and more plentiful, sections are the diagonal ones which pass through the proloculus at an acute angle to the axis of coiling and the tangential which miss the proloculus.

The terms "small," "medium" and "large" used in reference to the diameter or length of the organisms denote size ranges of $\leqslant 0.40$ mm., 0.41–0.80 mm., and $\geqslant 0.81$ mm. respectively.

Superfamilies and the families within them are introduced in their order of stratigraphic appearance. Samples which are located stratigraphically in figure 8 are listed in parentheses in the "Occurrence" section of the individual descriptions. Genus and species occurrences are also summarized in Tables 1–4.

Specimens are deposited in the University of Colorado Museum.

INCERTAE SEDIS

Calcisphaerids

Plate 1, figures 1–3

Description.—Test is small, unilocular, smooth and spherical. Wall is thin or relatively thick, nonporous and composed of dark, fine to coarse grained calcite. A few specimens have an outer clear fibrous layer (Plate 1, figure 3) which is interpreted as a secondary crystallization feature.

Discussion.—Organisms of this shape have been assigned to various genera (*e.g.* *Calcisphaera* Williamson, 1880; *Archaesphaera* Suleimanov, 1956; *Polyderma* Derville, 1950; *Pachysphaera* Conil and Lys, 1964) on the basis of the thickness, porosity, or layering of the wall. Specimens found in this study, however, are not considered distinctive enough to differentiate.

The affinity of calcisphaerids as well as that of other simple, globular organisms is problematical. They have been placed within both the foraminifers and the algae (*e.g.* see Conil and Lys, 1964, pp. 36, 50; Wray, 1967, pp. 47–48). Conil (*in* Conil and Lys, 1966, pp. 208–209) thinks that thin walled calcisphaerids may be a stage in the life cycle of *Eotuberitina.*

Occurrence.—Found in majority of samples. (See Tables 1–4 for specific occurrences.)

Radiosphaerids

Plate 1, figures 4–7

Description.—Test is small to medium in size, free and unilocular. The spherical interior cavity is surrounded by an inner, thin, dark microgranular layer and an outer, thick layer of radially arranged spines, blades or contiguous prisms of clear calcite. No aperture is seen.

Discussion.—Although formerly thought to be limited to the Upper Devonian in North America (Stanton, 1967), radiosphaerids have since been reported from rocks as young as Chester age in eastern Canada (Mamet 1968b, 1970) and Meramec age in the western United States and Canada (Sando *et al.*, 1969; Petryk *et al.*, 1970; and this report). In Eurasia the group ranges from Upper Devonian (Frasnian) through the lower Carboniferous (Stanton, 1967) and has also been reported from Upper Devonian strata in Australia (Wray, 1967).

These specimens were not studied sufficiently to be differentiated.

Occurrence.—Zone 7 or older (CP 1, CP 3, CP 4) Crystal Pass Limestone; zone 7 (CP 5, CP 6) Crystal Pass Limestone and (D 2) Dawn Limestone; zone 15 (Y 4, Y 5) Yellowpine Limestone and (BW 1) Battleship Wash Formation at Arrow Canyon Range.

Order FORAMINIFERIDA Eichwald, 1830

Suborder FUSULININA Wedekind, 1937

Superfamily PARATHURAMMINACEA Bykova, 1955

Family PARATHURAMMINIDAE Bykova, 1955

Genus **Bisphaera** Birina, 1948

Plate 1, figures 8–11

Type species: *Bisphaera malevkensis* Birina, 1948.

Description.—Test is free, unilocular, small to large and globular, ellipsoidal or slightly irregular in shape. Slight constrictions of the wall tend to divide the interior of the organism into two, in some cases more, proto-chambers, but the unilocular construction is always apparent. Wall is thin, dark, fine grained calcite. Drusy infilling of the interior cavity produces an inner, clear fibrous layer. No aperture is seen.

Discussion.—Speciation is based on the dimensions, wall structure and shape (Conil and Lys, 1964, p. 32). The wall may be composed of a single, dense or possibly perforate layer (Toomey *et al.*, 1970); or a dense outer layer and an inner clear, fibrous zone which, however, may be secondary. As Conil and Lys point out (1964, p. 32), the shape of such simple forms is of questionable taxonomic value because the environmen rather than heredity may control the morphology

This genus has been reported only recently from North America (Mamet and Mason, 1968 Sando *et al.*, 1969; Petryk *et al.*, 1970; Toome *et al.*, 1970).

Material is too sparse to be speciated.

Occurrence.—Zone 7 or older (CP 1, CP CP 3, CP 4) Crystal Pass Limestone; zone (CP 6) Crystal Pass Limestone; zone 8 (?D 6 Dawn Limestone at Arrow Canyon Range. Zo 8 (J 5) Joana Limestone at Ward Mountain.

Genus **Eovolutina** Antropov, 1950

Plate 1, figures 12–15

Type species: *Eovolutina elementa* Antropov, 1950.

Description.—Test is small and bilocular with the proloculus surrounded by the second spherical or subspherical chamber. Wall is dark, homogeneously fine grained calcite. Each chamber has a simple opening which commonly is not visible in these specimens possibly because the angle of section missed it.

Discussion.—Material is too scarce to be speciated.

Occurrence.—Zone 7 or older (CP 1) Crystal Pass Limestone; zone 7 (D 1) Dawn Limestone; zone 8 (D 3, D 7) Dawn Limestone at Arrow Canyon Range. Zone 7 (J 1) and zone 8 (J 5) Joana Limestone at Ward Mountain.

Genus **Parathurammina** Suleimanov, 1945

Plate 1, figures 16–21

Type species: *Parathurammina dagmarae* Suleimanov, 1945.

Description.—Test is small, unilocular, free and subglobular to polygonal in shape. Numerous spiny or rounded tubular protuberances radiate out from the shell. Apertures are located at the ends of the tubes. The wall is thin to relatively thick, dark, single-layered, fine grained calcite.

Discussion.—These specimens were not studied sufficiently to be speciated.

Occurrence.—Zone 7 (CP 5, CP 6) Crystal Pass Limestone and (D 1) Dawn Limestone; zone 8 (D 6, D 7) Dawn Limestone; zone 15 (BW 2) Battleship Wash Formation at Arrow Canyon Range. Zone 7 (J 2) Joana Limestone at Ward Mountain. Morrow (E 2) Ely Limestone at Moorman Ranch.

Family EARLANDIIDAE Cummings, 1955

Genus **Earlandia** Plummer, 1930

Type species: *Earlandia perparva* Plummer, 1930.

Description.—Test consists of a spherical to subspherical proloculus and a cylindrical or slightly flaring second nonseptate chamber. Commonly the wall at the base of the second chamber is thickened internally, producing a slight constriction in the passage between the two chambers. The single layered wall is composed of fine grained calcite. Aperture is an unrestricted opening at the end of the tubular chamber.

Discussion.—Speciation of this genus is based upon the maximum diameter of the proloculus, thickness of the test wall and overall shape. The plane of section, as well as breakage of the foraminifer after death, makes it difficult to ascertain the true length of the specimens and, in some cases, the true diameter of the second chamber.

Earlandia elegans (Rauzer-Chernousova and Reitlinger), 1937

Plate 1, figures 22–27

Hyperammina elegans RAUZER-CHERNOUSOVA and REITLINGER, *in* Rauzer-Chernousova and Fursenko, 1937, pp. 256–257, fig. 191.

Earlandia elegans (Rauzer-Chernousova and Reitlinger). BYKOVA and POLENOVA, 1955, p. 29, pl. 9, fig. 5; BOGUSH and YUFEREV, 1962, p. 70, pl. 1, fig. 1; CONIL and LYS, 1964, p. 53, pl. 7, figs. 98–99; BOGUSH and YUFEREV, 1966, pp. 83–84, pl. 1, figs. 18–19; MAMET, 1970, pl. 3, fig. 4.

Hyperammina minima BIRINA, 1948, pp. 155–158, pl. 2, figs. 7–8.

Earlandia minima (Birina). CONIL and LYS, 1964, p. 54, pl. 7, figs. 100–101; BOGUSH and YUFEREV, 1966, p. 83, pl. 1, fig. 17.

Measurements.—(based on 12 specimens) Maximum observed length: 0.330 mm. Maximum observed external diameter of each tubular chamber (11 specimens): 0.035–0.085 mm, average: 0.055 mm. External diameter of proloculus: 0.055–0.130 mm, average: 0.085 mm. Thickness of prolocular wall: 0.005–0.015 mm. Thickness of tubular wall (11 specimens): 0.005–0.025 mm.

Description.—The proloculus is spherical to sac-shaped. A distinct juncture separates it from the rectilinear, tubular chamber. Internal constrictions at the base of the tubular chamber are found in most specimens. The wall is dark and microgranular.

Discussion.—*E. minima* (Birina), 1948, is apparently distinguished from *E. elegans* on its smaller size alone. In the original description of *E. elegans* (1937) the diameter of the tubular chamber varies between 0.05 mm and 0.12 mm and the shell has an average thickness of 0.018 mm. No measurements were given for the diameter of the proloculus. The range of the tubular diameters of my specimens are a little smaller than in the type material. Bogush and Yuferev (1966, pp. 83–84) assign specimens with dimensions similar to mine to *E. minima*, and larger forms to *E. elegans*. Conil and Lys (1964, pp. 53–54), on the other hand, place specimens equal in dimensions to mine with *E. elegans*, and some smaller forms with *E. minima*. I have not seen Birina's original description, but it would seem that *E. minima* and *E. elegans* form a dimensional continuum and are divided arbitrarily. I feel that the two species should be considered one and the same; *E. elegans* has priority.

EXPLANATION OF PLATE 1

FIGS. PAGE

1–3. Calcisphaerids. × 60. 20
1. (UCM 28128a). Sample CP 4*, Crystal Pass Limestone, Arrow Canyon Range.
2. (UCM 28125a). Sample CP 1, Crystal Pass Limestone, Arrow Canyon Range.
3. (UCM 28152a). Sample Y 1, Yellowpine Limestone, Arrow Canyon Range.

4–7. Radiosphaerids. × 60. 20
4. (UCM 28128b). Sample CP 4, Crystal Pass Limestone, Arrow Canyon Range.
5. (UCM 28129a). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.
6. (UCM 28157a). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.
7. (UCM 28157b). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.

8–11. *Bisphaera* Birina, 1948. 20
8. (UCM 28127a), × 60. Sample CP 3, Crystal Pass Limestone, Arrow Canyon Range.
9. (UCM 28130a), × 60. Sample CP 6, Crystal Pass Limestone, Arrow Canyon Range.
10. (UCM 28127b), × 60. Sample CP 3, Crystal Pass Limestone, Arrow Canyon Range.
11. (UCM 28127c), × 40. Sample CP 3, Crystal Pass Limestone, Arrow Canyon Range.

12–15. *Eovolutina* Antropov, 1950. × 75. 21
12. (UCM 28125b). Sample CP 1, Crystal Pass Limestone, Arrow Canyon Range.
13. (UCM 28182a). Sample J 5, Joana Limestone, Ward Mountain.
14. (UCM 28133a). Sample D 3, Dawn Limestone, Arrow Canyon Range.
15. (UCM 28178a). Sample J 1, Joana Limestone, Ward Mountain.

16–21. *Parathurammina* Suleimanov, 1945. ×75. 21
16. (UCM 28137a). Sample D 7, Dawn Limestone, Arrow Canyon Range.
17. (UCM 28136a). Sample D 6, Dawn Limestone, Arrow Canyon Range.
18. (UCM 28129b). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.
19. (UCM 28129c). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.
20. (UCM 28129d). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.
21. (UCM 28185a). Sample E 2, Ely Limestone, Moorman Ranch.

22–27. *Earlandia elegans* (Rauzer-Chernousova and Reitlinger), 1937. × 75. 21
22. Diagonal section (UCM 28146a). Sample B 3, Bullion Limestone, Arrow Canyon Range.
23. Broken? axial section (UCM 28155a). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.
24. Diagonal section (UCM 28137b). Sample D 7, Dawn Limestone, Arrow Canyon Range.
25. Broken? axial section (UCM 28142a). Sample A 5, Anchor Limestone, Arrow Canyon Range.
26. Broken? axial section (UCM 28131a). Sample D 1, Dawn Limestone, Arrow Canyon Range.
27. Diagonal section (UCM 28128c). Sample CP 4, Crystal Pass Limestone, Arrow Canyon Range.

28. *Earlandia* sp. A. × 75. 23
28. Broken? axial section (UCM 28142b). Sample A 5, Anchor Limestone, Arrow Canyon Range.

29, 30. *Earlandia* sp. B. × 75. 24
29. Diagonal section (UCM 28158a). Sample BW 2, Battleship Wash Formation, Arrow Canyon Range.
30. Diagonal section (UCM 28153a). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.

31–35. *Eotuberitina* Miklukho-Maklai, 1958. × 100. 24
31. Section through base (UCM 28186a). Sample E 3, Ely Limestone, Moorman Ranch.
32. Section through base (UCM 28186b). Sample E 3, Ely Limestone, Moorman Ranch.
33. Section through base (UCM 28186c). Sample E 3, Ely Limestone, Moorman Ranch.
34. Three specimens: upper two sections through base; lowermost section missing base (UCM 28186d). Sample E 3, Ely Limestone, Moorman Ranch.
35. Section through base (UCM 28136b). Sample D 6, Dawn Limestone, Arrow Canyon Range.

36–40. *Turrispiroides* Reitlinger, 1959. × 75. 2
36. Tangential section, approaching axial (UCM 28186e). Sample E 3, Ely Limestone, Moorman Ranch.
37. Tangential section, approaching axial (UCM 28169a). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
38. Tangential section, approaching axial (UCM 28186f). Sample E 3, Ely Limestone, Moorman Ranch.
39. Tangential section (UCM 28186g). Sample E 3, Ely Limestone, Moorman Ranch.
40. Tangential section (UCM 28184a). Sample E 1, Ely Limestone, Moorman Ranch.

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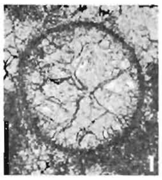
* Sample locations shown in fig. 8, p. 17.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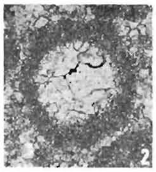
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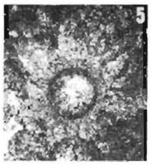
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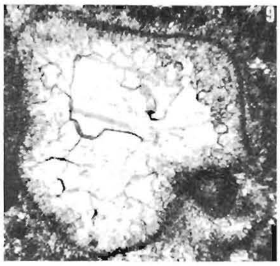
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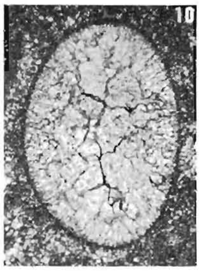
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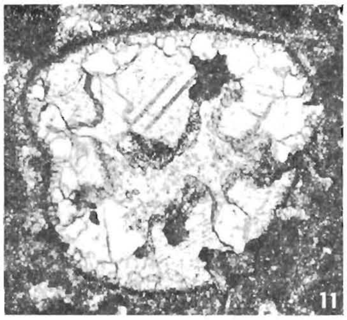
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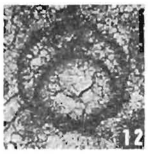
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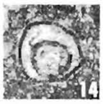
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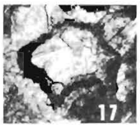
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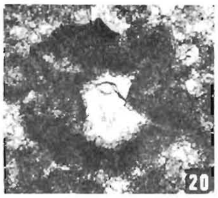
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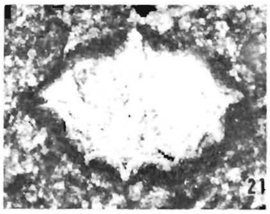
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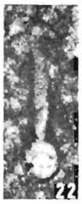
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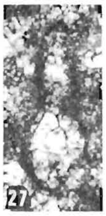
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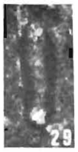
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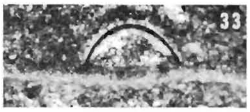
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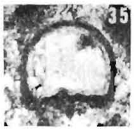
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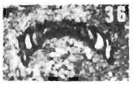
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BRENCKLE: CALCAREOUS FORAMINIFERS FROM NEVADA


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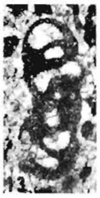
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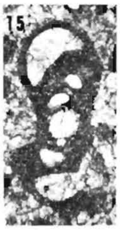
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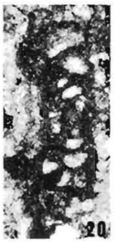
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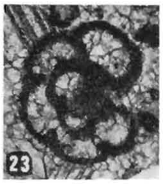
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BRENCKLE: CALCAREOUS FORAMINIFERS FROM NEVADA

Occurrence.—Zone 7 or older (CP 4) Crystal Pass Limestone; Zone 7 (D 1) Dawn Limestone; zone 8 (D 7) Dawn Limestone; zones 9–12 (A 5) Anchor Limestone and (B 3) Bullion Limestone; zone 15 (Y 3, Y 4) Yellowpine Limestone at Arrow Canyon Range. Zone 8 (J 4) Joana Limestone at Ward Mountain.

Earlandia sp. A

Plate 1, figure 28

Measurements.—(based on 1 specimen) Maximum observed length: 0.350 mm. Maximum observed diameter of tubular chamber: 0.100 mm. External diameter of proloculus: 0.095 mm.

EXPLANATION OF PLATE 2

All figures × 60 unless indicated otherwise

FIGS. — PAGE

1. *Paracaligella* Lipina, 1955. × 50. 24
   1. Axial section (UCM 28129e). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.

2–8. *Eoforschia* cf. *E. nonconstricta* (McKay and Green), 1963. 26
   2. Tangential section; piece of shell wall missing at top (UCM 28157c), × 40. Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.
   3. Tangential section, approaching axial (UCM 28157d), × 40. Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.
   4. Tangential section (UCM 28158b), × 40. Sample BW 2, Battleship Wash Formation, Arrow Canyon Range.
   5. Tangential section, approaching axial (UCM 28158c), × 50. Sample BW 2, Battleship Wash Formation, Arrow Canyon Range.
   6. Tangential section approaching axial (UCM 28157e), × 50. Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.
   7. Tangential section (UCM 28154a), × 50. Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.
   8. Tangential section (UCM 28154b), × 50. Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.

9, 10. *Septabrunsiina* sp. A. 28
   9. Tangential section, approaching axial (UCM 28157f). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.
   10. Tangential section, approaching axial (UCM 28157g). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.

11–18. *Septabrunsiina krainica* (Lipina), 1948. 27
   11. Axial section (UCM 28182b). Sample J 5, Joana Limestone, Ward Mountain.
   12. Tangential section, approaching axial (UCM 28182c). Sample J 5, Joana Limestone, Ward Mountain.
   13. Tangential section, approaching axial (UCM 28135a). Sample D 5, Dawn Limestone, Arrow Canyon Range.
   14. Axial section (UCM 28135b). Sample D 5, Dawn Limestone, Arrow Canyon Range.
   15. Axial section (UCM 28182d). Sample J 5, Joana Limestone, Ward Mountain.
   16. Axial section (UCM 28135c). Sample D 5, Dawn Limestone, Arrow Canyon Range.
   17. Tangential section (UCM 28135d). Sample D 5, Dawn Limestone, Arrow Canyon Range.
   18. Diagonal section (UCM 28135e). Sample D 5, Dawn Limestone, Arrow Canyon Range.

19–21. *Septabrunsiina* cf. *S. mckeei* Skipp, Holcomb and Gutschick, 1966. 28
   19. Axial? section (UCM 28157h). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.
   20. Tangential section, approaching axial; piece of shell wall missing at bottom (UCM 28155b). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.
   21. Axial section (UCM 28157i). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.

22–25. *Septaglomospiranella primaeva* (Chernysheva), 1940. 29
   22. Diagonal section (UCM 28182e). Sample J 5, Joana Limestone, Ward Mountain.
   23. Tangential section (UCM 28135f). Sample D 5, Dawn Limestone, Arrow Canyon Range.
   24. Diagonal section (UCM 28131b). Sample D 1, Dawn Limestone, Arrow Canyon Range.
   25. Axial section (UCM 28129f). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.

Thickness of prolocular wall: 0.015 mm. Thickness of tubular wall: 0.025 mm.

Description.—A thin, smooth neck separates the elongate proloculus from the flaring second chamber. The tubular chamber has a thicker shell than the proloculus. Wall is dark, microgranular calcite with inclusions of larger grains.

Discussion.—The larger grains in the wall may be primary but probably are secondarily enlarged as the specimen is in a recrystallized biomicrite. This form is distinguished from *E. elegans* by the smooth neck and flaring tubular chamber.

Occurrence.—Zones 9–12 (A 5) Anchor Limestone at Arrow Canyon Range.

Earlandia sp. B

Plate 1, figures 29, 30

Measurements.—(based on 2 specimens) Maximum observed length: 0.190 mm. Maximum observed external diameter of each tubular chamber: 0.055–0.065 mm. External diameter of proloculus: 0.050–0.060 mm. Thickness of prolocular wall: 0.005–0.010 mm. Thickness of tubular wall: 0.020 mm.

Description.—Proloculus is spherical and the second chamber is rectilinear. No external constriction separates the two chambers. They are differentiated internally by a thickening of the test at the base of the tubular chamber. Wall is dark and microgranular.

Discussion.—These specimens differ from *E. elegans* in the lack of an external juncture between the two chambers and by the greater thickness of the tubular wall relative to the prolocular wall. The morphology is similar to *E. bella* (Reitlinger), 1950, which, however, has a light colored hyaline wall.

Occurrence.—Zone 15 (Y 2) Yellowpine Limestone and (BW 2) Battleship Wash Formation at Arrow Canyon Range.

Genus **Paracaligella** Lipina, 1955

Plate 2, figure 1

Type species: *Paracaligella antropovi* Lipina, 1955.

Description.—Test is large and irregularly tubular or sac-like with a terminal, elongate, narrow tubular neck. Proloculus is ill-defined, and small invaginations of the wall produce irregular, rudimentary partitions throughout the organism. The wall is dark, fine grained calcite with a few inclusions of larger crystals. Aperture is at the end of the neck.

Discussion.—*Paracaligella* is rare in this study, and the description is based essentially on one specimen. Speciation is not attempted.

I have followed Skipp's suggestion (1969, p. 197) and assigned this genus to the Family Earlandiidae rather than the Caligellidae Reitlinger, 1959, which is probably synonymous with the Earlandiidae.

Occurrence.—Zone 7 (CP 5) Crystal Pass Limestone at Arrow Canyon Range.

Family TUBERITINIDAE Miklukho-Maklai, 1958

Genus **Eotuberitina** Miklukho-Maklai, 1958

Plate 1, figures 31–35

Type species: *Eotuberitina reitlingerae* Miklukho-Maklai, 1958, new name (=*Tuberitina maljavkini* Mikhailov [Suleimanov] *in* Reitlinger, 1950; not *Tuberitina maljavkini* Suleimanov, 1948).

Description.—Test is small, unilocular and attached. The shape varies from hemispherical to spherical. The area of attachment is flat (Plate 1, figures 32, 33, 35), broadly concave (Plate 1, figure 31) or narrowly arched with outwardly paired wall projections (Plate 1, figure 34). The wall is thin, dark, fine grained calcite and generally smooth, although a few specimens appear to have short exterior protuberances. Some specimens have an outer clear calcite layer or an inner clear fibrous layer which, however, are probably secondarily deposited. There is no aperture.

Discussion.—The variable shape of the basal attachment is probably caused by both the angle of section and the size of the encrusted object. Specimens with narrow attachment areas probably wrapped around thin objects.

These specimens are assigned to *Eotuberitina* rather than *Tuberitina* on the basis of their relatively thin, nonporous wall. Rich (1970, pl. 144), on the other hand, has assigned to *Tuberitina* similarly shaped but apparently porous walled specimens from the lower Ely and Bird Spring Limestones. However, the specimen figured by Rich to show wall porosity (text-fig. 3, p. 1062) strongly resembles *Diplosphaerina* Derville, 1952, an organism composed of a large principal sphere and a small peripheral one.

Material was not studied sufficiently to be speciated.

Occurrence.—Zone 8 (D 6, D 7) Dawn Limestone; zone 15 (Y 3) Yellowpine Limestone and (BW 2) Battleship Wash Formation; Morrow (BS 2) Bird Spring Formation at Arrow Canyon Range. Zone 8 (J 5) Joana Limestone at Ward Mountain. Morrow (E 2, E 3) Ely Limestone at Moorman Ranch.

Family MORAVAMMINIDAE Pokorný, 1951

Genus **Turrispiroides** Reitlinger, 1959

Plate 1, figures 36–40

Type species: *Turrispira mira* Reitlinger, 1950.

TABLE 5

Key to genera of the Tournayellidae.

GENUS	COILING	WALL STRUCTURE		SEPTA PRESENT		SEPTA ABSENT
		thick agglutinated	thin non-agglutinated	septate throughout	initially non-septate	
Tournayella	planispiral		×			×
Eoforschia	planispiral	×				×
Septatournayella	planispiral		×		×	
Septabrunsiina	initial volutions skewed, final volutions planispiral		×		×	
Uviella	initial volutions skewed, final volutions planispiral	×			×	
Septaglomospiranella	skew coiled throughout		×		×	
Chernyshinella	skew coiled throughout but with chambers unilaterally inflated		×	×		
Palaeospiroplectammina	initially skew coiled with unilaterally inflated chambers followed by an erect biserial tube		×	×		

Description.—Test is small. The proloculus is followed by a tubular, nonseptate chamber of at least two and one-half to seven volutions. The tube is evolute and coils in a low cone or in some cases almost planispirally. A broad umbilical depression forms on the ventral side. The spiral suture is mildly depressed and, in axial section, the tubular chamber appears semicircular or slightly crescentic. The wall is thin, dark, fine grained, secreted calcite and thickens around the sutures. Aperture was not seen but is reported to be the open end of the tubular chamber.

Discussion.—The coiling of my specimens closely resembles that of *Monotaxinoides* Brazhnikova and Yartseva, 1956. This latter genus, however, has an inner, granular wall layer surrounded by hyaline material which also fills the umbilical depression. No clear layer is apparent in my specimens.

This genus differs from *Cornuspira* Schultze 1854, in its low, conical spire.

There is insufficient material for speciation.

Occurrence.—Morrow (BS 3, BS 4, BS 7) Bird Spring Formation at Arrow Canyon Range. Morrow (E 1, E 3) Ely Limestone at Moorman Ranch.

Superfamily ENDOTHYRACEA Brady, 1884

Family TOURNAYELLIDAE Dain, 1953

This family is represented in Nevada by eight genera: *Tournayella, Eoforschia, Septatournayella, Septabrunsiina, Uviella, Septaglomospiranella, Chernyshinella* and *Palaeospiroplectammina.* The first six are placed in the subfamily Tournayellinae; the last two in the subfamily Chernyshinellinae. Table 5 distinguishes the genera.

Species are differentiated according to size, number of volutions, number of chambers or pseudochambers per volution, peripheral shape and in some cases by the presence of basal secondary deposits. Secondary thickenings are not common on the septa. The above features are illustrated in the sagittal and axial views of *Septatournayella* in figure 9.

Lipina (1965, p. 11) reports the tournayellid wall to be a one-, two-, or three-layered structure composed of randomly oriented, dark to light colored, granular, secreted calcite with agglutinated calcite particles present in some cases. The granular, single layered wall is most common, with the differentiated wall best developed in the late Tournaisian (late Osage). In this study some *Eoforschia* specimens have a thin, dark, microgranular layer on the interior side of a thick agglutinated zone. Many of the non-agglutinated specimens have dark, homogeneous walls, but others possess light colored grains commonly oriented as discontinuous middle layers. There are two probable explanations for these discontinuous layers. First, they may represent the remains of an original three-layered wall in which recrystallization has partially destroyed the structure. Or, second, the original wall may have been porcelane-

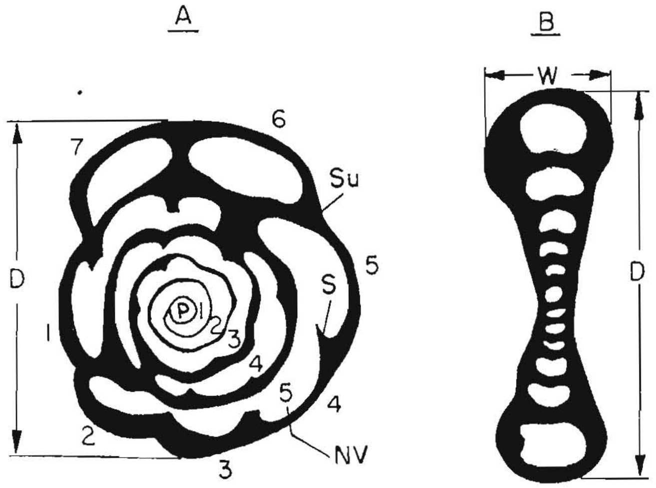

FIGURE 9

Cross sections of *Septatournayella*. *A* Sagittal section; 5 volutions, 7 chambers in last volution. *B* Axial section; 5½ volutions. D, diameter; W, width; P, proloculus; NV, number of volutions; S, septum; Su, suture (Redrawn from Grozdilova and Lebedeva, 1960).

ous and finely perforate as Skipp *et al.* (1966, pp. 7–8) contend. Diagenesis would change this unstable wall to a dark, granular structure, but the interior, being farthest from the surrounding matrix, may have partially survived recrystallization and is now seen as the discontinuous light colored middle layers. Therefore, at least in the case of my specimens, the thin, dark, granular, homogeneous wall possibly is not primary, but a result of secondary change.

In Eurasia the family appears in the Late Devonian and becomes extinct in the late Visean. In North America the family appears later, in the Kinderhook, but also dies out at the same time in early Chester.

Subfamily TOURNAYELLINAE Dain, 1953

Test is small to large. The proloculus is followed by a pseudotubular chamber undivided in the initial volutions and having slight thickenings (pseudosepta) or anteriorly directed septa in the later ones. Coiling is planispiral to skewed. The periphery can be smooth or lobate. Most forms are discoidal; some, however, are bimorphic with an initial coiled area followed by an erect chambered tube. The aperture is simple and rounded and is located either at the base or in the middle of the apertural face.

Genus **Eoforschia** Mamet, 1969

Type species: *Tournayella moelleri* Malakhova, 1953.

Description.—Test is discoidal, evolute, broadly umbilicate on both sides and generally large. Coiling is essentially planispiral. The inner volutions are tight, but the outer ones expand moderately to rapidly and in some specimens have a slightly crooked coil. A few diagonal sections show internal constrictions (pseudosepta) in the outer volutions. The peripheral outline is smooth. Secondary deposits commonly fill the corners of the volutions. The wall is thick and agglutinated with numerous light colored calcite grains randomly embedded in a dark, microgranular matrix. The better preserved specimens have an inner, dark, thin, secreted, microgranular layer. No aperture was seen.

Discussion.—The thick, agglutinated wall separates this genus from *Tournayella* and, along with the absence of septa, distinguishes it from *Septatournayella*. *Uviella* and *Uvatournayella* have a similar wall but are initially skew coiled.

Eoforschia cf. **E. nonconstricta**
(McKay and Green), 1963

Plate 2, figures 2–8

Tournayella? *nonconstricta* McKay and Green, 1963, p. 27, pl. 7, figs. 4–5; pl. 8, figs. 7–8; pl. 12, fig. 4.

Measurements.—(based on 11 specimens) Number of volutions (5 specimens): 6–7. Diameter (8 specimens): 0.95–1.63 mm. Width (5 specimens): 0.31–0.51 mm. Width/diameter (5 specimens): 0.34–0.44. Shell thickness last volution: 0.035–0.075 mm.

Description.—Test is large, discoidal, evolute, generally planispiral, and broadly umbilicate on both sides. Proloculus is relatively small. The rate of expansion of the inner volutions is slow, but the last two to three whorls expand moderately to rapidly and, in a few specimens, have a slightly crooked coil. Some pseudosepta are present in the last volutions of a few specimens, but better oriented sections are needed to determine the number in each volution. The peripheral outline is smooth. Secondary deposits fill in the corners of the volutions. One specimen (Plate 2, figure 7) has an unusual forked deposit on the floor of the last volution. The thick wall is two-layered. The outer layer is agglutinated, consisting of large, light colored calcite grains dispersed in a thick, dark microgranular matrix. The inner layer is thin, fine grained and not always preserved. No aperture or sagittal sections were seen.

Discussion.—These forms are related to *E. nonconstricta* in the number of volutions, wall structure and thickness and overall size but differ in lacking irregular secondary basal deposits and numerous pseudosepta. However, my specimens are poorly oriented in regard to these internal features which would probably be seen in sagittal section. They have the same age range as those of McKay and Green.

This species differs from Malakhova's type material of *T. moelleri* (as seen in Skipp *et al.*, 1966, pl. 7, figs. 1–5) in being larger, having more volutions, a more open aperture and possibly thicker walls and a smaller proloculus.

Occurrence.—Zone 15 (Y 3, Y 5) Yellowpine Limestone and (BW 1, BW 2) Battleship Wash Formation at Arrow Canyon Range.

Genus **Septabrunsiina** Lipina, 1955

Type species: *Endothyra? krainica* Lipina, 1948.

Description.—The test is small to medium sized, discoidal, evolute and slightly to distinctly umbilicate on one or both sides. The proloculus is followed by two and one-half to five volutions of which the initial one to two are skew coiled and commonly tight, and the remaining ones essentially planispiral and more loosely coiled. Small, thick septa divide the volutions into chambers but they are not well developed in the initial whorls. The peripheral outline is generally smooth. Secondary deposits in a few species consist of mounds and thickened floors. The wall is composed of dark, microgranular calcite. In some specimens larger, light colored grains are embedded in the dark matrix, appearing as either scattered grains or a middle layer. The aperture is low and basal.

Discussion.—*Septabrunsiina* is distinguished from *Brunsiina* Lipina, 1953 by the presence of small septa. Many of my sections, however, are axial, and, in these, the two genera cannot be distinguished because septa cannot be seen. Although possibly allied to *Brunsiina*, these specimens are classified with *Septabrunsiina* because their axial parameters resemble those of species of this genus.

Septabrunsiina krainica (Lipina), 1948

Plate 2, figures 11–18

Endothyra? krainica LIPINA, 1948, pp. 254–255, pl. 19, figs. 3–6.

Septabrunsiina krainica (Lipina). LIPINA, 1955, p. 43, pl. 4, figs. 12–13; BOGUSH and YUFEREV, 1962, pp. 112–113, pl. 2, fig. 21; LIPINA, 1965, pp. 52–53, pl. 11, figs. 1–7.

Plectogyra anteflexa (part) E. J. ZELLER, 1957, p. 698, pl. 81, fig. 11.

Plectogyra sp. ARMSTRONG, 1958, p. 976, pl. 127, figs. 16, 18.

Measurements.—(based on 12 specimens) Number of volutions: 2½–4. Diameter: 0.24–0.40 mm. Width (8 specimens): 0.09–0.18 mm. Width/diameter (8 specimens): 0.35–0.45. Interior diameter of proloculus (7 specimens): 0.045–0.070 mm. Shell thickness last volution: 0.010–0.020 mm.

Description.—Test is small, discoidal, almost completely evolute and more deeply umbilicate on one side. The initial one to two whorls are in general only slightly skewed relative to the remaining volutions which are more or less planispiral. The exterior volution is moderately high, expanding rapidly from the low, inner volutions. Septa are short, thick, and pointed well forward. Chamber inflation is slight, and the periphery is mostly smooth. The chamber floor is secondarily thickened in a few specimens. Wall is dark, microgranular calcite, but some specimens have inclusions of larger, light colored grains. Aperture is a low, basal opening.

Discussion.—The slightly skewed coiling of my specimens and the expansion of the whorls closely resemble that of *S. krainica* although the average size is smaller than previously reported (Lipina, 1965, p. 52). The axial dimensions fit those of *S. minuta* (Lipina) which, however, has on the average more highly skewed coiling and more chambers in the last volution. Although I have no complete sagittal sections of *S. krainica*, the last volution of the few diagonal and tangential sections (*e.g.* pl. 2, fig. 17) appears to have fewer chambers than the nine to fourteen reported for *S. minuta* (Lipina, 1965, p. 53).

Lipina (1965, pp. 52–53) places a single specimen of *Plectogyra anteflexa* E. J. Zeller and two of Armstrong's *Plectogyra* specimens with *S. krainica.*

Occurrence.—Zone 8 (D 5) Dawn Limestone at Arrow Canyon Range. Zone 8 (J 5) Joana Limestone at Ward Mountain.

Septabrunsiina cf. **S. mckeei** Skipp, Holcomb, and Gutschick, 1966
Plate 2, figures 19–21

Septabrunsiina mckeei Skipp *et al.*, 1966, p. 21, pl. 1, figs. 29–34.

Measurements.—(based on 3 specimens) Number of volutions: 4–5. Diameter: 0.41–0.51 mm. Width: 0.15–0.19 mm. Width/diameter: 0.34–0.37. Interior diameter of proloculus (1 specimen): 0.020 mm. Shell thickness last volution: 0.015–0.025 mm.

Description.—Test is medium sized, discoidal, evolute and slightly umbilicate on one side only. The initial one and one-half to two whorls are skew coiled to the remaining essentially planispiral volutions although the outer whorls do show some coiling distortion. The rate of expansion of the coil is gradual with the last one to two whorls looser than the interior ones. A single specimen has secondary basal mounds on the chamber floors. The wall is dark, microgranular calcite, but one specimen appears faintly layered in places. No mature sagittal sections were seen.

Discussion.—The mode of enrollment, dimensions, and age of these forms are similar to those of the Redwall specimens (Skipp *et al.*, 1966), but sagittal sections are needed for positive identification.

The axial sections of the species also resemble those of an older species, *S. minuta* (Lipina) which in sagittal section, however, appears to have a less lobate periphery and more chambers in the last volution.

Occurrence.—Zone 15 (Y 4) Yellowpine Limestone and (BW 1) Battleship Wash Formation at Arrow Canyon Range.

Septabrunsiina sp. A
Plate 2, figures 9, 10

Measurements.—(based on 3 specimens) Number of volutions: about 4–5. Diameter: 0.51–0.60 mm. Width: 0.18–0.23 mm. Width/diameter: 0.35–0.45. Shell thickness last volution: 0.015–0.020 mm.

Description.—Test is medium sized, evolute, discoidal and shallowly umbilicate on both sides. The outer two to three volutions are loose and planispirally coiled or slightly distorted; the interior coils are tightly enrolled and skewed. The walls are dark, microgranular calcite. No sagittal sections were seen.

Discussion.—These specimens, from a sample which also contains *S. mckeei*, differ primarily from that species by possessing a double umbilicus. They also resemble the doubly umbilicate species *S. krainica* (Lipina) which is older. But sagittal sections and better preserved specimens are needed before any specific assignment, old or new, can be made.

Occurrence.—Zone 15 (BW 1) Battleship Wash Formation at Arrow Canyon Range.

Genus **Septaglomospiranella** Lipina, 1955

Granuliferella (part) E. J. Zeller, 1957, pp. 694–695.

Type species: *Endothyra*? *primaeva* Rauzer-Chernousova, 1948 (not Chernysheva, 1940).

Description.—Test is small to medium in size, discoidal, nonumbilicate, and partially evolute. The one and one-half to four volutions are skew coiled, and the exterior volution has three and one-half to seven chambers. The rate of coiling expansion is generally low although the last whorl expands rapidly in one species. The chambers are semicircular or asymmetric. Initial septation is slight with later septa being of short to medium length, thick and pointed slightly to well forward. The periphery varies from smooth to lobate. Wall composition is generally dark, granular calcite although some larger, light colored grains are scattered throughout the matrix. Aperture is basal and simple.

Discussion.—Skipp *et al.* (1966, p. 22) question the use of *Endothyra*? *primaeva* Rauzer-Chernousova, 1948 as the type species, since Chernysheva (1940) used the same name for a different species also assignable to *Septaglomospiranella.* Skipp *et al.* submit that Rauzer-Chernousova's specimens should be given a new species name. However, Lipina in her 1965 publication (p. 63) not only retains *E.*? *primaeva* Rauzer-Chernousova as the type but changes the specimens assigned to *Endothyra primaeva* Chernysheva to *Septaglomospiranella compressa.*

As Skipp *et al.* (1966, p. 22) also point out, this genus and *Chernyshinella* are very similar in the mode of enrollment and are distinguished chiefly in that the periphery of *Septaglomospiranella* is generally less lobate and the chambers more symmetrical. With increasing chamber asymmetry in species of *Septaglomospiranella* the two genera are difficult to distinguish.

Part of the coarse walled genus *Granuliferella* is placed in synonymy with *Septaglomospiranella* because, as noted by Skipp *et al.* (1966, p. 19), the type species *G. granulosa* E. J. Zeller, 1957 appears identical to *S. primaeva* (Rauzer-Chernousova).

Septaglomospiranella primaeva
(Chernysheva), 1940
Plate 2, figures 22–25

Endothyra primaeva CHERNYSHEVA, 1940 (not Rauzer-Chernousova, 1948), p. 125, pl. 2, fig. 8.

Septaglomospiranella compressa LIPINA, 1965, new name (=*Endothyra primaeva* Chernysheva), p. 63, pl. 13, figs. 7–12.

Septaglomospiranella compressa Lipina *forma typica*. BRAZHNIKOVA *et al.*, 1967, pl. 2, figs. 13–14.

Septaglomospiranella primaeva (Chernysheva). SKIPP *et al.*, 1966, pp. 23–24, pl. 1, figs. 1–9.

Measurements.—(based on 6 specimens) Number of volutions (5 specimens): 2?–3½? Diameter: 0.29–0.41 mm. Width (2 specimens): 0.20–0.21 mm. Width/diameter (2 specimens): 0.49–0.52. Interior diameter of proloculus (2 specimens) 0.040–0.045 mm. Shell thickness last volution: 0.015–0.025 mm.

Description.—Test is small to medium sized, discoidal, nonumbilicate and partially evolute. Coiling is skewed throughout. The interior whorls are more tightly enrolled than the final one which, in general, maintains a constant height or only expands slowly. Septa are anteriorly directed, thick and short, although some attain a moderate length, and divide the shell into semicircular chambers. The septal sutures are faintly depressed in most specimens so that the periphery is smooth or mildly lobate. Wall is composed of dark, granular calcite, but a few inclusions of larger, light colored grains also appear. Aperture was not seen and is probably low and basal.

Discussion.—These specimens are classified with *S. primaeva* (Chernysheva) based on the essentially symmetrical chamber shape and on the generally smooth periphery and constant height of the last volution. The "Discussion" of *S. primaeva* (Rauzer-Chernousova) below distinguishes the two species.

Occurrence.—Zone 7 (CP 5) Crystal Pass Limestone and (D 1) Dawn Limestone; zone 8 (D 5, ?D 7) Dawn Limestone at Arrow Canyon Range. Zone 8 (J 5) Joana Limestone at Ward Mountain.

Septaglomospiranella primaeva
(Rauzer-Chernousova), 1948
Plate 3, figures 1–5

Endothyra? primaeva RAUZER-CHERNOUSOVA, 1948c (not Chernysheva, 1940), pp. 5–6, pl. 1, figs. 12–14.

Septaglomospiranella primaeva (Rauzer-Chernousova). LIPINA, 1955, pp. 46–47, pl. 4, fig. 21; BOGUSH and YUFEREV, 1962, p. 111, pl. 2, figs. 17–18; LIPINA, 1965, p. 62, pl. 12, figs. 24–26; BRAZHNIKOVA *et al.*, 1967, pl. 3, figs. 12–13.

Granuliferella granulosa E. J. ZELLER, 1957, p. 695, pl. 77, figs. 1, 7, 8, 14, 19–20; pl. 78, fig. 2; pl. 79, figs. 3–5, 20–22; pl. 81, figs. 4–5, 7–8, 10; pl. 82, figs. 6–7.

Measurements.—(based on 10 specimens) Number of volutions: 1½–2½. Number of chambers in last volution (7 specimens): 5–7. Diameter: 0.23–0.37 mm. Width (1 specimen): 0.21 mm. Width/diameter (1 specimen): 0.70. Interior diameter of proloculus (4 specimens): 0.035–0.050 mm. Shell thickness last volution: 0.015–0.025 mm.

Description.—Test is small, discoidal, nonumbilicate and partially evolute. Coiling is skewed throughout, but, in a few specimens, the last volution coils in one plane. The interior whorls are tightly enrolled whereas the last volution generally expands rapidly in height. Initial septa are quite small, but the ones in the last whorl are of moderate length, thick and pointed forward. The chambers have a characteristically asymmetric shape. Septal sutures are commonly depressed so that in many cases the periphery is moderately to strongly lobate. Wall is generally dark, granular calcite although some specimens have inclusions of larger, light colored grains. Aperture is a low, basal opening.

Discussion.—The asymmetric chambers, rate of expansion and number of chambers in the last whorl and lobate periphery of these specimens closely resemble the type material of Rauzer-Chernousova. *S. primaeva* (Chernysheva), 1940 differs primarily in having more symmetrically shaped chambers and generally a smoother periphery and a more tightly coiled final volution.

Skipp *et al.* (1966, p. 19) noted the apparent synonymy of *Granuliferella granulosa* E. J. Zeller, 1957 with the present species and proposed that *G. granulosa* is not an ancient endothyrid, as previously thought, but a tournayellid. Many specimens of *S. primaeva* (Rauzer-Chernousova), however, are completely septate with the later septa being thick and well developed. This complete and well developed septation is not ordinarily found in the Tournayellidae and, therefore, *S. primaeva* (Rauzer-Chernousova) may, in truth, be more closely related to the Endothyridae.

Occurrence.—Zone 7 (CP 5) Crystal Pass Limestone and (D 1) Dawn Limestone; zone 8 (?D 7) Dawn Limestone at Arrow Canyon Range. Zone 7 (J 1, J 2) Joana Limestone at Ward Mountain.

Genus Septatournayella Lipina, 1955

Type species: *Tournayella segmentata* Dain, 1953.

Description.—Test is small to medium in size, discoidal, mostly evolute and umbilicate on both sides. The proloculus is followed by a variably expanding, generally planispirally coiled, tubular chamber of two to six volutions. In a few specimens the initial volutions are slightly skewed. Septa are well developed in the outer volutions but are limited to slight wall constrictions or are lacking in the interior ones. One species has nodular secondary deposits on the chamber floors. The wall is calcareous, dark and microgranular although some larger, light colored grains are scattered throughout the matrix. The aperture was not seen but is reported to be simple, terminal and basal.

Discussion.—The distinct septa in the last volutions distinguish this genus from *Tournayella* and *Eoforschia* which also has a thick, agglutinated wall.

The planispiral coiling separates *Septatournayella* from the remaining tournayellids.

Septatournayella praesegmentata
Bogush and Yuferev, 1960
Plate 3, figures 6, 7

Septatournayella praesegmentata Bogush and Yuferev, 1960, p. 26, pl. 1, fig. 11; Bogush and Yuferev, 1962, pp. 115–116, pl. 2, fig. 26; Lipina, 1965, p. 43, pl. 8, figs. 10–11.

Measurements.—(based on 2 specimens) Number of volutions: about 2. Number of chambers in last volution: 6½. Diameter: 0.21–0.23 mm. Interior diameter of proloculus: 0.045–0.050 mm. Shell thickness last chamber: 0.010–0.015 mm.

Description.—Test is probably discoidal, evolute and umbilicate. Coiling is planispiral although there may be some slight distortion in the last volution. The whorls expand slowly in height. The interior of the first volution is smooth or has slight constrictions which develop into short, thick septa in the outer whorl. Chambers are more inflated posteriorly than anteriorly, giving an asymmetrically lobate outline to the periphery. Large light colored grains are interspersed in the dark, microgranular matrix. Aperture is apparently a very low, basal opening. No axial sections were seen.

Discussion.—The dimensions of the present specimens agree well with those of Bogush and Yuferev (1962) and Lipina although the asymmetrical inflation of the last chambers appears greater in mine. This species differs from others of *Septatournayella* in its smaller size and fewer volutions.

Occurrence.—Zone 15 (Y 4) Yellowpine Limestone at Arrow Canyon Range.

Septatournayella tumula
(E. J. Zeller), 1957
Plate 3, figures 8, 9

Plectogyra tumula (part) E. J. Zeller, 1957, p. 697, pl. 77, fig. 5; pl. 79, figs. 7–9.

Carbonella tumula (Zeller). Bogush and Yuferev, 1966, p. 112, pl. 5, fig. 19.

Septabrunsiina tumula (E. J. Zeller). Skipp, 1969, see description of subgenus *Tuberendothyra* (p. 211) and remarks about *Tuberendothyra paratumula* (p. 212).

Measurements.—(based on 7 specimens) Number of volutions: 4–6. Diameter (6 specimens): 0.42–0.66 mm. Width (2 specimens): 0.30–0.33 mm. Width/diameter (2 specimens): 0.61–0.65. Interior diameter of proloculus (3 specimens): 0.040–0.050 mm. Shell thickness last volution: 0.015–0.025 mm.

Description.—Test is medium sized, discoidal and umbilicate on both sides. Coiling is essentially planispiral, evolute or partially evolute although the initial one to two volutions are slightly skewed in some specimens. The interior whorls expand moderately and steadily in contrast to the rapid expansion of the exterior volution. Septa are short, thick, V-shaped and pointed anteriorly. Chambers are moderately inflated between septa; the periphery is lobate. Low, but massive, unconnected mounds line the floor of the chambers. Wall is dark and granular with some small areas of light colored calcite suggestive of a discontinuous middle layer. Aperture was not clearly seen.

Discussion.—The coiling, secondary deposits and the number of volutions of these specimens are similar to Zeller's figures. However, the expansion of the last volution is greater, and the diameter is slightly larger.

Skipp assigns this species to *Septabrunsiina* because of the initial coiling skewness. Bogush and Yuferev evidently consider the secondary basal mounds to be part of the aperture and assign the species to *Carbonella* Dain, 1953, a genus characterized by a central aperture.

Occurrence.—Zone 8 (D 3, D 5) Dawn Limestone at Arrow Canyon Range. Zone 8 (J 5) Joana Limestone at Ward Mountain.

Genus Tournayella Dain, 1953

Type species: *Tournayella discoidea* Dain, 1953.

Description.—Test is small to medium sized, discoidal, evolute and umbilicate on both sides. The second tubular chamber in many cases is constricted by slight wall thickenings which tend to divide the tube into pseudochambers. Coiling is essentially planispiral, and the rate of expansion of the coil is generally slow. The thin walls are composed of dark, microgranular calcite interspersed with lighter, coarse grained crystals, and appear layered in places. The aperture was not seen but is reported to be a simple basal opening at the end of the tubular chamber.

Discussion.—The slight constriction of the tubular chamber distinguishes this genus from the smooth-tubed *Cornuspira* Schultze, 1854. The coiling and wall structure appear quite similar in these two genera. *Eoforschia* differs in having a thick, agglutinated wall.

Tournayella discoidea Dain, 1953
Plate 3, figures 10–15

Tournayella discoidea Dain, *in* Dain and Grozdilova, 1953, pp. 32–33, pl. 2, figs. 8–17; Bogush and Yuferev, 1962, p. 113, pl. 2, figs. 22–23; Lipina, 1965, pp. 27–28, pl. 1, figs. 23–29; Bogush and Yuferev, 1966, pp. 109–110, pl. 5, figs. 8–10; Skipp *et al.*, 1966, pp. 27–28, pl. 2, figs. 1–9; pl. 3, fig. 2.

Measurements.—(based on 9 specimens) Number of volutions 3½–5. Diameter: 0.29–0.49 mm. Width (5 specimens): 0.12–0.16 mm. Width/diameter (5 specimens): 0.30–0.41. Interior diameter of proloculus (4 specimens): 0.040–0.060 mm. Shell thickness last volution: 0.010–0.020 mm.

Description.—Test is small to medium sized, discoidal, evolute and shallowly umbilicate on both sides. The coiling is essentially planispiral although some specimens show a slight skewness in the initial volution and slight sinuosity in later whorls. The coil expands slowly in height, but the last whorl may expand more rapidly. Small bulges on the interior wall slightly constrict the tubular chamber, yet the peripheral outline is smooth. The number of pseudochambers in the last volution could not be ascertained. Secondary deposits are generally absent; however, the walls of one specimen (plate 3, figure 10) appear laterally thickened, and another specimen (plate 3, figure 12) has an apparent basal mound on the floor of the last volution. The dark, microgranular wall has light colored grains scattered throughout and is discontinuously layered. Aperture was not seen.

Discussion.—These forms closely fit the dimensions of Dain's and Lipina's specimens but are much smaller than those of Skipp *et al.* which appear related to the variety *T. discoidea* Dain *forma maxima* Lipina, 1955.

Occurrence.—Zone 8 (D 6) Dawn Limestone; zone 15 (Y 2, Y 3, Y 4) Yellowpine Limestone at Arrow Canyon Range. Zone 8 (J 5) Joana Limestone at Ward Mountain.

Genus Uviella Ganelina, 1966

Type species: *Uviella aborigena* Ganelina, 1966.

Description.—Having only one specimen of *Uviella*, I cannot adequately describe its variations. But according to Ganelina (1966, p. 81–82) the genus has three and one-half to six and one-half volutions. The first one and one-half to two and one-half whorls are skew coiled to the remaining evolute, planispiral ones. Diameter is 0.58–1.08 mm; width is 0.40–0.58 mm. The first planispiral whorls have slight wall constrictions which develop into rudimentary septa in the outer volutions. The wall is commonly agglutinated with numerous inclusions of light colored calcite grains in a fine to coarsely granular matrix. In a few specimens the wall has a central light colored layer. Aperture is a narrow opening at the end of the coil.

Discussion.—In its manner of coiling *Uviella* resembles *Septabrunsiina, Uvatournayella* Ganelina, 1966 and *Brunsiina* Lipina, 1953. The thick agglutinated wall distinguishes it from the thin walled, non-agglutinated *Septabrunsiina. Uvatournayella* has a similar wall but is non-septate, and *Brunsiina* differs in being both non-septate and non-agglutinated. The present genus also has a wall similar to *Eoforschia* which, however, is completely planispiral and lacks septa.

Ganelina (1966, p. 82) reports the genus occurring in the Upper Devonian-lower Tournaisian (upper Kinderhook) Etroeungt layers and the upper Tournaisian (upper Osage) Cherepet and Kizel horizons in the U.S.S.R. My specimen is younger, being of late Visean (late Meramec) age.

Uviella sp. A
Plate 3, figure 19

Measurements.—(based on 1 specimen) Number of volutions: 5. Diameter: 0.70 mm. Interior diameter of proloculus: 0.055 mm.

Description.—Test is medium sized. The first volution is skewed at a large angle to the essentially planispiral younger whorls. The rate of expansion of the whorls is steady and moderate although the end of the last volution appears more inflated. The septa, extending back to the first planispiral volution, are short and curved well forward. The interior chambers appear slightly lobate. The shape of the outer chambers could not be determined from this section. The wall is thick and agglutinated. Large, light colored calcite grains are embedded in a finer, dark, calcite groundmass. The aperture was not seen.

Discussion.—This specimen differs from Ganelina's generic description (1966) in having fewer skewed whorls and more septa. Although the angle of the section is improper for determining many parameters, the manner of coiling, septation and wall structure are exposed well enough to assign this form to *Uviella*.

Occurrence.—Zone 15 (Y 3) Yellowpine Limestone at Arrow Canyon Range.

Subfamily CHERNYSHINELLINAE
Reitlinger, 1958

Test is small to medium in size. Most specimens are skew coiled throughout. Distinct sutural depressions and anteriorly pointed septa, starting in the initial volutions, partition the shell into convex chambers. The periphery is lobate. In other specimens the skewed volutions are followed by an erect chambered tube. Aperture is a simple opening at the end of the last chamber.

Genus **Chernyshinella** Lipina, 1955

Type species: *Endothyra glomiformis* Lipina, 1948.

Description.—The test is small to medium sized and contains one to four, simple to highly skewed, almost glomospiral, volutions. The height of the whorl increases slowly to moderately. Septa develop from the initial chamber and are generally short and pointed well forward. The chambers, which number three to six in the last volution, characteristically inflate rapidly at the posterior end and flatten out anteriorly. Sutures are depressed and the periphery is lobate. Well developed secondary mounds and thickened walls surround the proloculus in one species. The wall composition is commonly dark, microgranular to coarse granular, unlayered calcite although some forms have larger, light colored grains scattered throughout the wall, developing partially into a coarse grained middle layer. Aperture is a basal slit.

Discussion.—The highly asymmetric chamber shape, more lobate periphery and complete septation distinguish *Chernyshinella* from the closely related skew coiled genus *Septaglomospiranella*.

Chernyshinella cf. **C. disputabilis** Dain, 1958
Plate 3, figure 16

Chernyshinella disputabilis Dain, *in* Bykova *et al.*, 1958, pp. 18–19, pl. 4, figs. 4a–b, 5–6; Lipina, 1965, pp. 82–83, pl. 18, figs. 21–22; Ganelina, 1966, pp. 91–92, pl. 7, figs. 8–9; Brazhnikova *et al.*, 1967, pl. 4, figs. 5–6; Aizenverg *et. al.*, 1968, pl. 2, figs. 5–6.

Measurements.—(based on 1 specimen) Number of volutions: 1. Number of chambers in last volution: 3. Diameter: 0.35 mm. Interior diameter of proloculus: 0.065 mm. Shell thickness last chamber: 0.040 mm.

Description.—Test is small and nearly planispirally coiled. The large proloculus is followed by chambers of constantly high interior height. The chambers inflate moderately at the posterior end and are separated by short, thick septa angled well forward. The peripheral shape is square. Secondary thickenings may be deposited around the proloculus. Wall is thick, dark, granular and unlayered. Aperture is a large, basal opening.

Discussion.—This figured specimen has fewer chambers in the outside whorl and one-half volution less than those of Dain's type material, but square periphery, chamber shape, and large proloculus are identical. Possibly it is a juvenile.

Figured specimens of *Chernyshinella oldae* (Grozdilova and Lebedeva), 1954 look quite similar to *C. disputabilis* but supposedly differ in having a smoother periphery and less convex chambers (Lipina, 1965, p. 83). Unquestionably these two species must be closely related.

Occurrence.—Zone 7 (CP 5) Crystal Pass Limestone and (?D 1) Dawn Limestone at Arrow Canyon Range.

Chernyshinella glomiformis (Lipina), 1948
Plate 3, figure 18

Endothyra glomiformis Lipina, 1948, p. 254, pl. 19, fig. 9; pl. 20, figs. 1–3; Malakhova, 1956b, p. 106, pl. 5, figs. 9–10.

Chernyshinella glomiformis (Lipina). Lipina, 1955, pp. 48–49, pl. 5, figs. 4–7; Durkina, 1959, p. 154, pl. 7, figs. 2, 5–7; Lipina, 1965, pp. 84–85, pl. 18, fig. 30; pl. 19, figs. 1–10; Bogush and Yuferev, 1966, p. 137, pl. 8, figs. 15–16; Ganelina, 1966, p. 89, pl. 7, figs. 5–7; Brazhnikova *et al.*, 1967, pl. 5, figs. 4–5, 9; Aizenverg *et al.*, 1968, pl. 2, figs. 2–3.

Chernyshinella glomiformis (Lipina) forma *typica* Lipina. Conil and Lys, 1964, p. 147, pl. 21, figs. 417–423.

Measurements.—(based on 1 specimen) Number of volutions: about 4. Number of chambers in last volution: 4. Diameter: 0.40 mm. Shell thickness last chamber: 0.025 mm.

Description.—Test is small. The coiling is highly skewed although the last volution tends to be planispiral. The whorls expand moderately in height. The short, anteriorly directed septa separate the tear-shaped chambers whose rapid posterior inflation causes a rather deep sutural depression and a highly lobate periphery. The wall is composed predominantly of dark, granular calcite, but in some areas there is a hint of a coarse grained, light colored, middle layer. Aperture is a small, basal opening.

Discussion.—This form differs from *Chernyshinella paucicamerata* Lipina in having fewer chambers in the last volution, more convex chambers and greater sutural depressions.

Occurrence.—Zone 7 (CP 5) Crystal Pass Limestone at Arrow Canyon Range.

Chernyshinella paucicamerata Lipina, 1955
Plate 3, figure 17

Chernyshinella paucicamerata LIPINA, 1955, pp. 50–51, pl. 5, figs. 13–15; CONIL and LYS, 1964, p. 148, pl. 21, figs. 426–427; LIPINA, 1965, p. 86, pl. 19, figs. 12–14; BRAZHNIKOVA *et al.*, 1967, pl. 5, fig. 7.

Plectogyra anteflexa (part) E. J. ZELLER, 1957, p. 698, pl. 81, fig. 12.

Measurements.—(based on 1 specimen) Number of volutions: 3½. Number of chambers in last volution: 6. Diameter: 0.29 mm. Shell thickness last chamber: 0.025 mm.

Description.—Test is small and highly skewed. Each volution is coiled at approximately 90° to the preceding one. The rate of expansion of the coil is slow. Septa are small and have a strong anterior direction. The chambers are asymmetrically convex but not highly inflated. Sutures are only slightly depressed, and the periphery is mildly lobate. Wall is dark, granular calcite with some patches of lighter coarse grains suggestive of a middle layer. Aperture was not seen but is probably a very low opening at the base of the last chamber.

Discussion.—This specimen is a little smaller than Lipina's figured specimens. The "Discussion" of *Cherynshinella glomiformis* (p. 32) distinguishes these two species.

McKay and Green (1963, p. 36) note the resemblance between *Plectogyra anteflexa* E. J. Zeller, 1957 and *Chernyshinella*. Skipp (1969, pp. 223–224) places some of Zeller's figured specimens in *Chernyshinella* and others in *Septaglomospiranella*. At least one of Zeller's forms (1957, pl. 81, fig. 12) is very similar to *C. paucicamerata*. Lipina (1965, pp. 52–53) places two of his specimens (Zeller, 1957, pl. 79, fig. 10; pl. 81, fig. 11) into the genus *Septabrunsiina*.

Occurrence.—Zone 7 (J 2) Joana Limestone at Ward Mountain.

Chernyshinella tumulosa Lipina, 1955
Plate 3, figures 20–22

Chernyshinella tumulosa LIPINA, 1955, p. 51, pl. 5, figs. 16–18; LIPINA, 1965, p. 87, pl. 20, figs. 1–4; BOGUSH and YUFEREV, 1966, p. 138, pl. 8, figs. 17–18; GANELINA, 1966, p. 92, pl. 7, figs. 17–18.

Measurements.—(based on 9 specimens) Number of volutions: 1–1½. Number of chambers in last volution (8 specimens): 3–4. Diameter: 0.28–0.52 mm. Width (1 specimen): 0.19 mm. Width/diameter (1 specimen): 0.50 Interior diameter of proloculus (7 specimens): 0.065–0.120 mm. Shell thickness last volution: 0.010–0.030 mm.

Description.—Test is small to medium in size, discoidal and partially evolute. When present, the interior one-half volution is slightly skewed. The chambers of the exterior volution are high and ordinarily of constant height. Septa are thick, short to moderate in length and pointed moderately forward. The unilateral inflation of the chambers is not highly pronounced, but the sutures are depressed and the periphery is generally lobate. The large proloculus is surrounded by a thick wall and large nodes. These deposits are probably secondary thickenings secreted at the base of the exterior chambers. Wall is mostly dark, microgranular to coarse grained calcite. Large, light colored grains are scattered throughout the darker matrix in some specimens whereas others exhibit a coarse, light, middle layer. Aperture was not seen.

Discussion.—The orientation of the septa in these specimens is not as far forward as is common in this genus nor is the asymmetrical inflation of the chambers as well developed, although the characteristic chernyshinellid shape is still apparent.

The thickened prolocular wall and tubercles distinguish this species from others of the genus.

Occurrence.—Zone 7 (? CP 5) Crystal Pass Limestone and (D 1, ?D 2) Dawn Limestone; zone 8 (D 3, D 5, D 6) Dawn Limestone at Arrow Canyon Range. Zone 8 (J 5) Joana Limestone at Ward Mountain.

Genus **Palaeospiroplectammina** Lipina, 1965

Spiroplectamminoides SKIPP, 1969, pp. 227–228, pl. 24, figs. 8–12.

Type species: *Spiroplectammina tchernyshinensis* Lipina, 1948.

Description.—Test is small to medium sized and distinctly bimorphic. The initial portion of the shell has one to one and one-half volutions similar to *Chernyshinella* in coiling, segmentation and peripheral outline. The outer volution contains four to six chambers. The later portion is an erect biserial tube of two to seven tiers which has a greater total volume than the coiled portion. Wall is dark, granular calcite interspersed with lighter colored grains. Aperture appears to be a small opening at the base of the last chamber.

Discussion.—Lipina (1965, p. 92) considered *Palaeospiroplectammina* to be an intermediate stage between the families Tournayellidae and Textularidae. The chernyshinellid features of the initial whorls ally the genus to the tournayellids.

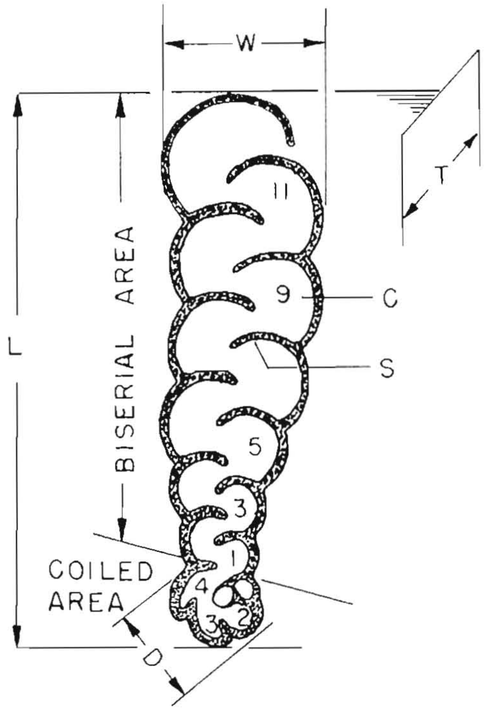

FIGURE 10

Sagittal section of *Palaeospiroplectammina.* L, length; W, width; T, thickness; D, diameter of coiled area; C, chamber; S, septum; 4 chambers in the coiled area, 12 in the biserial area; 6 biserial tiers (redrawn from Conil and Lys, 1964).

Other calcareous Carboniferous forms with initial endothyrid coiling were placed by Lipina (1965) in the long-ranging textularid genus *Spiroplectammina* but have since been shifted to a new endothyrid genus, *Endospiroplectammina* (Lipina, 1970).

For foraminifers morphologically similar to *Spiroplectammina* but having an apparently secreted wall, Skipp (1969) created a new genus, *Spiroplectamminoides*, and placed it in the family Palaeotextularidae. However, during publication of her paper, Skipp became aware of *Palaeospiroplectammina* and suggested that the two genera are probably the same. As many of the species that Skipp associates with her new genus, such as *Spiroplectammina parva* Chernysheva, 1940, *S. tchernyshinensis* Lipina, 1948 and *S. guttula* Malakhova, 1954 have been included in Lipina's description of *Palaeospiroplectammina*, and because Skipp's specimens have chernyshinellid features, it is clear that *Spiroplectamminoides* is a synonym of *Palaeospiroplectammina*.

According to Lipina (1965, pp. 90, 92) *Palaeospiroplectammina* differs primarily from the subgenus *Birectochernyshinella* (genus *Chernyshinella*) in having the biserial area larger than the coiled portion.

Figure 10 illustrates the important parameters of *Palaeospiroplectammina*.

Palaeospiroplectammina parva
(Chernysheva), 1940

Plate 3, figure 23

Spiroplectammina parva CHERNYSHEVA, 1940, p. 130, pl. 2, figs. 1–2.

Palaeospiroplectammina parva (Chernysheva). LIPINA, 1965, p. 94, pl. 22, figs. 8–11; BRAZHNIKOVA *et al.*, 1967, pl. 5, fig. 3; LIPINA, 1970, pl. 2, fig. 4.

Spiroplectamminoides cf. *S. parva* (Chernysheva). SKIPP, 1969, p. 228, pl. 24, figs. 9–10, 12.

Measurements.—(based on 1 specimen) Length: 0.51 mm. Width of biserial chambers: 0.33 mm. Diameter of coiled area: 0.32 mm. Number of volutions in coiled area: about 1. Number of chambers in last volution: 4. Number of chambers in biserial area: 3. Shell thickness last chamber: 0.035 mm.

Description.—Test size is medium. Short, thick, anteriorly directed septa divide the initial coiled volution into slightly lobate chambers on top of which grows an erect two tiered biserial tube. The septa in the biserial area are long, curved, and slightly thickened at their lower end. Chambers are large and moderately inflated. Wall is dark, granular calcite. Aperture was not seen but is probably a low, basal slit.

Discussion.—This specimen differs from the holotype in being slightly larger and having one less biserial tier. The ratio of coil diameter/length, reported to be one-third to one-half by Lipina and Skipp, is almost two-thirds in this specimen. However, the number of whorls and chambers in the coiled portion and the overall shape are similar to previously described specimens of this species. Were another biserial tier added, my specimen would have dimensions similar to Skipp's specimens from the Redwall Limestone. Possibly mine is a juvenile.

Occurrence.—Zone 7 (CP 5) Crystal Pass Limestone at Arrow Canyon Range.

Palaeospiroplectammina tchernyshinensis
(Lipina), 1948

Plate 3, figures 25–28

Spiroplectammina tchernyshinensis LIPINA, 1948, pp. 256–257, pl. 20, figs. 4–8; MALAKHOVA, 1956b, pp. 121–122, pl. 15, fig. 8; DURKINA, 1959, p. 221, pl. 24, fig. 3.

Spiroplectammina species MCKAY and GREEN, 1963, p. 28, pl. 1, figs. 7, 13.

TABLE 6

Genera and subgenera of the Endothyridae.

Endothyra	
Subgenus *Endothyra*:	skew coiled; partially to completely evolute; sparse to well developed, commonly connected, secondary basal deposits; layered and unlayered wall
Subgenus *Globoendothyra*:	skew coiled; involute; secondary basal deposits thinly connected or not; thick, three-layered wall
Subgenus *Tuberendothyra*:	skew coiled; partially evolute; large, unconnected, club-shaped, secondary basal deposits; mostly unlayered wall
Eoendothyranopsis:	planispirally coiled; involute; layered wall; secondary deposits
Plectogyrina:	innermost whorls planispiral and evolute, last whorl involute and at approximately 90° angle to penultimate whorl; layered wall; secondary deposits

Palaeospiroplectammina tchernyshinensis (Lipina). LIPINA, 1965, pp. 92–93, pl. 21, figs. 8–17; AIZENVERG *et al.*, 1968, pl. 1, figs. 8–10; LIPINA, 1970, pl. 2, figs. 1–2.

Rectochernyshinella tchernyshinensis (Lipina). GANELINA, 1966, pp. 93–94, pl. 8, figs. 5–6.

Palaeospiroplectammina tchernyshinensis subsp. *tchernyshinensis* (Lipina). BRAZHNIKOVA *et al.*, 1967, pl. 5, figs. 1–2.

Spiroplectamminoides cf. *S. tchernyshinensis* (Lipina). SKIPP, 1969, pp. 228–229, pl. 24, figs. 8, 11.

Measurements.—(based on 4 specimens) Length (3 specimens): 0.60–0.75 mm. Width of biserial chambers (2 specimens): 0.20–0.21 mm. Diameter of coiled area (2 specimens): 0.14–0.18 mm. Number of volutions in coiled area (2 specimens): 1. Number of chambers in last volution (2 specimens): 4–5. Number of chambers in biserial area (3 specimens): 9–12. Interior diameter of proloculus (1 specimen): 0.040 mm. Shell thickness biserial chambers: 0.015–0.025 mm.

Description.—Test is medium in size. The small initial coil is followed by a slightly expanding, erect biserial tube of five to six tiers in mature specimens. The coiled portion forms about one-fourth the length of the shell. Chambers in the coiled area are small and slightly lobate. The biserial chambers are relatively large and well inflated, and their septa are thick but lack secondary deposits. Wall appears to be a mixture of light and dark granular calcite. Aperture was not seen.

Discussion.—These specimens are smaller than Skipp's Redwall forms but fit within the dimensions of those described by Lipina. A juvenile specimen is illustrated on Plate 3, figure 25.

Occurrence.—Zone 7 (D 1) Dawn Limestone at Arrow Canyon Range.

Palaeospiroplectammina sp. A

Plate 3, figure 24

Measurements.—(based on 1 specimen) Length: 0.35 mm. Width of biserial chambers: 0.21 mm. Diameter of coiled area: 0.16 mm. Number of volutions in coiled area: 1½. Number of chambers in last volution: about 6. Number of chambers in biserial area: 6. Interior diameter of proloculus: 0.045 mm. Shell thickness last chamber: 0.020 mm.

Description.—Test is small. One and one-half skew coiled volutions are followed by three biserial tiers of chambers. The biserial chambers initially grow beside the coiled area and then rise up above. Septa in the coiled area are small and indistinct, and the small chambers are lobate. The biserial chambers are relatively large, and their septa are long, slightly curved but not secondarily thickened. The wall is composed of light colored grains embedded in a dark, microgranular matrix. Aperture is probably low and basal.

Discussion.—This form is quite similar in appearance and dimensions to *Palaeospiroplectammina parva* (Chernysheva) but differs in that the biserial chambers first grow laterally to the coiled area instead of directly above.

Occurrence.—Zone 7 (J 1) Joana Limestone at Ward Mountain.

Family ENDOTHYRIDAE Rhumbler, 1895

Three genera, *Eoendothyranopsis*, *Plectogyrina* and *Endothyra* including three subgenera, *Endothyra*, *Globoendothyra* and *Tuberendothyra*, represent the Endothyridae in this study. Table 6 distinguishes the genera and subgenera.

Of all the families of the Endothyracea this one has the most extensively developed secondary deposits. In sagittal view, typical septal deposits in-

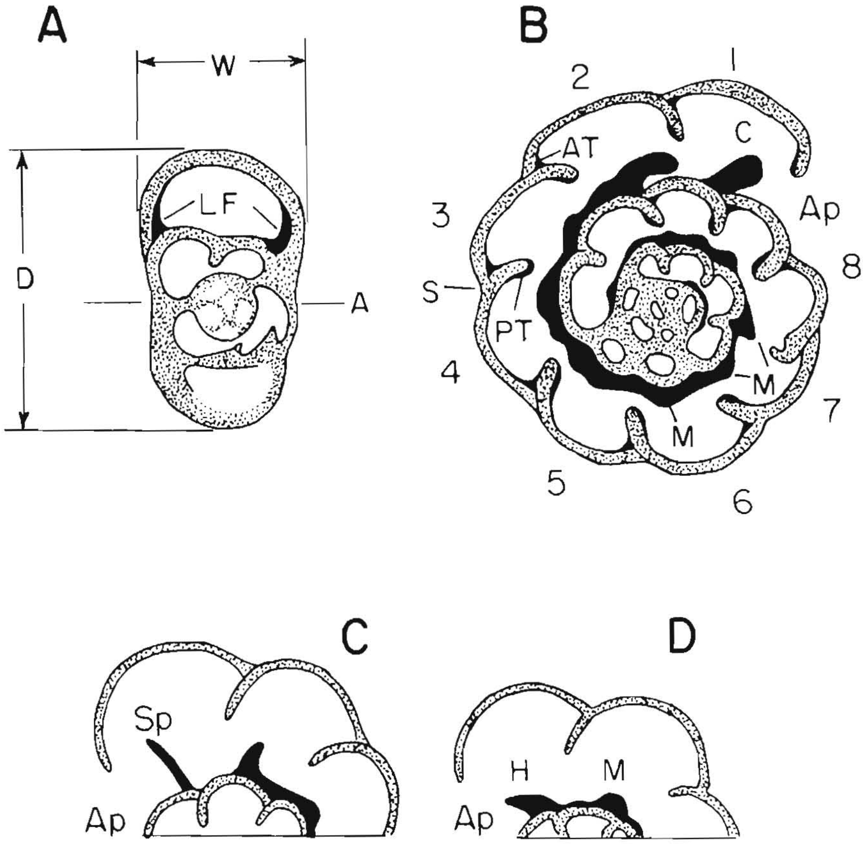

FIGURE 11

Morphological features of *Endothyra*. Dark areas represent secondary deposits. A.—Axial section showing skew coiling; W, width; D, diameter; A, axis of coiling of last volution; LF, lateral chamber fillings. B.—Sagittal section of slightly skew coiled form with 8½ chambers in last volution; Ap, aperture; S, septal suture; C, club-shaped basal deposit; AT, anterior thickening at septal join; PT, posterior septal thickening; M, basal mounds connected by thick floor covering. C.—Sagittal section; Ap, aperture; Sp, basal spine. D.—Sagittal section; Ap, aperture; H, hamulus (basal hook); M, basal mound probably resorbed remnant of former hamulus (modified from Conil and Lys, 1964).

clude thickenings on the anterior side at the join and on the posterior side. Basal deposits include large, club-shaped projections, spines, hooks (hamuli) and mounds joined by connecting deposits in some specimens. All these basal protuberances are actually continuous ridges situated behind and parallel to the septa. In axial view, lateral chamber fillings and paired mounds resembling rudimentary chomata are seen in some specimens although these two deposits are much better developed in the Quasiendothyridae. Figure 11 illustrates a variety of these deposits. Other forms (*e.g. Endothyra torquida*), however, lack some or most secondary deposits.

The wall can be a fine to coarse grained homogeneous layer or can exhibit two or three layers. The three-layered wall is composed of a central thick tectum and thin, upper and lower tectoria. As layered and unlayered walls are seen in the same specimen, secondary alteration may account for the homogeneous walls commonly reported as primary.

Species are distinguished on a combination of parameters including size, number of volutions, number of chambers per volution, amount and shape of secondary deposits and peripheral outline.

Genus **Endothyra** Phillips, [1846], emend. Brady, 1876

Subgenus **Endothyra** Phillips, [1846], emend. Brady, 1876, emend. Skipp, 1969

Type species: *Endothyra bowmani* Phillips, [1846], emend. Brady, 1876.

Description.—Test is small to medium, discoidal and umbilicate or non-umbilicate. The two to four volutions commonly are partially evolute and skew coiled, but the last whorl is more or less planispiral and has five to nine chambers. One species, however, is evolute and almost planispirally coiled throughout. The rate of expansion of the coil is moderate to rapid. Septa are medium or long, straight or curved and oriented perpendicular to the wall or pointed forward. They can be devoid of any secondary deposits or, more likely, be thickened anteriorly at the septal join and on the posterior side. The chambers are flush with the septal sutures or inflated either in a regular convex shape or with a slight asymmetry; the peripheral outline is smooth to highly lobate. Where present, secondary basal deposits are developed as thick, connected, tuberculate or relatively smooth floor coverings, also filling in the sides of the chambers in some specimens. The wall varies from dark, homogeneous, fine grained calcite to a three-layered structure. Aperture is a simple, low to high, basal opening in sagittal sections. In those species seen as whole specimens, the aperture is crescent-shaped.

Discussion.—Specimens of *Endothyra apposita*, *E. bowmani*, *E. excellens* and *E. rugosa* are similar to the subgenus *Globoendothyra* in coiling, secondary deposits and wall structure. However, they differ from *Globoendothyra* in being generally smaller, more compressed in axial view, partially evolute and commonly having a thinner wall and more massive, thickly connected, secondary basal deposits.

Group *Endothyra bowmani*

Many small to medium sized endothyrids closely resemble *Endothyra (E.) bowmani* Phillips, [1846], emend. Brady, 1876 in having three to four skew coiled volutions, generally lobate peripheries, six to nine (commonly seven or eight) chambers in the last whorl and thick, connected, secondary basal deposits. An incomplete list of species with these characteristics includes: *E. acantha* (Conil and Lys), 1964; *E. excellens* (D. Zeller), 1953; *E. irregularis* (E. J. Zeller), 1957; *E. kennethi* St. Jean, 1957; *E. kentuckyensis* (D. Zeller), 1953; *E. maxima* (D. Zeller), 1953; *E. obsoleta* Rauzer-Chernousova, 1948; *E. pandorae* (D. Zeller), 1953; *E. paraprisca* Shlykova, 1951; *E. phrissa* (D. Zeller), 1953; *E. plectogyra* (E. J. Zeller), 1950; and *E. rugosa* (E. J. Zeller), 1957. They have been described from rocks of Meramec, Chester and Desmoines age (Visean, lower Namurian and Westphalian).

These species are distinguished on the basis of the shape of the secondary deposits, degree of lobateness of the periphery, degree of coiling distortion, wall thickness and size. However, the parameters of the species are quite similar, and, in axial sections, distinctions other than size are slight. Mamet has often used the term "group *E. bowmani*" (*e.g.* Mamet, 1970; Mamet and Skipp, 1970) to refer to these species which are separated only by fine distinctions.

Three species, *E. bowmani*, *E. excellens* and *E. rugosa*, of the group *E. bowmani* are described in this study. A fourth species, *E. apposita* Ganelina, is placed here only tentatively because its smoother periphery suggests, instead, a possible relationship with *E. similis* Rauzer-Chernousova and Reitlinger, 1936.

Endothyra (E.) apposita Ganelina, 1956

Plate 3, figures 29, 30

Endothyra apposita GANELINA, 1956, p. 89, pl. 6, figs. 7–8; BOGUSH and YUFEREV, 1966, p. 121, pl. 6, fig. 17; CONIL and LYS, 1968, p. 516, pl. 6, figs. 67–68; DVOŘÁK and CONIL, 1969, p. 82, pl. 3, fig. 37.

Plectogyra apposita (Ganelina). CONIL and LYS, 1964, p. 165, pl. 24, figs. 464–468.

Measurements.—(based on 3 specimens) Number of volutions: about 3. Number of chambers in last volution (1 specimen): 6. Diameter: 0.39–0.45 mm. Interior diameter of proloculus (1 specimen): 0.060 mm. Shell thickness last volution: 0.015–0.020 mm.

Description.—Test is small to medium in size. The coiling is highly skewed throughout and the enrollment of the last volution is commonly distorted also. The rate of expansion of the last whorl is rapid; the inner whorls are more tightly coiled. Septa are long and have a slight to moderate anterior direction. Secondary septal deposits are found both at the join and along the posterior side. Chamber inflation between the sutures is slight; the periphery is smooth or mildly lobate.

EXPLANATION OF PLATE 3

All figures × 60

FIGS. PAGE

1–5. *Septaglomospiranella primaeva* (Rauzer-Chernousova), 1948. 29

1. Tangential section, approaching sagittal (UCM 28179a). Sample J 2, Joana Limestone, Ward Mountain.
2. Tangential section, approaching sagittal (UCM 28179b). Sample J 2, Joana Limestone, Ward Mountain.

3. Tangential section (UCM 28129g). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.
4. Axial section (UCM 28129h). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.
5. Tangential section, approaching sagittal (UCM 28129i). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.

6, 7. *Septatournayella praesegmentata* Bogush and Yuferev, 1960. 30
6. Diagonal section (UCM 28155c). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.
7. Sagittal section (UCM 28155d). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.

8, 9. *Septatournayella tumula* (E. J. Zeller), 1957. 30
8. Tangential section (UCM 28182f). Sample J 5, Joana Limestone, Ward Mountain.
9. Broken tangential section, approaching sagittal (UCM 28135g). Sample D 5, Dawn Limestone, Arrow Canyon Range.

10–15. *Tournayella discoidea* Dain, 1953. 31
10. Axial section (UCM 28136c). Sample D 6, Dawn Limestone, Arrow Canyon Range.
11. Tangential section, approaching axial (UCM 28182g). Sample J 5, Joana Limestone, Ward Mountain.
12. Axial section (UCM 28154c). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.
13. Tangential section (UCM 28154d). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.
14. Axial section (UCM 28154e). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.
15. Axial section (UCM 28136d). Sample D 6, Dawn Limestone, Arrow Canyon Range.

16. *Chernyshinella* cf. *C. disputabilis* Dain, 1958. 32
16. Near sagittal section (UCM 28129j). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.

17. *Chernyshinella paucicamerata* Lipina, 1955. 33
17. Tangential section (UCM 28179c). Sample J 2, Joana Limestone, Ward Monutain.

18. *Chernyshinella glomiformis* (Lipina), 1948. 32
18. Tangential section (UCM 28129k). Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.

19. *Uviella* sp. A. 31
19. Diagonal section (UCM 28154f). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.

20–22. *Chernyshinella tumulosa* Lipina, 1955. 33
20. Diagonal section (UCM 28135h). Sample D 5, Dawn Limestone, Arrow Canyon Range.
21. Axial section (UCM 28133b). Sample D 3, Dawn Limestone, Arrow Canyon Range.
22. Diagonal section (UCM 28133c). Sample D. 3, Dawn Limestone, Arrow Canyon Range.

23. *Palaeospiroplectammina parva* (Chernysheva), 1940. 34
23. Near sagittal section (UCM 28129l) Sample CP 5, Crystal Pass Limestone, Arrow Canyon Range.

24. *Palaeospiroplectammina* sp. A. 35
24. Near sagittal section (UCM 28178b). Sample J 1, Joana Limestone, Ward Mountain.

25–28. *Palaeospiroplectammina tchernyshinensis* (Lipina), 1948. 34
25. Sagittal section; juvenile (UCM 28131c). Sample D 1, Dawn Limestone, Arrow Canyon Range.
26. Tangential section (UCM 28131d). Sample D 1, Dawn Limestone, Arrow Canyon Range.
27. Diagonal section (UCM 28131e). Sample D 1, Dawn Limestone, Arrow Canyon Range.
28. Diagonal section (UCM 28131f). Sample D 1, Dawn Limestone, Arrow Canyon Range.

29, 30. *Endothyra (E.) apposita* Ganelina, 1956. 37
29. Diagonal section (UCM 28154g). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.
30. Tangential section, approaching sagittal (UCM 28153b). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.

31. *Endothyra (E.) bowmani* Phillips, [1846], emend. Brady, 1876. 40
31. Sagittal section (UCM 28165a). Sample IS 1, Indian Springs Formation, Arrow Canyon Range.


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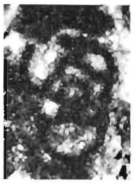
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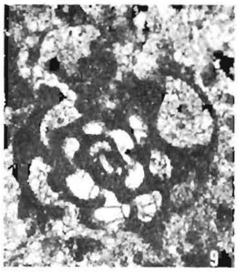
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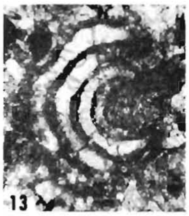
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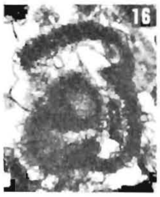
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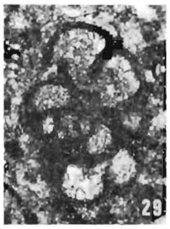
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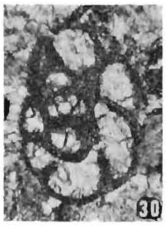
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BRENCKLE: CALCAREOUS FORAMINIFERS FROM NEVADA


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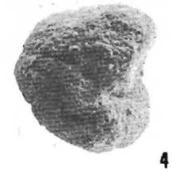
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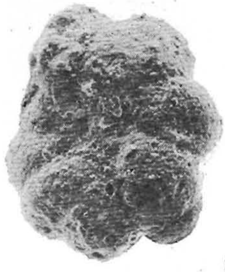
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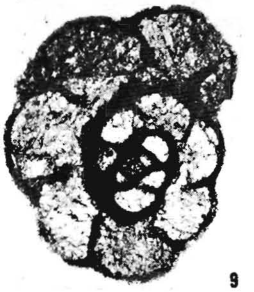
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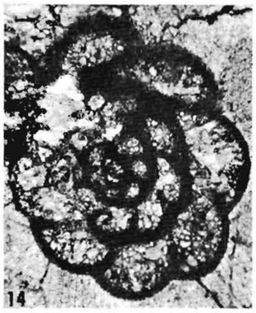
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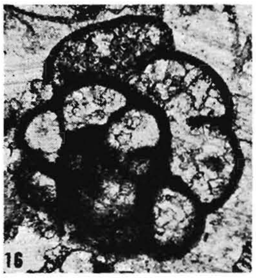
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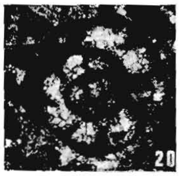
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BRENCKLE: CALCAREOUS FORAMINIFERS FROM NEVADA

EXPLANATION OF PLATE 4

All figures × 60

FIGS. PAGE

1–6. *Endothyra* (*E.*) *bowmani* Phillips, [1846], emend. Brady, 1876. 40
- 1. Axial section (UCM 28166a). Sample IS 2, Indian Springs Formation, Arrow Canyon Range.
- 2. Axial Section (UCM 28154h). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.
- 3. Tangential section, approaching sagittal (UCM 28153c). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
- 4. Whole specimen, side view (UCM 28165b). Sample IS 1, Indian Springs Formation, Arrow Canyon Range.
- 5. Whole specimen, apertural view showing skewed coiling of last volution; second chamber from beginning of last volution is partly damaged (UCM 28165c). Sample IS 1, Indian Springs Formation, Arrow Canyon Range.
- 6. Axial section (UCM 28155e). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.

7–9. *Endothyra* (*E.*) *excellens* (D. Zeller), 1953. 40
- 7. Whole specimen, apertural view showing slightly skewed coiling of last volution (UCM 28166b). Sample IS 2, Indian Springs Formation, Arrow Canyon Range.
- 8. Whole specimen, side view (UCM 28166c). Sample IS 2, Indian Springs Formation, Arrow Canyon Range.
- 9. Sagittal section (UCM 28166d). Sample IS 2, Indian Springs Formation, Arrow Canyon Range.

10–12. *Endothyra* (*E.*) *introjactans* (Conil and Lys), 1964. 41
- 10. Diagonal section (UCM 28155f). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.
- 11. Axial section (UCM 28155g). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.
- 12. Diagonal section (UCM 28155h). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.

13. *Endothyra* (*E.*) *planiformis*? n. sp. 41
- 13. Axial section (UCM 28188a). Questionable specimen from sample Bu 2, Ely Limestone, Butte Mountains.

14–16. *Endothyra* (*E.*) *planiformis* n. sp. 41
- 14. Sagittal section, damaged beneath aperture; holotype (UCM 28170). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
- 15. Tangential section, approaching axial, bottom crushed (UCM 28169b). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
- 16. Tangential section (UCM 28169c). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.

17, 18. *Endothyra* (*E.*) *rugosa* (E. J. Zeller), 1957. 42
- 17. Sagittal section (UCM 28154i). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.
- 18. Diagonal section (UCM 28155i). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.

19, 20. *Endothyra* (*E.*) *torquida* (E. J. Zeller), 1957. 42
- 19. Tangential section, approaching axial (UCM 28155j). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.
- 20. Near sagittal section (UCM 28155k). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.

21–24. *Endothyra* (*E.*) sp. A. 43
- 21. Tangential section; (UCM 28169d). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
- 22. Tangential section (UCM 28169e). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
- 23. Tangential section (UCM 28187a). Sample Bu 1, Ely Limestone, Butte Mountains.
- 24. Tangential section (UCM 28177a). Sample BS 9, Bird Spring Formation, Arrow Canyon Range.

25, 26. *Endothyra* (*E.*)? cf. *E.*? *tumida* (E. J. Zeller), 1957. 43
- 25. Tangential section (UCM 28137c). Sample D 7, Dawn Limestone, Arrow Canyon Range.
- 26. Tangential section, approaching sagittal (UCM 28131g). Sample D 1, Dawn Limestone, Arrow Canyon Range.

The last chamber has a thick forward directed spine. Older chambers in the last whorl have low mounds, regarded as the resorbed remnants of former spines; thin, secondary floor coverings connect the mounds. The wall appears primarily two-or three-layered, and the secondary connecting deposits add another layer. The aperture is a simple, medium sized, basal opening.

Discussion.—According to Conil and Lys (1964, p. 203) *E. apposita* differs from *E. paraprisca paraprisca* Shlykova (see Rozovskaya, 1963, pl. 1, figs. 14–18; Conil and Lys, 1964, pl. 24, figs. 665–667, 1968, pl. 9, figs. 116–118) in having greater coiling distortion (commonly all the chambers of the last volution are not visible), a less lobate periphery and a more sharply defined basal spine in the last chamber. I assigned my specimens to *E. apposita* based on their coiling and peripheral outline. Yet, I do not feel completely confident in separating these species because both have similar numbers of volutions and chambers in the last volution, similar enrollment and secondary deposits and both are of Visean age.

Endothyra kentuckyensis and *E. phrissa* are two lobate Chester species (described by D. Zeller, 1953, pl. 28, figs. 1, 4, 6, 16–17) which bear an extremely close similarity to *E. paraprisca paraprisca* and to each other. The only apparent difference between Shlykova's and Zeller's species is the slightly more massive secondary deposits of the latter forms.

Occurrence.—Zone 15 (Y 2, Y 3) Yellowpine Limestone at Arrow Canyon Range.

Endothyra (E.) bowmani Phillips, [1846], emend. Brady, 1876

Plate 3, figure 31; Plate 4, figures 1–6

Endothyra bowmani Phillips. Brady, 1876, (part) pp. 92–94, pl. 5, figs. 1–2.

Endothyra bowmani Phillips, emend. Brady. Loeblich and Tappan, *in* Loeblich, Tappan *et al.*, 1964, pp. C 343-C 346, fig. 262, 1–2; Mamet, 1970, pl. 6, figs. 1, 3.

Endothyra bradyi, Mikhailov, 1939, p. 51, pl. 4, figs. 1–2.

Measurements.—(based on 16 specimens) Number of volutions (12 specimens): 3–3½. Number of chambers in last volution (7 specimens): 7–8½. Diameter: 0.31–0.43 mm. Width (6 specimens): 0.17–0.23 mm. Width/diameter (6 specimens): 0.46–0.53. Interior diameter of proloculus (4 specimens): 0.030–0.050 mm. Shell thickness last volution (13 specimens): 0.010–0.020 mm.

Description.—Test is small to medium sized, discoidal, partially evolute and slightly umbilicate on one or both sides. Coiling is skewed throughout. In thin section the last one or one and one-half whorls appear planispiral, but the whole specimens (Plate 4, figure 5) show a slight deviation of the coiling axis. The rate of expansion of the last whorl is moderate to rapid. Septa are long, thin and pointed anteriorly at a small angle. Secondary deposits form at the septal join, but no definite posterior thickenings were seen. The chambers are only modestly inflated so that depression of the septal sutures is slight and the peripheral outline is mildly lobate. The floor of the chambers is covered with a thick continuous layer which fills in the corners of some specimens; however, well developed mounds or hooks are missing. The wall is generally dark, granular calcite, but some sections show a faint layering similar to that found in *Endothyra excellens.* The aperture is a low, basal crescent.

Discussion.—Brady considered *E. bowmani* and *Globoendothyra baileyi* (Hall) the same species and figured a cross section of the latter as a sagittal view of *E. bowmani* (1876, pl. 5, fig. 4). The International Commission of Zoological Nomenclature (China, 1965) upon validating *E. bowmani* Phillips, [1846], emend. Brady, 1876 designated Loeblich and Tappan's specimen (1964, fig. 262, 1–2) as the neotype. The cross section of the neotype (fig. 262, 2) is a drawing and provides no information on wall structure and secondary septal deposits. However, the floor of the chambers appears covered by an irregularly shaped thick basal deposit which lacks well developed mounds or spikes. Based on this cross section I have assigned to *E. bowmani* those specimens which have thick basal deposits yet lack prominent protuberances, whereas those *E. bowmani*-like specimens with more tuberculate basal deposits have been assigned to other species. As the shape of the secondary deposits is difficult to determine in axial cuts, some of my axial sections may actually belong to other tuberculate species such as *E. rugosa* (E. J. Zeller). In these sections, size was the differentiating factor.

Globoendothyra baileyi differs from *E. bowmani* in its larger size, general lack of connecting deposits between basal protuberances and a more bulbous shape in axial section.

Many whole specimens of *E. bowmani* were recovered from the shales of the Indian Springs Formation.

Occurrence.—Zone 15 (Y 2, Y 3, Y 4) Yellowpine Limestone; zone 19 (IS 1, IS 2) Indian Springs Formation at Arrow Canyon Range.

Endothyra (E.) excellens (D. Zeller), 1953

Plate 4, figures 7–9

Plectogyra excellens D. Zeller, 1953, p. 198, pl. 28, figs. 8–9.

Measurements.—(based on 3 specimens) Number of volutions (1 specimen): 3½. Number of chambers in last volution: 7–8. Diameter: 0.56–0.60 mm. Width (1 specimen): 0.27 mm. Width/diameter (1 specimen): 0.47. Interior diameter of proloculus (1 specimen): 0.040 mm. Shell thickness last chamber (1 specimen): 0.020 mm.

Description.—Test is medium sized, discoidal, partially evolute and slightly umbilicate on both sides. Coiling is skewed throughout. The last one and one-half whorls appear to be coiled in the same plane, but examination of whole specimens (Plate 4, figure 7) shows a slight rotation of the coiling axis of the final whorl. Expansion of the coil is rapid throughout. Septa are long and oriented slightly to well forward. Secondary septal deposits are found at the join and on the posterior tips of some septa. The chambers in the outer whorl are large and well inflated; the periphery is lobate. Basal secondary deposits are massive. The last chamber has a large hook, and mounds, the remnants of former hamuli, appear in the preceding four or five chambers. Thick deposits connect the mounds and hook. The wall is composed of a primary, thick, less dense tectum flanked by two thin, dark, microgranular tectoria. The outer tectorium, although not preserved in the spirotheca, is also primary because it covers the anterior side of the septa beneath the secondary thickenings at the septal join. The lower tectorium is probably secondary as it is not clearly visible under the secondary septal deposits. The aperture is a high, simple arch.

Discussion.—These specimens were recovered whole from shale of the Indian Springs Formation. Three typical specimens were used for identification. The coiling is quite similar to *E. bowmani*, and in whole specimen *E. excellens* is distinguished from the latter by its larger size and more lobate periphery. In thin section *E. excellens* exhibits better developed mounds and hooks than *E. bowmani.* Because of the invisibility of the basal secondary deposits in whole specimens, identification is best established by thin sectioning.

The single sagittal section of *Endothyra kennethi* St. Jean (1957, pl. 1, fig. 7) is quite similar to *E. excellens* except for a smaller size and a less massive basal deposit in the last chamber. *E. kennethi* is found in calcareous shale of Middle Pennsylvanian age in Indiana.

D. Zeller (1953, p. 198) distinguishes *E. excellens* from similar species, *E. pandorae* (D. Zeller), *E. versabilis* (D. Zeller) and *E. phrissa* (D. Zeller), on the massiveness of the secondary deposits, lobateness, wall thickness and coiling distortion.

Occurrence.—Zone 19 (IS 2) Indian Springs Formation at Arrow Canyon Range.

Endothyra (E.) introjactans
(Conil and Lys), 1964
Plate 4, figures 10–12

Plectogyra introjactans Conil and Lys, 1964, p. 191, pl. 30, figs. 600–605.

Plectogyra aff. *introjactans* Conil and Lys. Omara and Conil, 1965, pp. B232–B233, pl. 2, figs. 12–14; pl. 3, figs. 15–18.

Measurements.—(based on 4 specimens) Number of volutions: 3½–4½. Number of chambers in last volution (1 specimen): 8. Diameter: 0.58–0.63 mm. Width (1 specimen): 0.35 mm. Width/diameter (1 specimen): 0.55. Interior diameter of proloculus (3 specimens): 0.025–0.040 mm. Shell thickness last volution (3 specimens): 0.015–0.025 mm.

Description.—Test is medium sized, discoidal, nearly involute and umbilicate on both sides. Coiling is skew throughout, but the last whorl is more or less planispiral. The last two volutions expand moderately to rapidly; the inner ones are tightly coiled. Septa are long, straight or slightly curved and are oriented perpendicular to the wall or slightly forward. They are secondarily thickened along the anterior side. Chambers are flush with the septa; peripheral outline is smooth. Secondary basal deposits consist of low, broad unconnected mounds. Most specimens exhibit a three-layered wall. The tectum is composed of granular, light and dark colored grains and is flanked by thin, dark, microgranular layers. Aperture was not readily visible and must be a very low, basal opening.

Discussion.—These specimens lack the prominent posterior septal thickenings seen in the type material, but they are similar in most other respects. Conil and Lys do not mention any wall layering, yet their specimens appear three-layered although the tectum is more finely granular than mine.

Occurrence.—Zone 15 (Y 4) Yellowpine Limestone at Arrow Canyon Range.

Endothyra (E.) planiformis n. sp.
Plate 4, figures 13?, 14–16

Measurements.—(based on 3 specimens) Number of volutions (2 specimens): about 4. Number of chambers in last volution (1 specimen): 8. Diameter (1 specimen): 0.60 mm. Width (1 specimen): 0.25 mm. Interior diameter of proloculus (1 specimen): 0.030 mm. Shell thickness last volution: 0.015–0.020 mm.

Description.—Test is medium sized, discoidal, evolute and broadly umbilicate on both sides. The nermost whorl is skewed to the remaining planipiral volutions. Expansion of the coil is steady nd rapid. Septa are of medium length, curved nteriorly and slightly thickened at the join and ess commonly on the posterior end. Chambers are convex and asymmetric. The deep sutural depressions and highly inflated chambers produce a very distinctive scalloped periphery. The last chamber contains a straight, forward pointing spike, and other chambers have low, basal mounds, probably remnants of former spikes. Thin, secondary deposits connect the mounds. There are no lateral fillings. Two specimens have three-layered walls composed of a relatively thick, less dense, granular tectum flanked by two, dark, thin, microgranular tectoria. Aperture is simple, low and basal.

Discussion.—This species is distinguished from other *Endothyra* species by its evolute and almost planispiral enrollment and asymmetrically lobate periphery.

The coiling is quite similar to *Planoendothyra*; however, the highly lobate periphery, curved septa, posterior septal thickenings, secondary basal protuberances and layered wall are much more characteristic of species of the group *Endothyra bowmani*. Although more evolute and not as skew coiled as the *E. bowmani*, this species probably descended from one of its Mississippian members.

A single specimen (Plate 4, figure 13) from the Ely Limestone at the Butte Mountains section is tentatively assigned to this species although it is not included in the description. This specimen is similar in all parameters except for the irregular coiling of a portion of the final volution.

The species name refers to the planispiral coiling of most volutions.

Occurrence.—Morrow (BS 3) Bird Spring Formation at Arrow Canyon Range. Morrow (?Bu 2) Ely Limestone at Butte Mountains.

Endothyra (E.) rugosa (E. J. Zeller), 1957

Plate 4, figures 17, 18

Plectogyra rugosa E. J. Zeller, 1957, p. 699, pl. 78, figs. 3–4.

Measurements.—(based on 3 specimens) Number of volutions: 3. Number of chambers in last volution (1 specimen): 8. Diameter: 0.45–0.48 mm. Interior diameter of proloculus (1 specimen): 0.040 mm. Shell thickness last volution: 0.015–0.020 mm.

Description.—Test is medium sized. The coiling of the outer one and one-half volutions is nearly planispiral and loose; the inner one and one-half whorls are skew coiled and tight. Septa are generally long, straight and pointed slightly forward, and are enlarged secondarily at the join. The chambers are inflated between the septa, and the periphery is moderately lobate. Large mounds, decreasing in size in older chambers, cover the floors of the last few chambers. Thick floor deposits connect the mounds. The microgranular wall consists of a thick, less dense layer; a thin, dark, inner zone; and possibly an even thinner, dark, outer layer. The aperture is a simple, low, basal opening.

Discussion.—*Endothyra rugosa* is distinguished from the very similar species *Endothyra irregularis* (E. J. Zeller), 1957, by its larger size, less lobate periphery, thicker walls and milder coiling distortion. According to Zeller (1957, p. 699), it differs from *Endothyra phrissa* (D. Zeller), 1953 in its smaller proportional chamber size and thinner connecting deposits between mounds.

Occurrence.—Zone 15 (Y 3, Y 4) Yellowpine Limestone at Arrow Canyon Range.

Endothyra (E.) torquida (E. J. Zeller), 1957

Plate 4, figures 19, 20

Plectogyra torquida E. J. Zeller, 1957, pp. 698–699, pl. 75, fig. 33; pl. 78, fig. 7; pl. 80, fig. 27.

Endothyra torquida (E. J. Zeller). Skipp, 1969, p. 207, pl. 21, figs. 15–19; pl. 22, figs. 1–5, 9.

Measurements.—(based on 4 specimens) Number of volutions (3 specimens): 3–3½. Number of chambers in last volution (2 specimens): 8–9. Diameter: 0.30–0.37 mm. Width (1 specimen): 0.17 mm. Width/diameter (1 specimen): 0.49. Interior diameter of proloculus (1 specimen): 0.040 mm. Shell thickness last volution: 0.010–0.015 mm.

Description.—Test is small, discoidal, partially evolute and slightly umbilicate on one side. Coiling is skewed, although the last volution is essentially planispiral, and the whorls expand moderately. Septa are medium to long and are thickened secondarily at the join; most are oriented only slightly forward. The chambers are commonly flush with the septal join, and the peripheral outline is smooth or mildly lobate. Basal secondary deposits are not well developed. The wall is generally dark, granular calcite, but faint layering appears in three specimens. Aperture was not seen.

Discussion.—The measurements of these specimens compare favorably with Zeller's, but mine differ in being less lobate and having less anteriorly angled septa. The last chambers of the present forms are too poorly oriented to determine th presence of a basal hook reported by Zeller Skipp's specimens do not contain a hamulus.

My specimens resemble *Endothyra prisc* Rauzer-Chernousova and Reitlinger, 1936, having an almost smooth peripheral outline but differ in being larger on the average and having more volutions.

Occurrence.—Zone 15 (Y 4) Yellowpine Limestone at Arrow Canyon Range.

Endothyra (E.)? cf. E.? tumida (E. J. Zeller), 1957

Plate 4, figures 25, 26

Granuliferella tumida E. J. ZELLER, 1957, pp. 696–697, pl. 77, figs. 3, 21–22; pl. 81, figs. 14–15, 17–18; WOODLAND, 1958, p. 797, pl. 100, figs. 6–7; McKAY and GREEN, 1963, pp. 46–47, pl. 3, figs. 16–17, 21.

Measurements.—(based on 2 specimens) Number of volutions: about 2½. Number of chambers in last volution: 5–5½. Diameter: 0.29–0.49 mm. Average shell thickness last volution: 0.025 mm.

Description.—Test is small to medium sized. Proloculus is indistinct. The outer one and one-half to two volutions are very loosely coiled and almost planispiral whereas the interior whorl is tight and slightly skewed. Septa are generally short and perpendicular to the wall or angled anteriorly. Septa of the larger specimen (Plate 4, figure 26) are not secondarily thickened, but the short, blunt septa seen in the smaller one (Plate 4, figure 25) were probably shaped by posterior secondary deposits characteristic of the species. The chambers are semicircular and strongly swollen between septa. The peripheral outline is highly lobate. The larger specimen also exhibits a characteristically high tunnel which Zeller (1957, p. 696) thinks is formed by secondary resorption of the septa. Wall is dark, fine to coarse grained calcite. Some larger, light colored grains are also embedded in the wall. Aperture is a low opening in the small specimen and a high basal one in the larger.

Discussion.—The two specimens of this study are quite different in size. The smaller one conforms to Zeller's dimensions and the larger to Woodland's. The lobate periphery, high tunnel, secondary deposits, number of chambers in the last volution, number of whorls and coiling of the present specimens are very much like Zeller's original figures. However, the walls of my specimens are much thicker than expected. Also the larger specimen lacks the characteristic deposits on the septa although these deposits are not well developed in all of Zeller's specimens (cf. Zeller, 1957, pl. 81, figs. 14, 18).

Zeller (1957) applied the name *Granuliferella* to organisms with coarse grained walls and few volutions. The wall structure is quite possibly a product of recrystallization and not a valid morphologic feature. But the complete septation, coiling and secondary septal deposits of *Granuliferella tumida* are characteristic of *Endothyra* and this species should probably be recognized as a primitive member of that genus. However, even if the wall structure of *Granuliferella* is considered primary, a new generic name is needed because the type species *Granuliferella granulosa* E. J. Zeller, 1957, is now considered synonymous with *Septaglomospiranella primaeva* (Rauzer-Chernousova), 1948.

Occurrence.—Zone 7 (D 1) and zone 8 (D 7) Dawn Limestone at Arrow Canyon Range.

Endothyra (E.) sp. A

Plate 4, figures 21–24

Measurements.—(based on 4 specimens) Number of volutions: about 2½. Number of chambers visible at one time in last volution: 4–5. Diameter: 0.20–0.42 mm. Shell thickness last volution (3 specimens): 0.010–0.020 mm.

Description.—Test is generally small. Coiling is skewed throughout. The enrollment of the last volution is especially characteristic of these specimens. The middle portion of the last whorl is commonly missing in side view. Evidently, the initial and final portions of the whorl are nearly in the same plane whereas the middle area twists in a different plane. Expansion of the coil is steady and rapid. The septa are medium to long and slightly thickened at the join. The chambers are flush with the septal join or slightly inflated, and the periphery is correspondingly smooth or mildly lobate in outline. The floor is secondarily thickened. Wall is dark, microgranular calcite, but one specimen seems faintly layered. The aperture is a low to medium, simple, basal opening.

Discussion.—The distorted coiling of the last volution is diagnostic of this group. But sections through the proloculus are needed before assigning a specific name.

Occurrence.—Morrow (BS 3, BS 9) Bird Spring Formation at Arrow Canyon Range. Morrow (Bu 1) Ely Limestone at Butte Mountains.

Endothyra (E.)? sp. B

Plate 5, figures 1, 2

Measurements.—(based on 4 specimens) Number of volutions: 2–2½. Number of chambers in last volution (1 specimen): 7½. Diameter: 0.27–0.32 mm. Width (2 specimens): 0.17–0.19 mm. Width/diameter (2 specimens): 0.57–0.59. Interior diameter of proloculus: 0.025–0.040 mm. Shell thickness last volution: 0.010–0.020 mm.

Description.—Test is small, discoidal, partially evolute and slightly umbilicate on one side. The first one to one and one-half volutions are coiled 90° to the remaining whorls. The rate of expansion of the whorls is steady and rapid. The septa are long, mostly straight and pointed forward. The septal join is filled with small, secondary thickenings. Inflation of the chambers between the joins is small; the peripheral outline is almost smooth. The chamber floors are slightly thickened by secondary deposits. Wall is faintly three-layered. The aperture is low and basal.

Discussion.—These specimens differ from *Endothyra bowmani* in having fewer volutions, a smaller size and thinner basal deposits. They differ from *E. kleina* (Woodland), 1958 in possessing a layered wall and basal secondary deposits. The manner of coiling is similar to that of the juvenarium of *E. planiformis* (see Plate 4, figure 14), but no mature specimens of that species are found in association with the present specimens.

The coiling is also similar to *Planoendothyra*, but the characteristic thick floor coverings and lateral chamber fillings are lacking. However, my specimens could be juveniles of *P. aljutovica* Reitlinger, 1950, which have not yet developed the secondary deposits seen in the last volution of that species.

The thin, basal deposits and enrollment are also found in *Endostaffella* Rozovskaya, 1961. But the number of volutions are too few as the latter genus commonly has two to three volutions in the skew coiled juvenarium alone.

Occurrence.—Morrow (Bu 1) at Butte Mountains.

Subgenus **Globoendothyra** Reitlinger, 1959

Type species: *Globoendothyra pseudoglobulus* Reitlinger, 1959, new name (=*Endothyra globulus* Möller, 1878, not *Nonionina globulus* Eichwald, 1859).

Description.—Test is medium to large, involute, discoidal to subglobular and singly or doubly umbilicate. The initial whorls are slightly to moderately skewed, but the last one or two are commonly planispiral. There are three to five and one-half volutions, and the exterior whorl contains six to eleven chambers. Interior coiling is tight with moderate to rapid inflation of the outer volutions. Septa are short to long and thickened at the septal join and along the posterior side in a few instances. The peripheral outline varies from smooth to moderately lobate, depending on the amount of chamber inflation. Other secondary deposits include mounds or hooks in the last chamber, lower mounds in older chambers and, less commonly, corner fillings. Connecting deposits ordinarily are thin or lacking. The better preserved walls are three-layered, characteristically with a thick, light colored, granular layer (tectum) flanked by two thin, dark, calcareous, microgranular layers (outer and inner tectoria). Aperture is low, basal and simple.

Discussion.—Reitlinger (*in* Rauzer-Chernousova and Fursenko, eds., 1959, p. 196) describes *Globoendothyra* as a separate genus, but I agree with Skipp's (1969, p. 210) subgeneric designation because the characteristics do fit within those of the genus *Endothyra.* The important subgeneric features of *Globoendothyra* are the involute coiling and the thick, three-layered wall. In some specimens the outer tectorium is not preserved and the wall appears two-layered; in others the tectoria are not preserved at all and the wall is a homogeneous granular layer.

Endothyra globulus Möller 1878, (=*Globoendothyra pseudoglobulus* Reitlinger, 1959) may be synonymous with *Nonionina globulus* Eichwald, 1859, (Rozovskaya, 1963, p. 49; Skipp, 1969, p. 210) and, if so, the latter species should then be considered the type for the subgenus.

Endothyra (Globoendothyra) cf. G. gutschicki (Skipp), 1969

Plate 5, figures 9, 10

Endothyra gutschicki Skipp, 1969, p. 202, pl. 22, figs. 14–24.

Measurements.—(based on 3 specimens) Number of volutions: about 3–4. Number of chambers in last volution: 9½–11. Diameter: 0.70–0.88 mm. Interior diameter of proloculus (1 specimen): 0.065 mm. Shell thickness last volution (2 specimens): 0.025–0.040 mm.

Description.—Test is medium to large. The last one to one and one-half whorls are loosely coiled in the same plane. The inner whorls are skew coiled and tight. Septa are long, straight or slightly curved and ordinarily pointed forward; secondary deposits fill the join. The chambers are narrow and well inflated so that the peripheral outline is distinctly lobate. Secondary basal deposits are thin. The wall is faintly three-layered. Aperture is a low, simple, basal opening. No axial sections were seen.

Discussion.—These specimens differ slightly from Skipp's material in having longer septa and more chambers in the last volution. However, the size, chamber inflation, number of volutions, lack of posterior septal thickenings and coiling are quite similar.

These specimens may be more advanced members of the species as Skipp reports her material from the early and middle Meramec (zones 10–12) but these are found in the late Meramec.

Occurrence.—Zone 15 (Y 5) Yellowpine Limestone and (BW 1) Battleship Wash Formation at Arrow Canyon Range.

Endothyra (Globoendothyra) aequiparva new name (=*Globoendothyra parva* (Chernysheva), 1948)*

Plate 5, figures 5–8

Endothyra globulus (Eichwald) var. *parva* CHERNYSHEVA, 1948, p. 247, pl. 18, figs. 5–6.

Globoendothyra parva (N. Chernysheva). BOGUSH and YUFEREV, 1962, pp. 151–152, pl. 5, fig. 5; GANELINA, 1966, p. 115, pl. 12, figs. 8–9.

Measurements.—(based on 17 specimens) Number of volutions (15 specimens): 3–4½. Number of chambers in last volution (7 specimens): 6–7. Diameter: 0.51–0.81 mm. Width (3 specimens): 0.30–0.40 mm. Width/diameter (3 specimens): 0.57–0.65. Interior diameter of proloculus (6 specimens): 0.045–0.065 mm. Shell thickness last volution: 0.015–0.035 mm.

Description.—Test is medium to large, involute, discoidal to subglobular and umbilicate on one side. Coiling is skew throughout, but the last whorl is mostly planispiral. Expansion of the whorls is steady and moderate although the last volution may be more loosely coiled. Septa are short and ordinarily V-shaped because of secondary thickenings at the septal join. A few are thickened on their posterior ends. Chambers are only slightly inflated, and the periphery is smooth to mildly lobate. Basal hooks or large mounds are present in the last chamber of some specimens, and smaller mounds are seen in some of the older chambers. Wall appears two- or three-layered, but poor preservation obliterates much of the structure and leaves it as a granular unlayered deposit. Aperture is low and basal.

Discussion.—Chernysheva described this species as a variety of *Globoendothyra globulus* (Eichwald), 1859. These present specimens differ from *G. globulus* (Eichwald) in being smaller, having fewer whorls, fewer chambers in the last whorl and a thinner wall.

Occurrence.—Zone 15 (Y 5) Yellowpine Limestone and (BW 1, BW 2) Battleship Wash Formation at Arrow Canyon Range.

Endothyra (Globoendothyra) sp. A

Plate 5, figures 3, 4

Measurements.—(based on 7 specimens) Number of volutions (1 specimen): about 4. Number of chambers in last volution (1 specimen): 8. Diameter (4 specimens): 0.65–0.79 mm. Width (1 specimen): 0.37 mm. Width/diameter (1 specimen): 0.57. Shell thickness last volution: 0.025–0.035 mm.

Description.—Test is medium in size, discoidal, involute or possibly partially evolute, and has a broadly rounded periphery. Fragments of larger specimens were seen, but their overall diameter could not be measured. The coiling is skewed. The last whorl is loosely coiled in approximately the same plane. Septa are long, slightly curved, and oriented anteriorly or perpendicular to the wall. They are secondarily thickened at the join and on the posterior side. The large chambers are symmetrically inflated between the septa, and the periphery is moderately lobate. Most specimens have low, unconnected mounds on the chamber floors of the last whorl. The wall varies from a coarse granular homogeneous mass to an apparent three-layered structure in which the granular layer is flanked by two thin, darker, microgranular tectoria. Aperture was not clearly seen and is apparently a very low, basal opening.

Discussion.—The thick, layered wall, secondary septal and basal deposits and overall shape resemble *Globoendothyra baileyi* (Hall), 1858, emend. Henbest, 1931. The generally poor orientation and fragmentary nature of my specimens, however, make it difficult to assign these forms unequivocally to *G. baileyi.* Furthermore, *G. baileyi* has not yet been reported in rocks younger than middle Meramec (zone 12), and my samples are from the late Meramec (zone 15). More specimens are needed before a definite species assignment can be made.

Occurrence.—Zone 15 (Y 2, Y 3, Y 4) Yellowpine Limestone at Arrow Canyon Range.

Endothyra (Globoendothyra?) sp. B

Plate 5, figure 11

Measurements.—(based on 1 specimen) Number of volutions: about 4½. Number of chambers in last volution: 9. Diameter: 0.83 mm. Shell thickness last chamber: 0.025 mm.

Description.—Test is large. The coiling is highly variable, but the last whorl tends to enroll in a single plane. The inner whorls are tightly coiled relative to the last two loose volutions. Septa are of medium length, straight and pointed forward. They are thickened at the join and along the posterior sides. The peripheral outline is moderately lobate. Secondary basal deposits consist of a prominent hamulus in the last chamber and a few small unconnected mounds in the preceding ones. The wall is indistinctly layered. Aperture is a simple basal opening.

Discussion.—The large size, shape of the unconnected basal deposits, and manner of coiling are similar to *Globoendothyra.* The assignment is tentative because an axial section is needed to

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* Ellis and Messina (supplement no. 1, 1958) report that the name "*parva*" is preoccupied by *Endothyra parva* Möller, 1879. Because *Globoendothyra* is considered a subgenus of *Endothyra*, Chernysheva's species is renamed.

see the involute enrollment and because the wall is not well layered although recrystallization could have obliterated the structure. This specimen differs from other *Globoendothyra* species in its highly variable coiling.

Occurrence.—Zone 15 (Y 5) Yellowpine Limestone at Arrow Canyon Range.

Subgenus **Tuberendothyra** Skipp, 1969

Type species: *Endothyra tuberculata* Lipina, 1948.

Description.—Test is discoidal, partially evolute, umbilicate, and mostly medium in size. There are two and one-half to five skew coiled volutions. The last one to two whorls in some cases are coiled in the same plane. Expansion of the volution varies from moderate to rapid. Septa are short to long and curved forward. Some are thickened at the join and along the posterior end. The chambers are moderate to large and inflated between the septa; the peripheral outline is lobate. Massive, typically unconnected, secondary deposits in the shape of clubs, nodes, and wide mounds occur on the chamber floors. The wall is commonly dark, fine to coarse grained calcite interspersed with light colored grains. Faint layering is observed in the better preserved specimens. Aperture is a low, basal opening.

Discussion.—The massive, unconnected, secondary basal deposits are the identifying characteristic of this subgenus. Only a few other groups in the Endothyracea have such well developed deposits (Skipp, 1969, p. 211, description of *Tuberendothyra*).

Endothyra (Tuberendothyra) safonovae
Skipp, 1969

Plate 5, figures 12–15

Endothyra tuberculata Lipina subsp. *magna* Lipina and Safonova, *in* Lipina, 1955, p. 70, pl. 10, figs. 10–12.

Plectogyra tumula E. J. Zeller. Woodland, 1958, (part) p. 798, pl. 101, figs. 12, 14–15.

Endothyra tuberculata Lipina. McKay and Green, 1963, (part) pp. 39–40, pl. 3, fig. 4; Bogush

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EXPLANATION OF PLATE 5

All figures × 60

FIGS. PAGE

1, 2. *Endothyra (E.)?* sp. B. 43
  1. Axial section (UCM 28187b). Sample Bu 1, Ely Limestone, Butte Mountains.
  2. Sagittal section (UCM 28187c). Sample Bu 1, Ely Limestone, Butte Mountains.

3, 4. *Endothyra* (*Globoendothyra*) sp. A. 45
  3. Tangential section, approaching axial (UCM 28155L). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.
  4. Near sagittal section; top crushed (UCM 28154j). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.

5–8. *Endothyra* (*Globoendothyra*) *aequiparva* n.n. (Chernysheva), 1948. 45
  5. Near axial section (UCM 28156a). Sample Y 5, Yellowpine Limestone, Arrow Canyon Range.
  6. Diagonal section (UCM 28156b). Sample Y 5, Yellowpine Limestone, Arrow Canyon Range.
  7. Diagonal section (UCM 28158d). Sample BW 2, Battleship Wash Formation, Arrow Canyon Range.
  8. Tangential section, approaching sagittal (UCM 28156c). Sample Y 5, Yellowpine Limestone, Arrow Canyon Range.

9, 10. *Endothyra* (*Globoendothyra*) cf. *G. gutschicki* (Skipp), 1969. 44
  9. Near sagittal section (UCM 28156d). Sample Y 5, Yellowpine Limestone, Arrow Canyon Range.
  10. Tangential section, approaching sagittal (UCM 28157j). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.

11. *Endothyra* (*Globoendothyra*?) sp. B. 45
  11. Near sagittal section (UCM 28156e). Sample Y 5, Yellowpine Limestone, Arrow Canyon Range.

12–15. *Endothyra* (*Tuberendothyra*) *safonovae* Skipp, 1969. 46
  12. Tangential section, approaching sagittal (UCM 28131h). Sample D 1, Dawn Limestone, Arrow Canyon Range.
  13. Tangential section, approaching sagittal (UCM 28135i). Sample D 5, Dawn Limestone, Arrow Canyon Range.
  14. Sagittal section (UCM 28135j). Sample D 5, Dawn Limestone, Arrow Canyon Range.
  15. Tangential section, approaching sagittal (UCM 28181a). Sample J 4, Joana Limestone, Ward Mountain.


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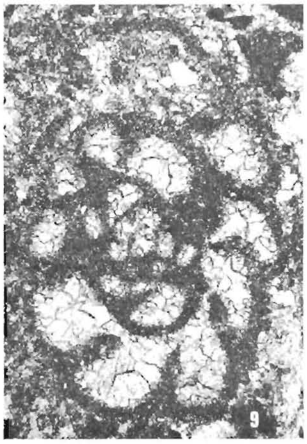
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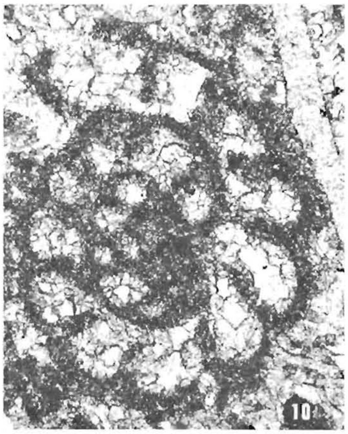
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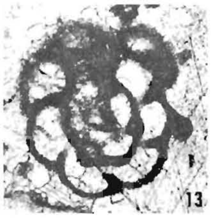
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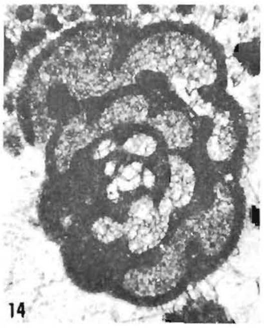
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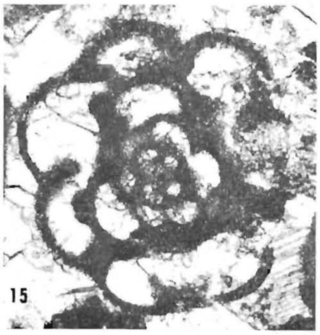
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BRENCKLE: CALCAREOUS FORAMINIFERS FROM NEVADA


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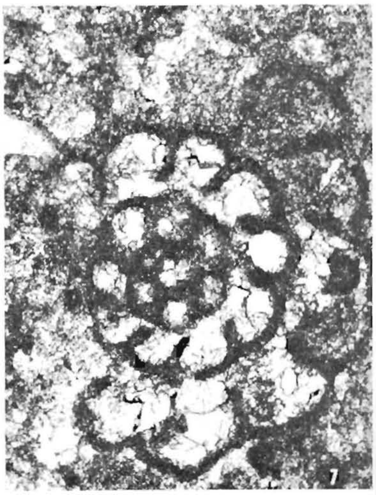
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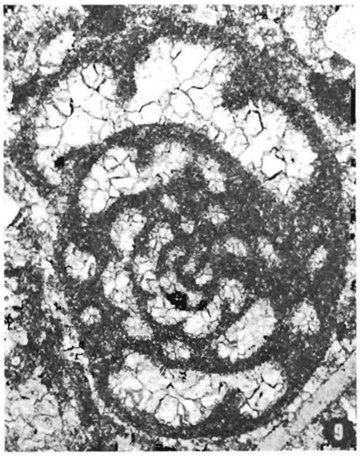
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BRENCKLE: CALCAREOUS FORAMINIFERS FROM NEVADA

and Yuferev, 1966, (part) pp. 127–128, pl. 7, fig. 17.

Plectogyra tuberculata (Lipina) subsp. *magna* (Lipina and Safonova). Brazhnikova *et al.*, 1967, pl. 5, figs. 8, 10.

Tuberendothyra safonovae Skipp, 1969, new name, (=*Endothyra tuberculata* Lipina subsp. *magna* Lipina and Safonova, 1955) pp. 212–213, pl. 19, figs. 1–3, 8–12.

Measurements.—(based on 4 specimens) Number of volutions (3 specimens): 4–5. Number of chambers in last volution (3 specimens): 7. Diameter: 0.40–0.67 mm. Interior diameter of proloculus (1 specimen): 0.050 mm. Shell thickness last volution: 0.010–0.025 mm.

Description.—Test is mostly medium sized. The interior volutions are skewed to the outer one to two volutions which are coiled in the same plane. The early whorls expand moderately, but the last one inflates rapidly. Septa are medium to long and curved anteriorly; a few are thickened at the join. Posterior septal thickenings are lacking. Chambers are large and inflated between septa; the periphery is strongly lobate. Secondary basal deposits in the last few chambers consist of large rounded knobs and in some cases elongate clubs. Older chambers have smaller mounds which are probably resorbed remnants of the younger deposits. Most of the basal deposits are unconnected. One specimen (Plate 5, figure 13) has a large knob in front of the last chamber. A similar deposit is described in Skipp's (1969, p. 212) specimens and is also seen in a specimen figured by Bogush and Yuferev (1966, pl. 7, fig. 17). Wall is generally dark, granular calcite although some light colored grains are scattered throughout. Aperture is a low, basal slit. No axial sections were seen.

Discussion.—The size, shape and coiling of these forms resemble Skipp's Redwall specimens, but have more volutions.

This species differs from *Tuberendothyra paratumula* Skipp, 1969 in being generally larger, having a more lobate periphery, more whorls and more massive basal deposits. It is differentiated from *E.* (*Tuberendothyra*) *tuberculata* in the "Discussion" of the latter species on page 48.

Occurrence.—Zone 7 (D 1) Dawn Limestone; zone 8 (D 5) Dawn Limestone at Arrow Canyon Range. Zone 8 (J 4) Joana Limestone at Ward Mountain.

Endothyra (Tuberendothyra) tuberculata
(Lipina), 1948, emend. Skipp, 1969

Plate 6, figures 1–4

Endothyra tuberculata Lipina 1948, p. 253, pl. 19, figs. 1–2; McKay and Green, 1963, (part) pp. 39–40, pl. 3, figs. 2–3, 5.

Plectogyra tumula E. J. Zeller. Woodland, 1958, (part) p. 798, pl. 102, fig. 13.

Tuberendothyra tuberculata (Lipina) emend. Skipp, 1969, pp. 213–214, pl. 19, figs. 13–22; pl. 20, figs. 18–29.

Measurements.—(based on 5 specimens) Number of volutions (3 specimens): 4–5. Diameter:

EXPLANATION OF PLATE 6

All figures × 60 unless indicated otherwise

Figs. — Page

1–4. *Endothyra* (*Tuberendothyra*) *tuberculata* (Lipina), 1948, emend. Skipp, 1969. 47
  1. Diagonal section (UCM 28135k). Sample D 5, Dawn Limestone, Arrow Canyon Range.
  2. Tangential section (UCM 28133d). Sample D 3, Dawn Limestone, Arrow Canyon Range.
  3. Diagonal section (UCM 28133e). Sample D 3, Dawn Limestone, Arrow Canyon Range.
  4. Diagonal section (UCM 28133f). Sample D 3, Dawn Limestone, Arrow Canyon Range.

5. *Plectogyrina* aff. *P. nevskiensis* (Lebedeva), 1954. × 40. 51
  5. Near sagittal section (UCM 28158e). Sample BW 2, Battleship Wash Formation, Arrow Canyon Range.

6. *Eoendothyranopsis* cf. *E. spiroides* (E. J. Zeller), 1957. 50
  6. Sagittal section (UCM 28156f). Sample Y 5, Yellowpine Limestone, Arrow Canyon Range.

7. *Eoendothyranopsis* aff. *E. macra* (E. J. Zeller), 1957. 48
  7. Sagittal section (UCM 28157k). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.

8–10. *Eoendothyranopsis redwallensis* (Skipp), 1969. 49
  8. Diagonal section (UCM 28154k). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.
  9. Near sagittal section (UCM 28156g). Sample Y 5, Yellowpine Limestone, Arrow Canyon Range.
  10. Near sagittal section (UCM 28158f). Sample BW 2, Battleship Wash Formation, Arrow Canyon Range.

0.47–0.69 mm. Interior diameter of proloculus (3 specimens): 0.040–0.065 mm. Shell thickness last volution: 0.020–0.030 mm.

Description.—Test is medium in size. Coiling is skewed throughout. The last volution does not lie in a single plane so that all its chambers are not commonly visible in thin section. Expansion of the coil changes from moderate in the inner whorls to rapid in the final one. Septa are generally long, curved anteriorly and, in some cases, thickened at the join and at the posterior tip. Chambers are large and well inflated. The peripheral outline is highly lobate. The last few chambers contain large, club-shaped or irregular mounds, some extending up to three-fourths of the interior height of the chambers. Smaller mounds appear in the older chambers and may be resorbed remnants of the younger clubs. Most of these secondary basal deposits are unconnected. Wall is dark, granular calcite interspersed with light colored grains. Aperture is a low, basal slit. No axial sections were seen.

Discussion.—This species differs primarily from *E.* (*Tuberendothyra*) *safonovae* in having posterior septal thickenings and a more variable plane of coiling in the last whorl. In contrast, the final volution of *E.* (*Tuberendothyra*) *safonovae* is commonly planispiral. *T. paratumula* Skipp, 1969 is smaller, has fewer volutions, less coiling distortion, smaller basal secondary deposits, a smoother periphery and typically lacks posterior septal thickenings.

The coiling of one specimen (Plate 6, figure 1) resembles that of *Plectogyrina* Reitlinger although the axes of coiling appear more variable and the last whorl does not appear to be completely involute. I have kept this specimen in the present species because of the massive basal deposits and variable coiling but realize that it may belong to *Plectogyrina* or be a transitional form.

Occurrence.—Zone 8 (D 3, D 5) Dawn Limestone at Arrow Canyon Range.

Genus **Eoendothyranopsis** Reitlinger, 1964

Eomillerella Skipp, 1969, pp. 216–217, pl. 17, figs. 22–25; pl. 24, figs. 5, 16; pl. 27, figs. 6–22, 24; pl. 28, figs. 1–14.

Type species: *Parastaffella pressa* Grozdilova, 1954.

Description.—Test is small to large, discoidal, involute, shallowly umbilicate on both sides and has a rounded peripheral edge. The proloculus is followed by three to six essentially planispiral volutions although some species exhibit coiling distortion. The rate of expansion of the whorls is moderate to rapid; the greatest inflation is in the outer volutions. Septa are curved or straight, short to long and have an anterior direction. The exterior volution contains eight to thirteen chambers. Most species have only slightly convex chambers, imparting a smooth outline to the periphery. But the chambers of other species are swollen between sutures, forming a correspondingly lobate periphery. Secondary deposits consist of thickened floors, low mounds, spines or hooks in the last chambers, septal thickenings at the join and posterior ends and rudimentary chomata. Walls are dark, granular calcite and have some inclusions of larger, light colored granules, but some appear two- or three-layered. Aperture is simple and basal.

Discussion.—Skipp (1969) erected a new planispiral genus, *Eomillerella,* and discussed the taxonomic and nomenclatural problems of these foraminifers. During publication of her paper, she discovered that Reitlinger had already named the genus *Eoendothyranopsis* for similarly coiled species. *Eomillerella,* therefore, is a junior synonym. Skipp also pointed out that planispiral endothyrids have previously been put in the genera *Endothyra* and *Paramillerella.*

Eoendothyranopsis aff. **E. macra**
(E. J. Zeller), 1957

Plate 6, figure 7

Endothyra macra E. J. Zeller, 1957, p. 702, pl. 80, figs. 7, 14; Armstrong, 1958, p. 975, pl. 127, fig. 4; McKay and Green, 1963, pp. 34–35, pl. 9, fig. 8; pl. 12, fig. 6.

Eomillerella macra (E. J. Zeller). Skipp, 1969, pp. 219–220, pl. 17, fig. 25; pl. 27, fig. 17.

Measurements.—(based on 2 specimens) Number of volutions: 3. Number of chambers in last volution (1 specimen): 10. Number of chambers in penultimate volution (1 specimen): 9. Diameter: 0.92–1.00 mm. Interior diameter of proloculus (1 specimen): 0.070 mm. Shell thickness last volution: 0.030–0.035 mm.

Description.—Test is large and planispirally coiled. The initial one and one-half whorls are tightly coiled, but the outer one and one-half are much looser. Septa are long and thin and covered by small secondary deposits at the join; some are also thickened on the posterior ends. The septa in the last volution are irregularly spaced and oriented at various angles to the wall; therefore, the shape of the chambers is not uniform. Chambers are inflated between the joins, and the peripheral outline is moderately lobate. Wall is dark, microgranular calcite. The aperture was not seen. No axial sections were found.

Discussion.—The rate of expansion of the coil relates this species to *E. macra.* Also, the chamber count of my specimens is similar to that for the first three volutions of Zeller's (1957) forms. However, this species differs from Zeller's in the absence of a large hamulus in the last chamber, and in having fewer volutions, a larger size, larger proloculus, irregularly shaped chambers and a test wall of relatively constant thickness throughout the coil.

Occurrence.—Zone 15 (BW 1) Battleship Wash Formation at Arrow Canyon Range.

Eoendothyranopsis redwallensis (Skipp), 1969

Plate 6, figures 8–10

Endothyra (*Globoendothyra*) *redwallensis* SKIPP, 1969, p. 210, pl. 26, figs. 3–12, 15–16.

Measurements.—(based on 5 specimens) Number of volutions: 4–5. Number of chambers in the last volution (4 specimens): 8–9. Number of chambers in penultimate volution (2 specimens): about 8–9. Diameter: 0.90–1.01 mm. Interior diameter of proloculus (2 specimens): 0.055–0.065 mm. Shell thickness last volution: 0.025–0.040 mm.

Description.—Test is large and compressed laterally in sagittal view. Coiling varies from planispiral to slightly distorted throughout all the volutions. The inner volutions are tightly coiled, but the last whorl expands rapidly. Septa are straight, of short to moderate length and pointed slightly to well forward. Secondary deposits are commonly found at the septal join. Chambers are only mildly inflated. The periphery, therefore, is smooth or slightly lobate. A mound or hook is ordinarily found in the last chamber. Low mounds also appear in the other chambers of the last volution. Wall is dark, granular calcite and is discernably layered in better preserved specimens. Aperture is a very low, basal opening. No axial sections were seen.

Discussion.—The slightly distorted coiling, dimensions and generally smooth periphery of these specimens resemble Skipp's type material although the septal deposits may be better developed.

Endothyra hamula Woodland, 1958 is similar to the present specimens in secondary deposits, number of chambers in the last volution and number of volutions but differs in having a more lobate periphery, a more regular expansion of the coil and a larger size. Woodland, however, did not illustrate enough good specimens to permit a thorough comparison. Skipp (1969, p. 210) considers *E. hamula* a probable member of the subgenus *Globoendothyra*, but, in my opinion, the coiling distortion is not great enough in this species for assignment to the subgenus.

E. redwallensis is distinguished from *E. utahensis* in the "Discussion" of the latter species.

Occurrence.—Zone 15 (Y 3, Y 4, Y 5) Yellowpine Limestone and (BW 2) Battleship Wash Formation at Arrow Canyon Range.

Eoendothyranopsis aff. E. scitula (Toomey), 1961

Plate 7, figures 1–4

Endothyra symmetrica E. J. ZELLER, 1957, p. 701, pl. 75, figs. 14, 18–19; pl. 78, figs. 8–9; pl. 80, fig. 6; WOODLAND, 1958, p. 800, pl. 101, figs. 7, 9–10.

Endothyra cf. *E. symmetrica* E. J. Zeller. SKIPP, 1961, p. C241, fig. 236.3–0.

Endothyra scitula TOOMEY, 1961, new name (=*Endothyra symmetrica* E. J. Zeller) p. 26.

Eomillerella scitula (Toomey). SKIPP, 1969, pp. 220–221, pl. 28, figs. 7–14.

Endothyra zelleri MCKAY and GREEN, 1963, new name (=*Endothyra symmetrica* E. J. Zeller) pp. 41–42, pl. 7, figs. 7, 12–14.

Measurements.—(based on 14 specimens) Number of volutions (12 specimens): 3–4. Number of chambers in last volution (5 specimens): 10–12. Number of chambers in penultimate volution (4 specimens): 7–9. Diameter: 0.27–0.52 mm. Width (5 specimens): 0.16–0.26 mm. Width/diameter (5 specimens): 0.49–0.53. Interior diameter of proloculus (6 specimens): 0.030–0.060 mm. Shell thickness last volution: 0.005–0.020 mm.

Description.—Test is small to medium sized, discoidal, involute and commonly more umbilicate on one side than the other. The initial whorl is skewed in the majority of specimens; all other volutions are planispiral. The septa, secondarily thickened at the join, are thick, V-shaped and pointed forward at about the same angle throughout the coiling. Whorls expand moderately and steadily. The chambers have a uniform shape and are only slightly inflated so that the periphery is commonly smooth. One specimen has a hamulus in the last chamber. Low mounds are irregularly deposited in the chambers of all specimens. Walls are composed of both dark, fine grained and lighter, coarse grained calcite. Layering is apparent in some. Aperture is low and basal.

Discussion.—The asymmetry of the initial whorl and fewer chambers in the interior volutions distinguish these forms from those described by Zeller although Skipp attributes similarly skew coiled foraminifers to this species. The initial coiling skewness resembles that of *Eoendothyranopsis spiroides* (E. J. Zeller), 1957 but the thick, V-shaped septa and fewer volutions and chambers separate my specimens from the latter species.

Those specimens assigned to *E. utahensis* in this study differ from the present species in having irregularly oriented septa and, in general, fewer chambers in the last volution, larger dimensions and a greater width/diameter ratio.

Occurrence.—Zone 13 (Y 1) Yellowpine Limestone; zone 15 (Y 2, Y 3, Y 4, Y 5) Yellowpine Limestone and (BW 1, BW 2, BW 3) Battleship Wash Formation at Arrow Canyon Range.

Eoendothyranopsis cf. E. spiroides
(E. J. Zeller), 1957

Plate 6, figure 6

Endothyra spiroides E. J. Zeller, 1957, p. 702, pl. 75, fig. 25; pl. 76, figs. 6–8; pl. 80, figs. 18–19, 28.

Eomillerella spiroides (E. J. Zeller). Skipp, 1969, p. 221, pl. 17, figs. 22–24; pl. 24, fig. 16; pl. 27, figs. 6–16.

Measurements.—(based on 1 specimen) Number of volutions: about 6. Number of chambers in last volution: about 13. Number of chambers in penultimate volution: 12. Diameter: 0.81 mm. Shell thickness last volution: 0.025 mm.

Description.—Test is large and planispirally coiled. The whorls expand slowly and evenly. Septa are of medium length, slightly curved forward and thickened at the join. The numerous inflated chambers produce a slightly lobate peripheral outline. Other secondary deposits include a prominent hook in the last chamber and smaller mounds in prior ones. The wall is dark, granular calcite. Aperture appears central.

Discussion.—The aperture is questionably in the central position. Because there is only one section, I cannot tell if the mound under the aperture is actually part of the apertural face, a secondary mound, or a pellet fortuitously deposited in the aperture. However, the absence of mounds directly opposed to the septa in the inner chambers argues against a central aperture.

This specimen differs from the type material of Zeller in having one more volution, more chambers in the last whorl and being larger. The size and number of chambers in the last whorl correspond, however, with Skipp's material.

This species has not been previously reported from the upper Meramec (zone 15), and more specimens are desirable for a positive identification.

Occurrence.—Zone 15 (Y 5) Yellowpine Limestone at Arrow Canyon Range.

Eoendothyranopsis utahensis
(E. J. Zeller), 1957

Plate 7, figures 5–12, 14

Endothyra utahensis E. J. Zeller, 1957, p. 702, pl. 80, figs. 15–16.

Measurements.—(based on 28 specimens) Number of volutions (20 specimens): 3½–4½. Number of chambers in last volution (8 specimens): 8–10. Number of chambers in penultimate volution (3 specimens): 8–9. Diameter: 0.50–0.79 mm. Width (14 specimens): 0.28–0.45 mm. Width/diameter (14 specimens): 0.45–0.62. Interior diameter of proloculus (7 specimens): 0.045–0.060 mm. Shell thickness last volution: 0.015–0.030 mm.

Description.—Test is of medium size, discoidal, involute and umbilicate on both sides. The coiling is generally planispiral although the inner volutions of some specimens are slightly skewed. The exterior volution expands more rapidly whereas the interior whorls coil steadily but more tightly. Septa are short to long, secondarily thickened at the join and commonly not oriented at a uniform angle to the wall; the chambers, therefore, exhibit a variety of shapes. Periphery is slightly to moderately lobate. A hook or mound is seen in the last chamber of a few specimens, and other low mounds appear irregularly in prior chambers. In axial section the floors appear secondarily thickened, and rudimentary chomata are present. The wall varies from dark, granular calcite to a apparent two- or three-layered structure. The secondary floor coverings add another layer to the inner walls. The unlayered walls may reflect poor preservation. Aperture is low and basal.

Discussion.—The shape, coiling, number of volutions and number of chambers in the last volution agree well with Zeller's description. However, a prominent hook (hamulus) is not consistently present in the last chamber and my specimens are larger and have more secondary deposits than described originally.

The double umbilicus and fewer chambers in the last volution distinguish these specimens from the Redwall species *Eomillerella hinduensis* Skipp, 1969. *Eoendothyranopsis redwallensis* (Skipp), 1969 is slightly skew coiled throughout, lacks rudimentary chomata and has generally thinner septal deposits and a larger average size than the present species. *Endothyra prodigiosa* Armstrong, 1958 is larger and has more chambers in the last whorl. One of McKay and Green's figured specimens (1963, pl. 10, fig. 12) of their species *Endothyra flatile* bears a close resemblance to one of Zeller's original figures (1957, pl. 80, fig. 16) of *E. utahensis* and may be the same species.

Occurrence.—Zone 15 (Y 2, Y 3, Y 4, Y 5) Yellowpine Limestone and (BW 1, BW 2) Battleship Wash Formation at Arrow Canyon Range.

Genus **Plectogyrina** Reitlinger, 1959

Type species: *Endothyra? fomichaensis* Lebedeva, 1954.

Description.—I have found only one well-oriented specimen of this genus. Therefore, I cannot adequately describe the variations of this group in Nevada. Reitlinger's original Russian description (*in* Rauzer-Chernousova and Fursenko, eds., 1959, p. 196, translated by Israel Program for Scientific Translations, 1962) follows:

> . . . Differs from *Plectogyra* [now *Endothyra*] by the character of the coiling of the test—the inner coils are almost planispiral, evolute, the external coil is situated at an angle near to 90° with respect to the previous one, and is involute. . .

Discussion.—My single specimen (*Plectogyrina* aff. *P. nevskiensis*) has a three-layered wall and, in its large dimensions, resembles the subgenus *Globoendothyra.* However, *Plectogyrina* has initially planispiral, evolute volutions and an exterior involute whorl coiled at an angle of approximately 90° to the penultimate one. *Globoendothyra*, on the other hand, has neither planispiral nor completely evolute whorls in the interior and does not commonly have such an abrupt change in coiling direction between the penultimate and last volution.

Plectogyrina aff. P. nevskiensis (Lebedeva), 1954

Plate 6, figure 5

Endothyra nevskiensis LEBEDEVA, 1954, p. 265, pl. 8, figs. 2–3.

Measurements.—(based on 1 specimen) Number of volutions: 6½. Number of chambers in last volution: about 7. Diameter: 1.37 mm. Shell thickness last chamber: 0.030 mm.

Description.—Test is large. First two whorls are highly skewed to the following two and one-half evolute volutions which are coiled in one plane. The axis of coiling again changes in the penultimate volution which is turned at an acute angle to the inner whorls and 90° to the almost planispiral exterior volution. The inner few volutions are tightly coiled, but the last two are loose. Septa are moderately long and secondarily thickened at the septal join. The chambers in the last volution are high but not inflated between the septa; so the periphery is smooth. Secondary deposits include a hook in the last chamber and sharply pointed mounds, probably slightly resorbed hooks, in a few other chambers in the last whorl. Thick lateral deposits surround the inner four volutions. Wall is three-layered. Aperture is low and basal. No axial section was seen.

Discussion.—This specimen differs significantly from Lebedeva's species in the skewness of the first two volutions. Although Lebedeva's specimens show some coiling skewness in the first three whorls, the angular distortion is much smaller than in mine. Other minor differences include my specimen being larger, having one and one-half more volutions, more pointed basal mounds and a layered wall. The difference in wall structure is not considered important because Lebedeva's specimens are strongly recrystallized and primary layering is probably obliterated. But the coiling, secondary deposits, shell thickness and rate of expansion of our specimens are so similar that they must be closely related.

Occurrence.—Zone 15 (BW 2) Battleship Wash Formation at Arrow Canyon Range.

Family BRADYINIDAE Reitlinger, 1950

Members of this family are involute, planispirally coiled and have a perforate, commonly agglutinated wall. More advanced genera such as *Bradyina* Möller, 1878 and *Janischewskina* Mikhailov, 1935 have complex, cribrate apertures and chambers partitioned into small septal chamberlets by outgrowths of the wall on either side of the septum. Only the primitive genus *Endothyranopsis* is found in this study. This form has a granular, calcareous, agglutinated wall, a simple, basal aperture and undivided chambers. Secondary alteration, however, has destroyed the porosity of the wall.

Genus **Endothyranopsis** Cummings, 1955

Type species: *Involutina crassa* Brady, 1869.

Description.—Test is medium sized, involute, commonly subglobular and slightly umbilicate. The large proloculus is followed by two to four volutions. The first one or two whorls are mildly skewed to the remaining ones which are planispiral or slightly distorted. Expansion of the coil is steady and rapid. The septa are long and either perpendicular to the wall or pointed slightly forward. Thickenings at the join and on the posterior side give the septa a characteristic "ploughshare-like or ax-shaped" outline (Cummings, 1955, p. 1). The chambers are large but not well inflated between septa. The peripheral outline, therefore, is mostly smooth. Basal secondary deposits are not well developed. The thick wall is generally composed of coarsely granular, probably agglutinated, calcite. A few specimens have a thin, dark inner layer. Aperture is a basal opening of small to medium size.

Discussion.—Cummings (1955, pp. 1–2) noted that this genus has a distinctive agglutinated perforate wall structure when well preserved. Recrystallization has undoubtedly obliterated the perforations in my specimens with the remaining coarse granular layer reflecting the original agglutinated material.

The small degree of coiling skewness of some specimens produces sections that resemble the planispiral genus *Eoendothyranopsis*. *Endothyranopsis* is distinguished from *Eoendothyranopsis* by its thicker walls, characteristically formed septa, subglobular shape in axial section and less pervasive secondary deposits. The two genera are doubtlessly closely related. The perforate wall structure of *Eoendothyranopsis scitula* links this species with *Endothyranopsis* (Skipp, 1969, p. 220). On the other hand, *Endothyra robusta* McKay and Green, 1963, has been correctly placed in *Endothyranopsis* (Skipp, 1969, p. 216) based on the thick agglutinated wall and septal shape and yet it has the basal spines and other massive secondary deposits characteristic of *Eoendothyranopsis*.

Endothyranopsis cf. E. crassa (Brady), 1869

Plate 7, figures 13, 15, 16

Involutina crassa Brady, 1869, pp. 379, 382.
Endothyra crassa Brady, 1876, p. 97, pl. 5, figs. 15–17; Durkina, 1959, pp. 183–184, pl. 11. figs. 4–6; pl. 12, figs. 1–3.
Endothyra crassa crassa Brady. Rauzer-Chernousova, 1948a, p. 167, pl. 4, fig. 2.
Endothyranopsis crassus (Brady) new name (=*Endothyra crassa* Brady). Cummings, 1955, p. 3, figs. 5A–C; Grozdilova and Lebedeva, 1960, pp. 72–73, pl. 7, fig. 3; Bogush and Yuferev, 1962, pp. 152–153, pl. 5, fig. 6; Aizenverg *et al.*, 1968, pl. 11, figs. 1–2.
Endothyranopsis crassa (Brady). Mamet, 1968c, p. 134, pl. 5, figs. 1–3; Mamet, 1970, p. 36, pl. 5, fig. 3.
Endothyranopsis crassa crassa (Brady). Rozovskaya, 1963, p. 54, pl. 6, figs. 10–11; pl. 7, figs. 1–3; pl. 8, fig. 1.
Endothyranopsis crassus var. *crassa* (Brady). Conil and Lys, 1964, p. 150, pl. 21, figs. 432–434; pl. 22, fig. 435; Brazhnikova *et al.*, 1967, pl. 12, fig. 1.

EXPLANATION OF PLATE 7

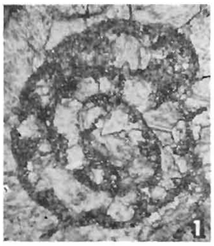
All figures × 60

Figs. — Page

1–4. *Eoendothyranopsis* aff. *E. scitula* (Toomey), 1961. 49
1. Tangential section, approaching sagittal (UCM 28152b). Sample Y 1, Yellowpine Limestone, Arrow Canyon Range.
2. Tangential section, approaching sagittal (UCM 28159a). Sample BW 3, Battleship Wash Formation, Arrow Canyon Range.
3. Tangential section, approaching axial (UCM 28157L). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.
4. Axial section (UCM 28157m). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.

5–12, 14. *Eoendothyranopsis utahensis* (E. J. Zeller), 1957. 50
5. Sagittal section (UCM 28154L). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.
6. Tangential section, approaching axial (UCM 28156h). Sample Y 5, Yellowpine Limestone, Arrow Canyon Range.
7. Axial section (UCM 28154m). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.
8. Diagonal section (UCM 28158g). Sample BW 2, Battleship Wash Formation, Arrow Canyon Range.
9. Diagonal section (UCM 28157n). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.
10. Axial section (UCM 28153d). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
11. Axial section (UCM 28153e). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
12. Tangential section, approaching sagittal (UCM 28156i). Sample Y 5, Yellowpine Limestone, Arrow Canyon Range.
14. Tangential section (UCM 28157o). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.

13, 15, 16. *Endothyranopsis* cf. *E. crassa* (Brady), 1869. 52
13. Axial section (UCM 28153f). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
15. Near axial section (UCM 28157p). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.
16. Tangential section, approaching axial (UCM 28155m). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.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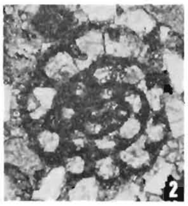
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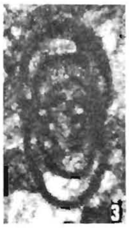
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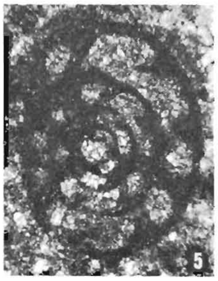
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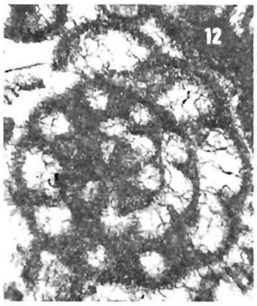
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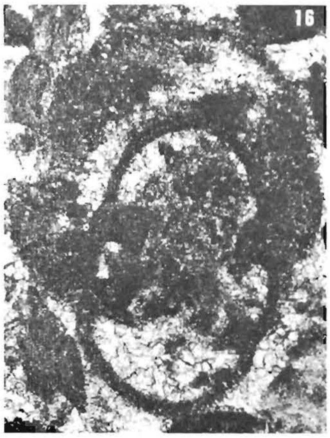
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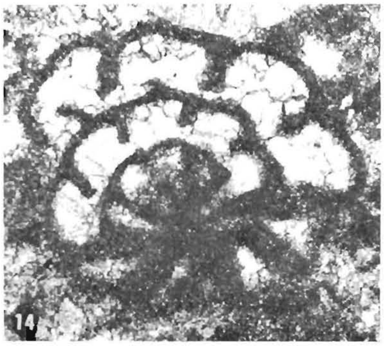
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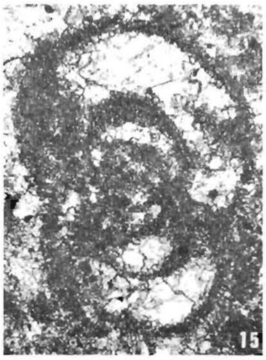
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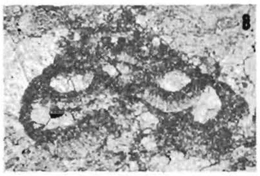
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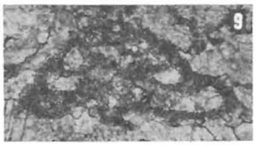
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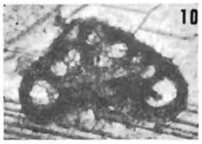
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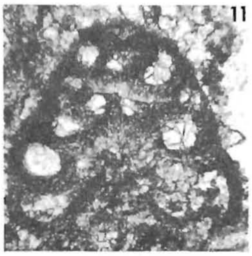
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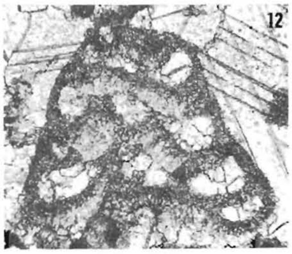
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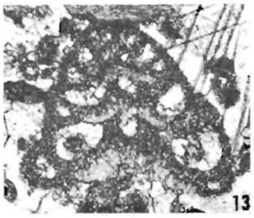
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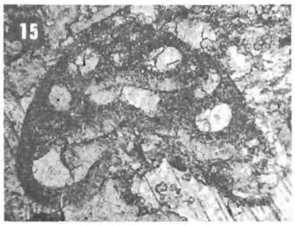
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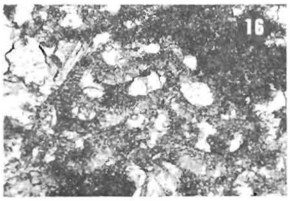
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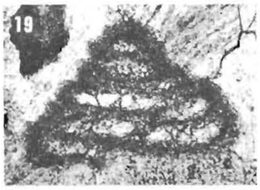
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BRENCKLE: CALCAREOUS FORAMINIFERS FROM NEVADA

Measurements.—(based on 3 specimens) Number of volutions (2 specimens): 3. Diameter: 0.65–0.86 mm. Width: 0.54–0.67 mm. Width/diameter: 0.78–0.83. Interior diameter of proloculus (1 specimen): 0.035 mm. Shell thickness last volution: 0.025–0.040 mm.

Description.—Test is medium to large, involute, subglobular and slightly umbilicate on both sides.

EXPLANATION OF PLATE 8

All figures × 60 unless indicated otherwise

FIGS. PAGE

1, 2. *Endothyranopsis* cf. *E. compressa* (Rauzer-Chernousova and Reitlinger), 1936. 54
  1. Tangential section, approaching axial (UCM 28157q). Sample BW 1, Battleship Wash Formation, Arrow Canyon Range.
  2. Axial section (UCM 28155n). Sample Y 4, Yellowpine Limestone, Arrow Canyon Range.

3–6. *Endothyranopsis eocompressa* Skipp, 1969. 54
  3. Sagittal section (UCM 28153g). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
  4. Near sagittal section (UCM 28153h). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
  5. Tangential section, approaching sagittal (UCM 28153i). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
  6. Near axial section; shell wall possibly missing at top right; (UCM 28153j). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.

7, 8. *Tetrataxis* sp. A. 57
  7. Tangential section (UCM 28153k). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
  8. Tagential section, approaching axial (UCM 28153L). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.

9. *Tetrataxis* sp. B. 58
  9. Tangential section, approaching axial (UCM 28169f). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.

10. *Tetrataxis vulgaris* Malakhova, 1956. 57
  10. Tangential section, approaching axial (UCM 28153m). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.

11–13. *Tetrataxis* aff. *T. acutus* Durkina, 1959. 56
  11. Tangential section, approaching axial (UCM 28153n). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
  12. Tangential section, approaching axial (UCM 28153o). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
  13. Tangential section, approaching axial (UCM 28153p). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.

14. *Tetrataxis* cf. *T. obtusus* Malakhova, 1956. 56
  14. Tangential section, approaching axial (UCM 28153q). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.

15, 16. *Tetrataxis media* Vissarionova, 1948. 56
  15. Tangential section, approaching axial (UCM 28153r). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
  16. Tangential section, approaching axial (UCM 28153s). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.

17. *Tetrataxis parviconica* Lee and Chen, 1930. 57
  17. Tangential section, approaching axial (UCM 28169g). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.

18. *Tetrataxis* aff. *T. parviconica* Lee and Chen, 1930. 57
  18. Tangential section, approaching axial (UCM 28168a). Sample BS 2, Bird Spring Formation, Arrow Canyon Range.

19. *Tetrataxis* sp. C. 58
  19. Tangential section, approaching axial (UCM 28169h). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.

20, 21. *Archaediscus* sp. A. × 125. 61
  20. Near sagittal section (UCM 28153t). Sample Y 2, Yellowpine Limestone, Arrow Canyon Range.
  21. Near axial section; top of last volution missing; (UCM 28154n). Sample Y 3, Yellowpine Limestone, Arrow Canyon Range.

The interior whorls are slightly angled to the outer one. The volutions expand rapidly and steadily. In one of the measured specimens (Plate 7, figure 13) the wall appears two-layered. The inner layer is thin, dark and microgranular. The thick outer zone is composed of large calcite grains scattered throughout a light colored, microgranular matrix. The walls of the other measured specimens are mostly dark, granular, unlayered calcite. No sagittal sections were seen.

Discussion.—The thick wall, slight coiling distortion and involute, subglobular axial shape of these specimens resemble the features of *Endothyranopsis crassa.* The coarse grained outer shell layer of the specimen in Plate 7, figure 13 may be the agglutinated wall characteristic of the species; however, the surrounding matrix is partially recrystallized and the large calcite grains may actually be secondarily enlarged through grain growth. The average size of these specimens is about one-half that of those described by Cummings (1955) but is within the size limits reported by Rauzer-Chernousova (1948a), Grozdilova and Lebedeva (1960), and Rozovskaya (1963). Without sagittal sections to determine the size and shape of the septa and number of chambers, the present forms cannot be definitely assigned to *E. crassa.*

These specimens are within the size range of *Endothyranopsis compressa* (=*Endothyra crassa* Brady var. *compressa* Rauzer-Chernousova and Reitlinger, 1936) but are more globular. On the other hand they differ from *Endothyranopsis sphaerica* (=*Endothyra crassa* Brady var. *sphaerica* Rauzer-Chernousova and Reitlinger, 1936) in being smaller and less spherical. In the original descriptions *E. compressa* and *E. sphaerica* have width/diameter ratios of 0.50–0.70 and 0.90–1.00 respectively.

Occurrence.—Zone 15 (Y 2, Y 4) Yellowpine Limestone and (BW 1) Battleship Wash Formation at Arrow Canyon Range.

Endothyranopsis cf. E. compressa (Rauzer-Chernousova and Reitlinger), 1936

Plate 8, figures 1, 2

Endothyra crassa Brady var. *compressa* RAUZER-CHERNOUSOVA and REITLINGER, *in* Rauzer-Chernousova *et al.*, 1936, p. 209, pl. 6, figs. 1–2; RAUZER-CHERNOUSOVA, 1948a, pp. 166–167, pl. 4, figs. 5–7.

Endothyra compressa Rauzer-Chernousova and Reitlinger. DURKINA, 1959, pp. 185–186, pl. 14, figs. 2–3.

Endothyranopsis compressa (Rauzer-Chernousova and Reitlinger). ROZOVSKAYA, 1963, pp. 57–58, pl. 10, figs. 3–9; pl. 11, figs. 1–2.

Endothyranopsis compressus (Rauzer-Chernousova and Reitlinger). GROZDILOVA and LEBEDEVA, 1960, pp. 73–74, pl. 7, fig. 1; AIZENVERG *et al.*, 1968, pl. 11, figs. 3–5.

Endothyranopsis compressus compressa (Rauzer-Chernousova and Reitlinger). BRAZHNIKOVA *et al.*, 1967, pl. 12, figs. 2–3.

Endothyranopsis crassus (Brady) *compressa* (Rauzer-Chernousova and Reitlinger). CONIL and LYS, 1964, p. 150, pl. 22, figs. 436–437.

Measurements.—(based on 2 specimens) Number of volutions (1 specimen): 4. Diameter: 0.67–0.77 mm. Width: 0.44–0.56 mm. Width/diameter: 0.67–0.73. Interior diameter of proloculus (1 specimen): 0.040 mm. Shell thickness top of last volution: 0.020–0.030 mm.

Description.—Test is medium sized, involute, subglobular and slightly umbilicate. The first volution is skewed to the other essentially planispiral ones. The rate of expansion of the coil is rapid. One specimen exhibits slight secondary thickenings on the chamber floors. Wall contains larger light colored grains embedded in a darker, finer grained matrix. No sagittal sections were seen.

Discussion.—The manner of coiling, wall thickness, size and width/diameter ratio agree well with forms assigned to *E. compressa* by other workers. Sagittal sections are needed, however, for a positive identification.

This species is similar to *Endothyranopsis* cf. *E. crassa* and *E. eocompressa* (see the "Discussion" under each of these species). It differs from *Endothyra robusta* McKay and Green, 1963, in its smaller size and less massive secondary deposits. Also, *E. robusta* has a basal spine in the last chamber, not seen in this species.

Occurrence.—Zone 15 (Y 4) Yellowpine Limestone and (BW 1) Battleship Wash Formation at Arrow Canyon Range.

Endothyranopsis eocompressa Skipp, 1969

Plate 8, figures 3–6

Endothyranopsis eocompressa SKIPP, 1969, pp. 215–216, pl. 28, figs. 15–23.

Measurements.—(based on 6 specimens) Number of volutions: 2–3. Number of chambers in last volution (4 specimens): 6–7. Diameter: 0.46–0.58 mm. Interior diameter of proloculus (4 specimens): 0.060–0.070 mm. Shell thickness last volution: 0.025–0.035 mm.

Description.—Test is medium sized, involute and slightly umbilicate on one side. The initial one to two whorls are slightly skewed to the final, essentially planispiral whorl. The rate of expansion of the coil is steady and rapid. Septa are long and oriented perpendicular to the wall or slightly anteriorly. Secondary deposits cover the join and the posterior side of the septa. The chambers, although large, are only slightly inflated between septa. The peripheral outline, therefore, is almost smooth. Secondary basal mounds reported by Skipp are not well developed in these specimens. Most specimens have a thick, coarsely granular wall, probably agglutinated. A thin, dark, interior layer is less commonly present and some specimens (*e.g.* Plate 8, figure 4) have two thin, dark layers flanking the coarse granular one. Aperture is a small to medium sized, simple, basal opening.

Discussion.—Skipp considers this species to be ancestral to *Endothyranopsis compressa* (Rauzer-Chernousova and Reitlinger, 1936 and to differ primarily from this latter species in having fewer chambers in the last volution. The present specimens of *E. eocompressa* are further distinguished from my individuals of *E.* cf. *E. compressa* on the basis of fewer volutions, smaller size and a deeper umbilicus.

Occurrence.—Zone 15 (Y 2, Y 4) Yellowpine Limestone at Arrow Canyon Range.

Family TETRATAXIDAE Galloway, 1933

Test is conical, trochospirally coiled and has few chambers per volution. An umbilical cavity commonly develops along the axis of coiling. Chambers are simple or divided into chamberlets. Wall is granular calcite and, in most specimens, has an additional hyaline-radial layer deposited on the basal side of the chambers. Aperture opens into the umbilical cavity along the inner margin of the chambers. Only *Tetrataxis* is found in this study.

Genus Tetrataxis Ehrenberg, 1843

Type species: *Tetrataxis conica* Ehrenberg, 1854.

Description.—Test is small to medium in size. A narrow to broad umbilical cavity is commonly developed along the axis of coiling. The whorls coil trochospirally, producing a conically shaped test. The flanks of the cone can be relatively straight-sided (regular cone, see figure 12), arched or subparallel (subcylindrical shape). Commonly, the apical area is rounded. The whorls number from four to seven and their height expands slowly. In axial section chambers appear semicircular, flat-elongate or curved upward into the umbilical area. Each volution typically has four chambers. Sutures are flush or depressed; the flanks are correspondingly smooth or lobate. In some specimens the lateral expansion of a few whorls is disproportionate to that of others, producing a slightly irregular peripheral outline. The wall always has a dark, granular calcite layer and commonly an additional hyaline-radial zone on the basal side of the chambers. This fibrous layer is best developed around the umbilicus where in many cases it comprises one-half to three-fourths or more of the shell thickness. Aperture is not seen in cross-section but opens into the umbilical cavity along the inner margin of the chambers. One specimen exhibits a basal appendage which may be an apertural cover or flap.

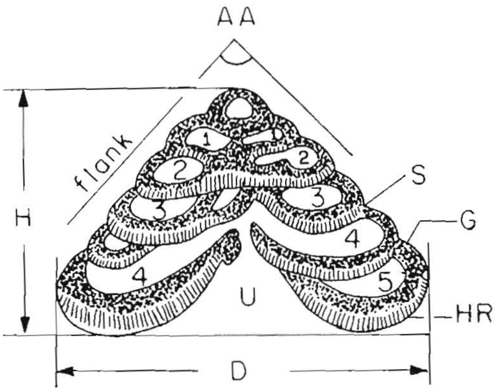

FIGURE 12

Axial section of *Tetrataxis.* 4½ volutions; AA, apical angle; H, height; D, diameter; U, umbilical cavity; HR, hyaline-radial layer; G, granular layer; S, suture (redrawn from Conil and Lys, 1964).

Figure 12 illustrates the features of this genus.

Discussion.—Species are differentiated by a combination of factors including dimensions (height, width, height/width ratio, shell thickness), number of volutions, shape of the cone, presence of the fibrous layer, basal appendages, chamber shape and apical angle.

The apical angle for variously shaped specimens was determined in the following ways: (a) for regular cones, the angle was measured along the flanks up to the apex; (b) for regular cones with a rounded apex, the angle was measured along the flanks; and (c) for convex or subcylindrical cones, the angle, if measured at all, was taken around the apex, disregarding the shape of the lower side of the flanks. In any case, most apical angles are approximate because a true angle can be determined only from a perfect axial section (as seen in figure 12) which is rarely found.

The shell thickness was measured around the umbilical area where the hyaline-radial layer, if present, is best developed. The dark, granular layer commonly thins or is nearly absent in this area so that, although the shell is at its maximum width, around the umbilicus, the granular layer is generally better developed along the flanks. Shell thickness was measured only in sections approaching axial to exclude the overly large dimensions produced by tangential cuts.

Tetrataxis aff. **T. acutus** Durkina, 1959

Plate 8, figures 11–13

Tetrataxis acutus DURKINA, 1959, pp. 221–222, pl. 23, figs. 8–9; CONIL and LYS, 1964, p. 87, pl. 11, figs. 215–216.

Measurements.—(based on 5 specimens) Number of volutions: about 4–5. Apical angle (along flanks, 3 specimens): 45–55°. Height (3 specimens): 0.37–0.45 mm. Diameter: 0.47–0.60 mm. Height/diameter (3 specimens): 0.79–0.86. Shell thickness (3 specimens): 0.040–0.065 mm.

Description.—Test is medium sized, deeply umbilicate and regularly conical. The apical region may be slightly rounded, but the curvature is accentuated by the tangential sections. Volutions expand slowly. Individual chambers appear semicircular or slightly elongate toward the interior. The flanks are smooth or slightly irregular. Wall consists of a dark, coarse, granular layer and a radial-hyaline zone developed on the basal side of the chambers around the umbilical cavity. This clear layer makes up well over half the thickness of the wall in some parts of the shell.

Discussion.—These specimens are related to *T. acutus* because of the small apical angle and well developed two-layered wall. Although no axial sections were seen, the apical angles appear representative because the measured specimens show deep umbilical cavities indicative of a central cut. Therefore, the small angles were not caused by highly tangential sections which would show no clearly outlined umbilicus. These specimens are not definitely assigned to *T. acutus* because the deep umbilicus is neither figured nor described by Durkina (although umbilicate forms are assigned to this species by Conil and Lys) and because the chambers are not as elongate as in other figured specimens. The dimensions and deep umbilicus of my specimens resemble *T. kiselicus* Malakhova, 1956 which, however, lacks a prominent hyaline-radial layer.

Conil and Lys (1964, p. 87) raise the possibility that *T. acutus* may be synonymous with *T. submedia* Brazhnikova, 1956. The only apparent differences in the latter are a larger apical angle and slightly smaller dimensions. A much younger species, *T. volongaensis* Grozdilova and Lebedeva, 1960 differs from *T. acutus* only in having a more rounded periphery and larger dimensions. The thicker and more pervasive hyaline-radial layer distinguishes *T. acutus* from *T. angusta* Vissarionova, 1948.

Occurrence.—Zone 15 (Y 2) Yellowpine Limestone at Arrow Canyon Range.

Tetrataxis media Vissarionova, 1948

Plate 8, figures 15, 16

Tetrataxis media VISSARIONOVA, 1948, p. 191, pl. 8, figs. 1–2; GOLUBTZOV, 1957, p. 135, pl. 5, fig. 16; BOGUSH and YUFEREV, 1966, p. 174, pl. 12, figs. 1, 3.
Tetrataxis medius Vissarionova. CONIL and LYS, 1964, p. 91, pl. 12, figs. 232–234.

Measurements.—(based on 4 specimens) Number of volutions (2 specimens): 4. Apical angle (at top, 2 specimens): about 100°. Height (2 specimens): 0.35–0.41 mm. Diameter: 0.51–0.60 mm. Height/diameter (2 specimens): 0.68–0.69. Shell thickness (3 specimens): 0.040–0.060 mm.

Description.—Test is medium sized, broadly umbilicate and has convex sides. Volutions expand very slowly, and the chambers appear semicircular or elongate. The flanks are smooth. Wall is composed of a dark, granular layer and an additional hyaline-radial layer comprising up to three-fourths of the wall thickness on the basal side of the chambers around the umbilical area.

Discussion.—My specimens have fewer volutions than those described by Vissarionova but are similar in other respects. Bogush and Yuferev also assign specimens with four volutions to this species.

T. paraminima Vissarionova, 1948 differs from *T. media* in having a less broadly rounded periphery and a narrower umbilicus.

Occurrence.—Zone 15 (Y 2) Yellowpine Limestone at Arrow Canyon Range.

Tetrataxis cf. **T. obtusus** Malakhova, 1956

Plate 8, figure 14

Tetrataxis obtusus MALAKHOVA, 1956b, p. 119, pl. 14, fig. 12.

Measurements.—(based on 1 specimen) Number of volutions: 5. Apical angle (along top): 85°. Height: 0.44 mm. Diameter: 0.37 mm. Height/diameter: 1.19. Shell thickness: 0.040 mm.

Description.—Test is medium in size and narrowly umbilicate. The cone is subcylindrical in shape and has a rounded apex. Expansion of the whorls is slow. Chambers are elongate and high. Flanks are smooth on the left side and irregular on the right. Wall is mostly dark, granular calcite. There is a trace of a lower light-colored layer in the center of the shell, but no well developed hyaline-radial layer is present.

Discussion.—More specimens are needed for a positive assignment to *T. obtusus*, but this specimen appears quite similar, differing slightly in having more parallel flanks and a better developed umbilicus. The apical angle of my specimen is much larger than that reported by Malakhova. This discrepancy results not from a basic difference in the shell shapes but from the position where the angle was measured. Evidently, Malakhova measured the angle lower down on the sides than I did.

Malakhova differentiates this species from *T. angusta* Vissarionova var. *serpukhovensis* Reitlinger, 1950 on the basis of its greater height/diameter ratio, fewer number of whorls and a less developed hyaline-radial layer. This species also differs from *T. hemisphaerica* Morozova var. *elongata* Morozova, 1949 in its smaller dimensions and fewer whorls.

Occurrence.—Zone 15 (Y 2) Yellowpine Limestone at Arrow Canyon Range.

Tetrataxis parviconica Lee and Chen, 1930
Plate 8, figure 17

Tetrataxis parviconica LEE and CHEN, *in* Lee *et al.*, 1930, p. 93, pl. 3, figs. 3, 5; BOGUSH and YUFEREV, 1966, pp. 173–174, pl. 12, fig. 2.

Measurements.—(based on 1 specimen) Number of volutions: 5 or 6. Apical angle: 95°. Height: 0.33 mm. Diameter: 0.67 mm. Height/diameter: 0.49. Shell thickness: 0.045 mm.

Description.—Test is medium in size, regularly conical and has a shallow umbilicus. Volutions expand slowly. Chambers are relatively flat and elongate, turning upward toward the umbilical cavity. Flanks are smooth. The wall is two-layered with the usual upper, dark, granular zone and hyaline-radial layer which is moderately developed on the basal side of the chambers.

Discussion.—This specimen differs from the type material of Lee and Chen in having a smaller height/diameter ratio and a shallower umbilicus. However, the dimensions agree well with Bogush and Yuferev's figure.

T. quasiconica Brazhnikova, 1956 has more volutions than the present species, but otherwise appears similar. In shape, height, width and number of volutions, *T. quasiconica* var. *plana* Golubtzov, 1957 appears identical to *T. parviconica*. But Golubtzov's description (1957, pp. 137–138) indicates that the former species has a thinner wall and more poorly developed hyaline-radial layer. The wall, however, is indistinct in Golubtzov's figures and cannot be adequately compared with *T. parviconica.*

Occurrence.—Morrow (BS 3) Bird Spring Formation at Arrow Canyon Range.

Tetrataxis aff. T. parviconica
Lee and Chen, 1930
Plate 8, figure 18

Measurements.—(based on 1 specimen) Number of volutions: 4. Apical angle (along flanks): 95°. Height: 0.28 mm. Diameter: 0.53 mm. Height/diameter: 0.53. Shell thickness: 0.040 mm.

Description.—Test is medium sized, regularly conical and has a rounded apex. Umbilicus is not clearly defined. Volutions expand slowly. Chambers are elongate and maintain a constant height in each whorl. Sides are smooth. The granular wall layer is thick along the flanks and on the basal side of the last volution but is almost completely replaced by the hyaline-radial layer in the center of the shell.

Discussion.—This section differs from typical *T. parviconica* specimens in having fewer volutions, an indistinct umbilicus and smaller dimensions.

Occurrence.—Morrow (BS 2) Bird Spring Formation at Arrow Canyon Range.

Tetrataxis vulgaris Malakhova, 1956
Plate 8, figure 10

Tetrataxis vulgaris MALAKHOVA, 1956b, p. 119, pl. 14, figs. 11, 15–16.

Measurements.—(based on 1 specimen) Number of volutions: 4. Apical angle: 105°. Height: 0.23 mm. Diameter: 0.37 mm. Height/diameter: 0.62. Shell thickness: 0.035 mm.

Description.—Test is small, umbilicate and regularly conical. The last volution expands more rapidly than the others. Chambers are mostly semicircular. Flanks are smooth. The wall is generally dark, granular calcite. A light colored layer appears on the lower side of a few chambers around the umbilicus.

Discussion.—*T. vulgaris* is almost identical to *T. eominima* Rauzer-Chernousova, 1948 differing only in having a thin, light colored layer (absent in the latter) and a thicker wall. Based on the above features, my specimen is more closely allied to *T. vulgaris.*

T. dzhezkazganicus Vdovenko, 1962 is distinguished from the present specimen in its relatively lower height, fewer volutions and thinner wall. *T. ovalis* Vdovenko, 1962 differs in its semicircular outline and thinner wall. *T. conica* Ehrenberg var. *lata* Spandel, 1901 has a narrower apical angle and larger dimensions and apparently lacks a hyaline-radial layer. *T. pusillus* Conil and Lys, 1964 (invalid name, preoccupied by *T. pusillus* Golubtzov, 1957) also has a smaller apical angle and no clear fibrous layer.

Occurrence.—Zone 15 (Y 2) Yellowpine Limestone at Arrow Canyon Range.

Tetrataxis sp. A
Plate 8, figures 7, 8

Measurements.—(based on 4 specimens) Number of volutions: 3–4. Apical angle (along top, 3 specimens): 100–105°. Height (3 specimens): 0.25–0.28 mm. Diameter: 0.40–0.51 mm. Height/diameter (3 specimens): 0.53–0.62. Shell thickness (3 specimens): 0.045 mm. up to 0.070 mm. at base of one specimen.

Description.—Test is broadly umbilicate, flattened and mostly medium sized, and the sides are slightly arched. Volutions expand slowly. Chambers appear semicircular to elongate. Flanks are smooth or slightly irregular. Wall is two-layered with a dark, granular layer throughout and a hyaline-radial zone comprising at least half the shell thickness around the umbilical area.

Discussion.—For want of better oriented material, these specimens are not formally given a new species name, although their parameters seem distinctive. The well developed hyaline-radial layer readily distinguishes my specimens from other single to indistinctly layered, low-spired species such as *T. eominima* Rauzer-Chernousova, 1948, *T. expansus* and *T. vulgaris* Malakhova, 1956, and *T. dzhezkazganicus* and *T. ovalis* Vdovenko, 1962. Except for a narrower apical angle (as measured from the illustration) *T. conica* Ehrenberg var. *lata* Spandel, 1901 appears quite similar to my specimens in size, shape and number of whorls. However, Spandel did not describe the wall structure of his species and his line drawings do not show a fibrous layer.

There are also a few distinctly double-layered species which may be distinguished from the present form. *T. irregularis* Morozova, 1949 has more volutions and larger dimensions. *T. media* Vissarionova, 1948 has more convexity, a greater height/diameter ratio, larger dimensions and commonly more volutions. *T. pusillus* Golubtzov, 1957 has a smaller apical angle, narrower umbilicus, greater height/diameter ratio and smaller dimensions.

Occurrence.—Zone 15 (Y 2) Yellowpine Limestone at Arrow Canyon Range.

Tetrataxis sp. B
Plate 8, figure 9

Measurements.—(based on 1 specimen) Number of volutions: 4. Apical angle (along top): 105°. Height: 0.21 mm. Diameter: 0.46 mm. Height/diameter: 0.45. Shell thickness: 0.030 mm.

Description.—Test is medium sized and umbilicate. The cone is flattened with a rounded apex, mildly arched flanks and a slightly flaring final volution. Expansion of the whorls is slow. Chambers are mostly elongate. Sutures are indented; flanks are slightly lobate and somewhat irregularly shaped. The test wall is composed almost exclusively of a thin, single, granular layer. The additional hyaline-radial layer appears on the lower side of only a few chambers in the center of the shell above the umbilical cavity, appreciably thickening the wall in this spot. A small appendage, possibly some type of apertural projection, extends downward from the umbilical area.

Discussion.—The basal appendage primarily distinguishes this specimen from other similarly sized and shaped species such as *T. vulgaris* Malakhova.

Occurrence.—Morrow (BS 3) Bird Spring Formation at Arrow Canyon Range.

Tetrataxis sp. C
Plate 8, figure 19

Measurements.—(based on 1 specimen) Number of volutions: 4–5. Apical angle: 85°. Height: 0.33 mm. Diameter: 0.46 mm. Height/diameter: 0.72. Shell thickness: 0.040 mm.

Description.—Test is medium in size, regularly conical and appears non-umbilicate although the umbilicus may be missed by the angle of section. The height of the volutions increases very slowly, yet each whorl extends laterally beyond the one above it, producing a "stair-step" outline along the flanks. Chambers are relatively flat and long. The dark, granular wall becomes progressively lighter colored toward the basal side of the chambers. The fibrous layer, however, is not clearly exhibited.

Discussion.—In its "stair-step" outline, apical angle and wall thickness and structure, this specimen appears related to *T. dentata* Vissarionova var. *magna* Vissarionova, 1948. My specimen differs, however, in being smaller, having longer and straighter chambers and possibly lacking an umbilicus. This present form may be a descendant of Vissarionova's Visean species. More specimens must be studied before a definite specific assignment can be made.

Occurrence.—Morrow (BS 3) Bird Spring Formation at Arrow Canyon Range.

Family ARCHAEDISCIDAE Cushman, 1928

Specimens of this family are generally small and discoidal to subglobular in shape. The surface of the shell is smooth or rough, and in some specimens lateral thickenings occur in the axial region. The proloculus is followed by a single, undivided chamber that coils from completely skew to completely planispiral. In general, the initial whorls are involute and the later ones evolute, although both completely involute and completely evolute forms are common. The interior of the second chamber, the lumen, varies from closed to open. The two-layered wall is composed of a typically thicker, light colored, fibrous (hyaline-radial) layer

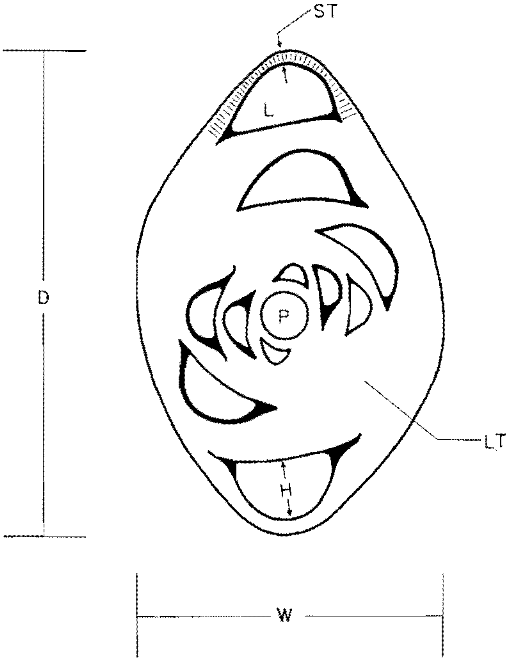

FIGURE 13

Axial section of *Archaediscus* with 5½ volutions. L, lumen; H, height of lumen; P, proloculus; LT, lateral thickenings; ST, peripheral shell thickness with an outer, light colored, fibrous layer and an inner, dark, microgranular layer; D, diameter; W, width (redrawn from Grozdilova *in* Dain and Grozdilova, 1953).

and an inner, thin, dark, microgranular zone which is nearly absent in some genera. The fibrous layer is highly stable and is commonly preserved even in recrystallized limestones, but its color, which is the same as that of the surrounding spar, and the small size of the organisms make the specimens difficult to find. Aperture is a simple opening at the end of the second chamber.

Figure 13 shows some of the important morphological features of the family. Most descriptions are based exclusively on axial, or near axial, sections in which most of the important parameters are exposed.

An outline of the characteristics of the five genera (*Planospirodiscus, Archaediscus, Quasiarchaediscus, Asteroarchaediscus* and *Neoarchaediscus*) found in this study are presented in Table 7 as well as characteristics of other genera presently placed in this family.

Genus **Archaediscus** Brady, 1873

Type species: *Archaediscus karreri* Brady, 1873.

Description.—Test is small, smooth sided, discoidal to subglobular with a broadly rounded periphery. Lateral thickenings are formed in the axial region. The present specimens contain three to four involute whorls which are gently to moderately skew-coiled; the last one to two volutions tend to be planispiral in some specimens. The lumina are open, semicircular or mildly crescentic in shape, and they expand slowly to moderately in height throughout the coil. The wall has two well developed layers—an outer, light colored, fibrous layer and an inner, dark, microgranular zone. The fibrous layer is considerably thicker than the dark layer along the sides because of the overlap of the fibrous wall layer during coiling, but around the periphery the dark layer sometimes attains almost half the thickness of the wall. Aperture was not seen, but is reported to be a simple opening at the end of the tubular chamber.

Discussion.—This genus exhibits a variety of shapes, lateral thickenings and coiling habits which were not encountered in the few specimens found in this study. Conil and Lys (1964, pp. 100–102) give an excellent discussion of archaediscid coiling.

The nonplanispiral, mostly involute coiling, the well developed, dark wall layer and the lateral fillings, when present, distinguish *Archaediscus* from *Planospirodiscus* Sosipatrova, 1962. *Propermodiscus* Miklukho-Maklai, 1953 has much thicker lateral fillings than *Archaediscus*, and *Planoarchaediscus* Miklukho-Maklai, 1956 has a poorly developed fibrous layer in its last few planispiral whorls which are also evolute.

Depending on the thickness of the lateral deposits, most specimens of *Paraarchaediscus* Orlova, 1955 (*e.g.* see Conil and Lys, 1964, pl. 20, figs. 406–410; 1966, pl. 2, fig. 16; 1968, pl. 11, figs. 142–144) resemble either *Archaediscus* or *Propermodiscus* but differ primarily from these two genera in having the last whorl evolute commonly with the sutures depressed.

Miklukho-Maklai erected the genus *Hemiarchaediscus* in 1957 as a form similar in coiling to *Propermodiscus* but lacking the thick, symmetrical umbilical thickenings. However, other *Archaediscus* species such as *A. stilus* Grozdilova and Lebedeva, 1955 (not 1953) and those forms assigned to *A. krestovnikovi* Rauzer-Chernousova, 1948 prior to the reinterpretation of the enrollment by Conil and Lys (1968, pp. 510–512) have coiling, compressed lateral shape and wall structure similar to *Hemiarchaediscus*. This coiling is not sufficiently distinctive, in my estimation, to warrant a new genus.

Archaediscus cf. **A. pauxillus** Shlykova, 1951
Plate 9, figure 1

Archaediscus pauxillus Shlykova, 1951, pp. 160–161, pl. 3, figs. 15–17; Sosipatrova, 1962, p. 56, pl. 4, figs. 12–13; Aizenverg *et al.*, 1968, pl. 17, fig. 13.

TABLE 7

Genera of the Archaediscidae. Characteristics of these genera are summarized from the literature. Only the starred (*) taxa are found in the present study.

GENUS	COILING	SHAPE	WALL
Permodiscus Chernysheva, 1948	planispiral; involute; open lumen	lenticular with thick, symmetrical, fillings; smooth sided	both outer, light colored, fibrous layer and inner, dark granular layer well developed
**Planospirodiscus* Sosipatrova, 1962	mostly planispiral and evolute; open lumen	discoidal with no lateral thickenings; commonly smooth sided	well developed outer, light colored, fibrous layer and poorly developed inner, thin, dark granular layer
Propermodiscus Miklukho-Maklai, 1953	initial volutions skew, later ones planispiral; involute, open lumen	lenticular with thick, symmetrical, lateral fillings; smooth sided	both fibrous and granular layers well developed
**Archaediscus* Brady, 1873 = *Hemiarchaediscus* Miklukho-Maklai, 1957	skew throughout, sigmoidal, initially skew or sigmoidal and later planispiral; mostly involute; open lumen	discoidal to subglobular; lateral thickenings slight to thick; smooth sided	both fibrous and granular layers well developed
Paraarchaediscus Orlova, 1955	initial volution skew, later ones planispiral; last whorl evolute, interior ones involute; open lumen	discoidal or lenticular; lateral fillings slight to thick; suture of last volution is depressed	both fibrous and granular layers well developed
Planoarchaediscus Miklukho-Maklai, 1956	initial volutions skew and involute; later ones planispiral and evolute; open lumen	discoidal with no lateral thickenings; sutures of planispiral volutions are depressed	wall mostly dark and granular; fibrous layer poorly developed
**Quasiarchaediscus* Miklukho-Maklai, 1960	inner and outer volutions coiled in two planes at right angles to one another; open and closed (?) lumen	lenticular with no lateral fillings; smooth sided	well developed fibrous and poorly developed granular layers
**Asteroarchaediscus* Miklukho-Maklai, 1956	mostly skew throughout; involute to evolute; lumen closed and has stellate outline	discoidal or lenticular; some asymmetrical lateral thickenings; surface commonly rough	well developed fibrous and poorly developed granular layers
Lensarchaediscus Porshnyakova, 1957	mostly planispiral; involute; lumen closed and has stellate outline	lenticular; lateral fillings thick and symmetrical; smooth sided	well developed fibrous and poorly developed granular layers
**Neoarchaediscus* Miklukho-Maklai, 1957	initial volutions skew and involute and have a closed, commonly stellate lumen; later volutions mostly planispiral and evolute and have an open lumen	discoidal with no lateral fillings; surface rough or smooth	well developed fibrous and poorly developed granular layers
Rugoarchaediscus Miklukho-Maklai, 1957	skew throughout; initial volutions involute and have a closed, stellate lumen; later ones evolute and have an open lumen	lenticular; some symmetrical to asymmetrical lateral thickenings; smooth sided	well developed fibrous and poorly developed granular layers

Measurements.—(based on 1 specimen) Number of volutions: 3. Diameter: 0.15 mm. Interior diameter of proloculus: 0.035 mm. Height of lumen last volution: 0.020 mm. Peripheral shell thickness last volution: 0.010 mm.

Description.—Test is small and smooth, and the subglobular shape is accentuated by the diagonal section. The planes of coiling of the last two whorls are at a slight angle to one another but positioned at 90° to the initial planispiral volution. The semicircular lumina expand slowly in height and are moderately high. The wall is two-layered with a thicker, light colored, fibrous layer on the outside and an inner, thin, dark, microgranular layer which is well developed in places. Aperture was not seen.

Discussion.—This specimen differs from Shlykova's type material in having a larger proloculus surrounded by fewer planispiral whorls (one in this specimen versus one and one-half to two in Shlykova's). Also a well oriented axial section is needed to determine the width. *Archaediscus itinerarius* Shlykova, 1951 coils in a manner similar to this specimen but has a greater diameter and higher and more rapidly expanding lumina.

Conil and Lys (1964, pp. 101–102) point out that fortuitous sections through specimens with sigmoidal coiling will produce the same kind of enrollment as *A. pauxillus.* My specimen slightly resembles the sigmoidal species *A. moelleri* Rauzer-Chernousova, 1948 which has larger dimensions and more whorls.

Obviously more specimens are needed to check the coiling and other parameters before a positive species identification can be made.

Occurrence.—Zone 17–18 (BW 4) Battleship Wash Formation at Arrow Canyon Range.

Archaediscus sp. A

Plate 8, figures 20, 21

Measurements.—(based on 3 specimens) Number of volutions (2 specimens): 3–4. Diameter (2 specimens): 0.19—about 0.23 mm. Width (2 specimens): 0.12—about 0.13 mm. Width/diameter (1 specimen): about 0.57. Interior diameter of proloculus (2 specimens): 0.30 mm. Lumen height last volution (2 specimens): 0.025–0.035 mm. Peripheral shell thickness last volution (2 specimens): 0.010–0.015 mm.

Description.—Test is small, smooth sided, discoidal-lenticular and has a rather broadly rounded periphery. Coiling is involute and the overlap of the whorls produces lateral thickenings around the proloculus. The plane of coiling oscillates during growth, but the last one or two whorls tend to be planispiral. The lumina are high, semicircular or mildly crescentic in shape and expand steadily and moderately in size. Both the outer, light colored, fibrous layer and the inner, dark, microgranular layer are well developed and are approximately of equal width along the peripheral edge of the shell. Aperture was not seen, but is probably a simple opening at the end of the tube.

Discussion.—At least in coiling habit, these specimens resemble *Archaediscus stilus* Grozdilova and Lebedeva, 1955 (not 1953) and those forms assigned to *A. krestovnikovi* Rauzer-Chernousova, 1948 prior to the reinterpretation of the enrollment by Conil and Lys (1968, pp. 510–512). However, I do not have enough well oriented specimens to assign a species name.

Occurrence.—Zone 15 (Y 2, Y 3) Yellowpine Limestone at Arrow Canyon Range.

Genus Asteroarchaediscus Miklukho-Maklai, 1956

Type species: *Archaediscus baschkiricus* Krestovnikov and Theodorovich, 1936.

Description.—Test is small, discoidal to slightly lenticular and has a broadly rounded axial periphery. Shell surface is mildly rugose or smooth in some cases. Lateral thickenings are not well developed in my specimens, although other workers (*e.g.* Miklukho-Maklai, 1956, p. 10) report large asymmetrical deposits. The second chamber contains three to five volutions. All the whorls are more or less skew coiled, but the last one to two tend to be planispiral and evolute whereas the inner whorls are more glomospirally coiled and involute or partially evolute. The lumina are completely closed or, less commonly, slightly open in the last one or two volutions. The height of the open lumina, however, is lower than the thickness of the surrounding peripheral wall. The folding or crenulation of the surface of the whorls give all the lumina a characteristic wavy appearance referred to as "stellate." The wall consists of an outer, thick, light colored, fibrous layer and an inner, thin, dark, fine grained zone which is commonly absent. Aperture is a slit at the end of the tubular chamber.

Discussion.—This genus differs primarily from *Neoarchaediscus* in having closed or, occasionally, low, open lumina. *Neoarchaediscus* has initially closed stellate lumina which change to high, open ones in later whorls. As a rule, lumen heights of *Asteroarchaediscus* species, when open, are consistently lower than the thickness of the surrounding wall.

Lensarchaediscus Porshnyakova, 1957 has closed, stellate lumina which are, however, mostly planispirally arranged and also has massive, symmetrical lateral thickenings. This genus is infrequently encountered in the literature and may be considered synonymous with *Asteroarchaediscus.*

Asteroarchaediscus gnomellus n. sp.

Plate 9, figures 2–6

Measurements.—(based on 9 specimens) Number of volutions: 3–4. Diameter (7 specimens): 0.09–0.14 mm. Width (7 specimens): 0.05–0.07 mm. Width/diameter (5 specimens): 0.46–0.60. Interior diameter of proloculus (4 specimens): about 0.015–0.020 mm. Peripheral shell thickness last volution (6 specimens): 0.005–0.010 mm.

Description. Test is small, discoidal to slightly lenticular and has a broadly rounded periphery. Shell surface is slightly rugose or smooth. Proloculus is small and not readily distinguished from the surrounding wall, making measurement difficult. Coiling is generally skew throughout with the outer whorls tending to be planispiral and evolute. Most lumina are closed and stellate. Rarely the lumina are slightly open, but the final lumen in a few specimens is high. The wall is two-layered with the light colored, fibrous layer being dominant. An inner, thin, dark layer appears in some specimens and outlines the shape of the lumen. Aperture is a slit at the end of the tube.

Discussion.—The specimens with a high, open, final lumen were included in this species because all other features including age are similar to the other specimens; the high opening is just an individual variation and does not appear consistently. This species differs from *Asteroarchaediscus rugosimilis* in its smaller dimensions and greater width/diameter ratio.

The name, derived from the word "gnome" and the Latin diminutive "*ellus*," refers to the small size of the organisms.

Occurrence.—Zone 17–18 (BW 4, BW 5) Battleship Wash Formation at Arrow Canyon Range.

Asteroarchaediscus rugosimilis n. sp.

Plate 9, figures 7–10

Measurements.—(based on 6 specimens) Number of volutions (3 specimens): about 5. Diameter (4 specimens): 0.17–0.20 mm. Width (5 specimens): 0.07–0.08 mm. Width/diameter (3 specimens): 0.40–0.47. Interior diameter of proloculus (3 specimens): 0.025–0.030 mm. Peripheral shell thickness last volution (4 specimens): 0.010–0.020 mm.

Description.—Test is small and discoidal with a broadly rounded periphery. Shell surface is slightly rough. The last one or two volutions are planispiral or only slightly skewed and evolute; the initial whorls are highly skewed and involute or partially evolute. Lumina are mostly closed throughout the coil and have a stellate outline. A few lumina in the later volutions are slightly open, but their height does not equal the thickness of the surrounding wall. The wall consists of thick, light colored, fibrous calcite. An inner, very thin, dark, discontinuous layer is present, and helps define the shape of the lumina. Aperture was not seen but probably is a slit at the end of the tubular chamber.

Discussion.—These specimens are closest in appearance to *Archaediscus rugosus* Rauzer-Chernousova, 1948. They differ in that the lumina are much lower in the last volutions than those described by Rauzer-Chernousova (1948c, p. 11) in which the height equals or exceeds the wall thickness.

Miklukho-Maklai (1956, p. 11) refers Rauzer-Chernousova's species to *Asteroarchaediscus.* Bogush and Yuferev (1962, p. 205) also attribute specimens to *Asteroarchaediscus rugosus* (Rauzer-Chernousova) in which the height of the lumina of the last whorl (0.018–0.030 mm.) exceeds the shell thickness (0.009–0.024 mm.). But because of the relatively high, open lumina, *A. rugosus* may actually belong to *Neoarchaediscus*, and it is placed in this genus by Sosipatrova (1962, pp. 61–62, pl. 5, figs. 12–14).

The present species is named for its resemblance to *A. rugosus.*

Occurrence.—Zone 17–18 (BW 4, BW 5) Battleship Wash Formation; zone 19 (BS 1) Bird Spring Formation; Morrow (BS 3) Bird Spring Formation at Arrow Canyon Range.

Genus **Neoarchaediscus** Miklukho-Maklai, 1956

Type species: *Archaediscus incertus* Grozdilova and Lebedeva, 1954.

Description.—Test is small, smooth sided or rough and discoidal with a rounded periphery. Lateral thickenings are absent. There are three (commonly four) to six volutions. The first one to three are skew coiled, involute and have closed lumina. Typically the surface of the inner whorls are irregular and the lumen has a stellate appearance. The remaining whorls are planispiral or slightly skewed, partially or completely evolute and have open lumina. The open lumina are semicircular or crescentic in axial view; the interior surface is commonly smooth, but roughness is seen in at least one species. In the last whorl, the height of the lumen equals or exceeds the peripheral thickness of the shell wall. The wall is composed of a thick, light colored, fibrous outer layer and a thin, dark, microgranular, inner layer which is nonexistent in many cases. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—*Neoarchaediscus* is most easily distinguished from other genera by the change from a closed to open lumen during coiling. In contrast, *Asteroarchaediscus* has closed lumina throughout, and *Planospirodiscus, Propermodiscus,* and *Archaediscus* have completely open lumina.

Rugoarchaediscus Miklukho-Maklai, 1957 ostensibly differs from *Neoarchaediscus* in being completely skew coiled and lenticular. However, it is seldom mentioned in the literature and a specimen of the type species, *Archaediscus akchimensis* Grozdilova and Lebedeva, 1954 is referred to *Neoarchaediscus* by Bogush and Yuferev (1966, p. 208, pl. 9, fig. 18). *Neoarchaediscus* does show some skew coiling in the later volutions as well as in the earlier ones; therefore, *Rugoarchaediscus* possibly is not sufficiently distinctive to be considered a separate genus.

There is confusion in the literature in assigning some specimens to *Neoarchaediscus* or *Asteroarchaediscus*. For example, *Archaediscus postrugosus* Reitlinger, 1949 is referred to *Neoarchaediscus* by Miklukho-Maklai (1956, p. 11) and Bogush and Yuferev (1962, p. 207, pl. 9, fig. 17 and 1966, p. 169, pl. 11, fig. 24) but to *Asteroarchaediscus* by Brazhnikova *et al.* (1967, pl. 20, fig. 4; pl. 21, fig. 3) and Aizenverg *et al.* (1968, pl. 24, fig. 9). The cause of this confusion possibly lies in Miklukho-Maklai's original description of *Neoarchaediscus* (1956, p. 11) which states that the last two to three whorls have open lumina. *Archaediscus postrugosus* has approximately one volution with high, open lumina. The presence or absence of open lumina, rather than the number of open lumina, would provide the most consistent basis for the generic distinction. Therefore, I would place in *Neoarchaediscus* all species, including *A. postrugosus*, which have closed to open lumina and in which the height of at least the final lumen consistently equals or exceeds the thickness of the surrounding wall. Occasional specimens of *Asteroarchaediscus* have a few open lumina, but they are typically quite low.

Neoarchaediscus incertus
(Grozdilova and Lebedeva), 1954

Plate 9, figures 16–25

Archaediscus incertus GROZDILOVA and LEBEDEVA, 1954, p. 60, pl. 7, figs. 14–15.

Neoarchaediscus incertus (Grozdilova and Lebedeva). MIKLUKHO-MAKLAI, 1956, p. 11; GROZDILOVA and LEBEDEVA, 1960, p. 98, pl. 11, fig. 11.

Neoarchaediscus incertus var. *incerta* (Grozdilova and Lebedeva). CONIL and LYS, 1964, p. 130, pl. 20, figs. 389–391.

Neoarchaediscus incertus (Grozdilova and Lebedeva) var. *carnosa*. CONIL and LYS, 1964, p. 130, pl. 20, fig. 392.

Measurements.—(based on 16 specimens) Number of volutions (12 specimens): 5–6. Diameter (15 specimens): 0.21–0.34 mm. Width (14 specimens): 0.07–0.13 mm. Width/diameter (13 specimens): 0.32–0.45. Interior diameter of proloculus (9 specimens): 0.020–0.030 mm. Height of lumen last volution (13 specimens): 0.020–0.040 mm. Peripheral shell thickness last volution (14 specimens): 0.005–0.020 mm.

Description.—Test is small, smooth, or slightly rough and discoidal, commonly with a broadly rounded periphery. The intial one to three (mostly two or three) volutions are involute, skew coiled, and have a closed lumen which exhibits a rugose or stellate outline caused by the irregular peripheral shape of the whorls. The remaining two to four (typically three or four) volutions are mostly evolute, planispiral or slightly skewed and have a smooth, open lumen which is semicircular or mildly crescentic in shape. In the last two volutions, also less commonly in the third and fourth, the lumen is higher than the shell thickness. The wall is composed of a thick, light colored, faintly fibrous outer layer and a poorly developed thin, dark, inner layer which is commonly absent. Aperture was not seen but is inferred to be a simple opening at the end of the tubular chamber.

Discussion.—The dimensions of my specimens agree for the most part with those of Grozdilova and Lebedeva although some specimens have a greater number of open lumina.

A number of other species are quite similar and are not always easily distinguishable. Grozdilova and Lebedeva (1954, p. 60, translated in Ellis and Messina, supplement no. 1, 1964) say that this present species differs from *N. gregorii* (Dain), 1953 in the abrupt transition from skew to planispiral coiling, larger lumina of the outer volutions, smaller dimensions and a thinner wall. *N. parvus* (Rauzer-Chernousova) var. *regularis* (Suleimanov), 1948 has, in the last two whorls, open lumina which apparently are lower than those in *N. incertus*. *N. borealis* (Reitlinger), 1949 has a more narrowly angled periphery, more planispiral coiling and highly crescentic open lumina.

Occurrence.—Zone 17–18 (BW 4, BW 5) Battleship Wash Formation; Morrow (BS 2, BS 3) Bird Spring Formation at Arrow Canyon Range.

Neoarchaediscus cf. N. parvus
(Rauzer-Chernousova), 1948

Plate 9, figures 11–15

Archaediscus parvus RAUZER-CHERNOUSOVA, 1948b, p. 233, pl. 16, figs. 9–12; MALAKHOVA, 1956a, p. 41, pl. 3, figs. 4–5.

Neoarchaediscus parvus (Rauzer-Chernousova). MIKLUKHO-MAKLAI, 1956, p. 11.

Measurements.—(based on 6 specimens) Number of volutions: about 4–5. Diameter: 0.17–0.18 mm. Width (5 specimens) 0.07–0.10 mm. Width/diameter (5 specimens): 0.41–0.55. Interior diameter of proloculus (2 specimens): 0.015–0.030 mm. Height of lumen last volution (5 specimens): 0.015–0.025 mm. Peripheral shell thickness last volution: 0.005–0.015 mm.

Description.—Test is small and discoidal with a broadly rounded periphery. Surface of the test is notably rough. The first two and one-half to three volutions are skew coiled, involute and have closed lumina with an irregular or stellate outline. The final one to one and one-half whorls are planispiral or slightly skewed, partially evolute and have open lumina. These lumina are mildly crescentic in shape and their interior surface is slightly irregular, caused by the crenulations on the surface of the previous whorl. The wall is composed of light colored, finely fibrous calcite. A dark, inner, microgranular layer is very thin or absent. Aperture is a simple opening at the end of the tube.

Discussion.—These specimens differ from the type material in being slightly wider, having a larger proloculus in one specimen (Plate 9, figure 12) and a higher, open, final lumen in another (Plate 9, figure 11). The irregular surface and smaller size distinguish this species from *N. incertus* and related forms. *N. latispiralis* (Grozdilova and Lebedeva), 1953 (as seen in Bogush and Yuferev, 1966, p. 168, pl. 11, fig. 23) differs from my specimens in being smoother, having a larger proloculus and a higher lumen relative to the shell thickness. *Asteroarchaediscus*? *rugosus* (see discussion of *Asteroarchaediscus rugosimilis*) appears similar but larger.

Occurrence.—Zone 17–18 (BW 4) Battleship Wash Formation; Morrow (BS 2, BS 3) Bird Spring Formation at Arrow Canyon Range.

Genus **Planospirodiscus** Sosipatrova, 1962

Type species: *Planospirodiscus tajmyricus* Sosipatrova, 1962.

Description: Test is narrowly discoidal, mostly small and has a rounded periphery. The sides are generally smooth, but the suture at the end of the final whorl is depressed in one species. Lateral thickenings are absent. Specimens definitely placed in the genus have four to five volutions, the first of which is skewed and partially involute, but the remainder are essentially planispiral and evolute. The lumen is slightly crescentic, semicircular or omega-shaped and open throughout the coil, although the initial whorls are tightly enrolled. However, one species (*P*? *altiluminis*) tentatively assigned to the genus has about seven volutions, the first three to four of which are slightly skewed and, in one specimen, closed. Rate of expansion of the coil is steady and moderate, but in some specimens the last whorl expands more rapidly than the earlier ones. The wall has an outer, thick, hyaline-radial layer and an inner, thin, dark, microgranular zone which is not present in all specimens. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—This genus differs from *Permodiscus* Chernysheva, 1948 by the absence of thick axial deposits and from *Planoarchaediscus* by the well developed fibrous layer and poorly represented inner, dark layer.

The skewness and tight coiling of the initial volutions make it difficult to separate some specimens of this genus from the ancestral genus *Neoarchaediscus* which generally has more closed, skew-coiled volutions.

Planospirodiscus? altiluminis n. sp.

Plate 9, figures 26, 27

Measurements.—(based on 2 specimens) Number of volutions: about 7. Diameter: 0.49 mm. Width (1 specimen): 0.11 mm. Width/diameter (1 specimen only): 0.22. Interior diameter of proloculus: 0.025 mm. Height of lumen last volution: 0.040–0.050 mm. Peripheral shell thickness last volution: 0.015–0.020 mm.

Description.—Test is medium sized, smooth sided and discoidal. The first three to four volutions are slightly skew coiled and involute; the remainder are planispiral and evolute. In the axial section (Plate 9, figure 27) the lumina of the skew whorls appear closed and stellate, but in the sagittal section (Plate 9, figure 26) the lumina are open back to the proloculus. The open lumina of the final volutions are relatively high, and they are narrow and slightly crescentic in axial view. The wall is light colored, finely fibrous calcite with only a trace of a dark, inner layer. Aperture is the open end of the lumen.

Discussion.—These two specimens are questionably assigned to *Planospirodiscus* because one of them appears to have closed lumina in the initial whorls. The sagittally oriented specimen exhibits the completely open lumina characteristic of *Planospirodiscus*, yet the axial section with its closed to open lumina could belong to *Neoarchaediscus*. Both specimens must belong to the same species inasmuch as the dimensions, number of volutions, coiling and wall structure are similar, and both are from the same sample. They are placed with *Planospirodiscus* rather than *Neoarchaediscus* because of the small width/diameter ratio and final, high and relatively narrow open lumina seen in the axial specimen and the completely open lumina of the sagittal one. Furthermore, *Planospirodiscus* commonly exhibits some initial coiling skewness.

The large size, number of volutions and number of skew coiled whorls as well as the initial closed lumina in the axial section, distinguish these specimens from other *Planospirodiscus* species encountered in this study.

The name, derived from the Latin words "*altus*" meaning high and "*lumen*" meaning light, refers to the high, open lumen of the last few volutions.

Occurrence.—Morrow (BS 3) Bird Spring Formation at Arrow Canyon Range.

Planospirodiscus cf. **P. minimus**
(Grozdilova and Lebedeva), 1953

Plate 9, figures 28–34

Archaediscus minimus GROZDILOVA and LEBEDEVA, *in* Dain and Grozdilova, 1953, pp. 111–112, pl. 4, fig. 15.

Archaediscus (?) *minimus* Grozdilova and Lebedeva. GROZDILOVA and LEBEDEVA, 1954, pp. 62–63, pl. 7, fig. 16.

Planospirodiscus minimus (Grozdilova and Lebedeva). SOSIPATROVA, 1962, pp. 64–65, pl. 5, figs. 22–24; SOSIPATROVA, 1966, p. 21, pl. 3, figs. 5–6; BOGUSH and YUFEREV, 1966, p. 170, pl. 11, figs. 26–27; MAMET, 1970, pl. 7, figs. 15, 18.

Measurements.—(based on 11 specimens) Number of volutions (9 specimens): 4–5. Diameter (9 specimens): 0.32–0.41 mm. Width (5 specimens): 0.08–0.14 mm. Width/diameter (5 specimens): 0.25–0.35. Interior diameter of proloculus (2 specimens): 0.015–0.025 mm. Height of lumen last volution (8 specimens): 0.030–0.045 mm. Peripheral shell thickness last volution: 0.010–0.025 mm.

Description.—Test is smooth sided, discoidal and generally small. The initial whorl is skewed, but the remaining volutions are essentially planispiral and evolute. The lumen is relatively high, expands moderately in height and has an omega shape in axial section. The wall is composed of an outer, thick, light colored, fibrous layer and an inner, thin, dark, discontinuous, microgranular zone. Aperture is a simple opening at the end of the tube.

Discussion.—My material differs from figured specimens of Grozdilova and Lebedeva and Bogush and Yuferev in being larger and having a higher lumen in the last volution relative to the wall thickness. But they are similar in the peripheral shape, manner of coiling and highly arched lumina. The figured specimens of Sosipatrova (1962) are smaller and have a lower, less arched lumen than the present specimens. Sosipatrova's later material (1966) is similarly proportioned to mine but is also smaller.

Occurrence.—Morrow (BS 3) Bird Spring Formation at Arrow Canyon Range.

Planospirodiscus sulculus n. sp.

Plate 9, figures 35–37

Measurements.—(based on 7 specimens) Number of volutions (5 specimens): 4–5. Diameter (6 specimens): 0.16–0.22 mm. Width (4 specimens): 0.06–0.07 mm. Width/diameter (4 specimens): 0.30–0.38. Interior diameter of proloculus (2 specimens): 0.020–0.025 mm. Height of lumen last volution (6 specimens): 0.015–0.030 mm. Peripheral shell thickness last volution (6 specimens): 0.005–0.010 mm.

Description.—Test is small and discoidal. The initial whorl may be slightly skewed, but the remaining ones are essentially planispiral and evolute. The lumina are either semicircular or slightly crescentic in shape, and the outer ones are relatively large. The rate of expansion of the volutions is steady and moderate. The lumen at the end of the last whorl in some specimens inflates more rapidly, and commonly the suture is slightly depressed at this point. The sides of the older whorls are smooth. Wall has a thick, light colored, fibrous, outer layer and a thin, dark, microgranular, inner zone which is not present throughout. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—This species differs from my specimens of *Planospirodiscus* cf. *P. minimus* in its smaller diameter, lower lumen height, thinner wall and in the slight depression of the last suture. It is distinguished from *P. tajmyricus* Sosipatrova, 1962 and other described specimens of *P. minimus* by the depression of the suture at the end of the tubular chamber and by the generally larger size of the final lumen relative to the shell thickness.

The species name, taken from the Latin word for a small groove or furrow, refers to the final sutural depression.

Occurrence.—Zone 17–18 (BW 4, BW 5) Battleship Wash Formation at Arrow Canyon Range.

Genus **Quasiarchaediscus** Miklukho-Maklai, 1960

Type species: *Quasiarchaediscus pamirensis* Miklukho-Maklai, 1960.

Description.—(from Miklukho-Maklai, 1960, p. 150, and 1963, pp. 164–165): Test is small, smooth sided and lenticular with a rounded periphery, and it lacks lateral thickenings. The initial whorls of the second, unsegmented chamber commonly coil in one plane which is at approximately right angles to the plane of coiling of the outer volutions. The wall is composed primarily of a light colored, fibrous layer. The dark, inner layer is weakly developed or absent. Aperture opens at the end of the second chamber.

Discussion.—The two mutually perpendicular planes of coiling distinguish *Quasiarchaediscus*

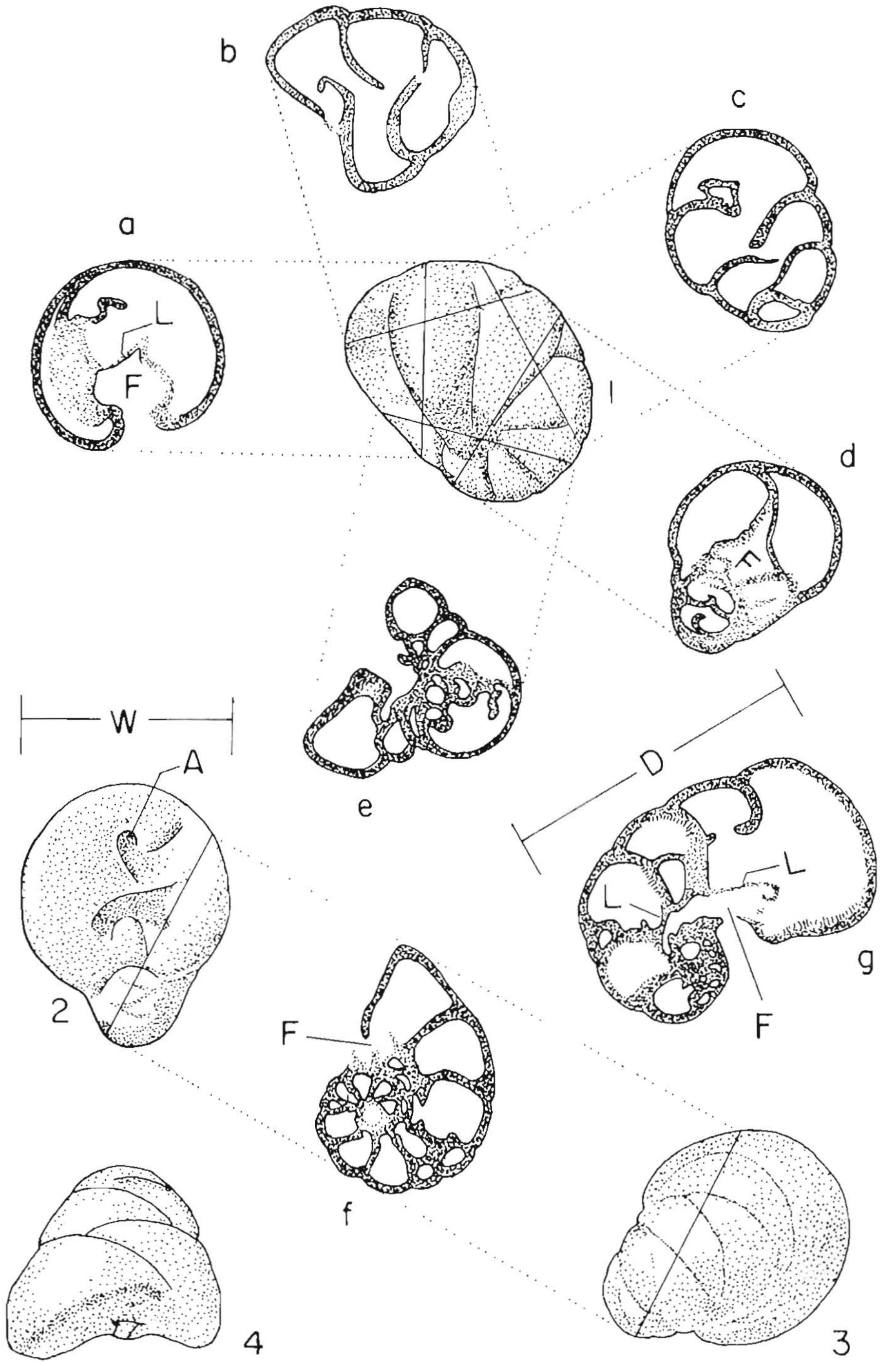

FIGURE 14

Whole specimen and cross sectional views of *Globivalvulina*. 1–4, whole specimens: 1, side; 2, apertural (ventral); 3, dorsal; 4, anterior. a–f, cross sections: a, b, c, d, tangential; e, f, diagonal; g, diagonal nearly sagittal. A, aperture; D, diameter; F, funnel; L, lamina; W, width (redrawn from Reichel, 1946).

from other archaediscid genera. Two Upper Paleozoic miliolid genera, *Eosigmoilina* and *Agathammina*, coil in a manner somewhat similar to *Quasiarchaediscus*. They both differ in possessing a nonfibrous porcelaneous wall, and *Eosigmolina* has septa in its last few volutions as well.

Quasiarchaediscus? sp. A

Plate 9, figure 38

Measurements.—(based on 1 specimen) Number of volutions: about 5. Diameter: 0.19 mm. Width: 0.08 mm. Width/diameter: 0.42. Height of final lumen: 0.020 mm. Shell thickness last volution: 0.010 mm.

Description.—Test is small, smooth sided and lenticular with a narrowly rounded periphery. The first three involute whorls are coiled in approximately the same plane and at about 90° to the outer two planispiral volutions which are evolute or partially so. The lumen is closed and stellate in all but the last whorl. Wall is composed of light colored, fibrous calcite. An inner, dark, microgranular layer is, at best, barely perceptible. Aperture and proloculus were not seen.

Discussion.—The closed to open lumina resemble *Neoarchaediscus*, but the apparent, mutually perpendicular coiling planes tentatively link this specimen with *Quasiarchaediscus*. However, to my knowledge, no other *Quasiarchaediscus* species have been described with closed lumina.

Occurrence.—Zone 19 (BS 1) Bird Spring Formation at Arrow Canyon Range.

Family BISERIAMMINIDAE Chernysheva, 1941

Genera of this family have a biserial chamber arrangement. Coiling is planispiral or trochoid and involute. Wall is fine to coarse grained calcite, homogeneous or layered, commonly with an additional inner hyaline layer. *Globivalvulina* is the only genus found in this study.

Genus **Globivalvulina** Schubert, 1920

Description.—Test is small to medium, involute and semicircular or subcircular in side view. One to two biserial volutions are coiled more or less planispirally. Coiling varies from tight to loose, almost upright growth. Chambers expand steadily in size, but commonly the last one to three pairs inflate at a disproportionately greater rate compared to the older chambers. Peripheral outline is smooth to lobate. The wall is either dark, granular and single-layered, some specimens having inclusions of lighter colored grains, or three-layered with a thick lighter colored tectum flanked by two thin, dark tectoria. In a few of my specimens the interior is covered with an additional hyaline layer best developed usually on the lower side of the septa. Reitlinger (1950, p. 76) likewise reports a two-layered wall composed of a light colored, outer zone and a dark, inner one. The interior hyaline layer is rarely found with this wall structure. The aperture is covered by a valvular projection and is located centrally on the concave apertural face at the junction of the last two chambers. This aperture, seldom seen in thin section, opens up into a basal cavity, the funnel, located between the interior septal margins and the base of the chambers. A partition, the lamina, partially restricts communication between the aperture and the lower positioned funnel.

Figure 14 illustrates some features of this genus.

Discussion.—Species are differentiated by a combination of features including wall structure, funnel shape, rate of chamber growth, peripheral outline, tightness of coil and number of chambers in the last volution. But because of the manner of coiling and small number of volutions, few of the above features appear together in thin section. The cross sections of figure 14 illustrate the difficulties of correlating tangential and diagonal sections. Since few well oriented specimens were found in this study, no new species are named, but comparisons are made with existing ones.

Globivalvulina sp. A

Plate 9, figures 39, 40

Description.—Test is probably small. The chambers are added alternately on either side of the plane of coiling with little overlap. Wall is dark, granular calcite. No sagittal sections were seen.

Discussion.—In the strong alternation of chambers, these specimens resemble *G. biserialis* Cushman and Waters, 1928 and *G. ovata* Cushman and Waters, 1928. However, comparisons cannot be carried further because my material is sparse and poorly oriented and because the two latter species are differentiated solely on external characteristics. No data on their internal features has been published.

Occurrence.—Morrow (BS 2) Bird Spring Formation at Arrow Canyon Range.

Globivalvulina sp. B

Plate 10, figures 1–5

Measurements.—(based on 5 specimens) Number of volutions (2 specimens): about 1½. Number of biserial chamber pairs in last volution (2 specimens): 6–7. Apparent diameter (4 specimens): 0.28–0.31 mm. Apparent interior height of last chamber (3 specimens): 0.115–0.135 mm. Shell thickness last volution: 0.010–0.015 mm.

Description.—Test is small. Coiling is essentially planispiral and the chambers are added in a loose arc. Chambers expand steadily in size throughout growth except for the more rapid inflation of the last chamber. Septa are straight or slightly curved in side view. Sutures are flush or slightly depressed, giving a smooth to mildly lobate peripheral outline. The wall is light or dark granular calcite and faintly layered in places. An additional indistinct, light colored (hyaline?) layer partially lines the lower surface of the septa in some specimens. Funnel is distinctly separated from the chambers by the interior lamina wall. The middle portion of the apertural face is concave in one specimen.

Discussion.—This species differs from *G. mosquensis* Reitlinger, 1950 in its poorly developed hyaline layer, more erect coiling and deeper funnel.

The specimen in Plate 10, figure 5 is a juvenile and not included in the description. It can be distinguished from *G.* species C by its tighter coil, fewer biserial chambers and having more than one volution.

Occurrence.—Morrow (BS 2, BS 7) Bird Spring Formation at Arrow Canyon Range. Morrow (E 3) Ely Limestone at Moorman Ranch.

Globivalvulina sp. C

Plate 10, figures 6, 7

Measurements.—(based on 2 specimens) Number of volutions: less than 1. Number of biserial chamber pairs: 6–7. Diameter: 0.16–0.19 mm. Interior height of last chamber: 0.045–0.050 mm. Interior diameter of proloculus: 0.030–0.035 mm. Shell thickness last chamber: 0.015 mm.

Description.—Test is small and slightly compressed in sagittal view. Coiling is planispiral, and the biserial chambers tend to unroll. Chambers expand regularly in size except for the more enlarged final one. Septa are slightly curved, and the peripheral outline is smooth. Wall is dark, granular calcite. The funnel is deep and well defined by the laminar deposits.

Discussion.—This species differs from *G. minima* Reitlinger, 1950 in having fewer whorls, more chambers in the last whorl, a smoother periphery, more regular chamber growth and a better developed funnel. It differs from *G. parva* Chernysheva, 1948 in having more chambers in the last whorl, more erect chamber addition, a more compressed lateral shape and no trochospiral coil.

Occurrence.—Morrow (BS 4) Bird Spring Formation at Arrow Canyon Range. Morrow (E 3) Ely Limestone at Moorman Ranch.

Globivalvulina sp. D

Plate 10, figures 8, 9, 14, 15

Measurements.—(based on 5 specimens) Number of volutions (1 specimen): between 1–2. Number of biserial chamber pairs in last volution (1 specimen): 6. Apparent diameter (1 specimen): 0.43 mm. Apparent width (1 specimen): 0.42 mm. Apparent interior height of last chamber (1 specimen): 0.185 mm. Shell thickness last volution: 0.015–0.020 mm.

Description.—Test is medium sized. Coiling is essentially planispiral, and the chambers grow in a loose arc. The initial chambers are small, but the last three pairs are highly inflated, accounting for almost the complete volume of the last volution. Septa are slightly curved in side view, and the sutures are flush with the outer wall, producing a smooth peripheral outline. In most specimens the peripheral wall is distinctly three-layered with a thick, coarse, inner tectum flanked by two thin, darker, microgranular tectoria. This layering becomes indistinct in the septa. An additional clear layer intermittently lines the interior of the chambers; however, this rim may be a secondary drusy filling rather than an organically produced hyaline layer. Funnel is well defined at the base of the whorl.

Discussion.—These specimens most closely resemble *G. kamensis* Reitlinger, 1950 in size, manner of coiling and rate of chamber expansion. They differ from *G. bulloides* (Brady), 1876 in having a more rapid expansion of the last chambers, a smoother periphery and a non-perforate wall. *G. biserialis* Cushman and Waters, 1928 and *G. ovata* Cushman and Waters, 1928 have diameters similar to my specimens but are more lobate and have a more regular chamber expansion. The wall structure of the above two species is unknown.

The layering of the wall easily distinguishes this present species from most others, but, as in other groups of Endothyracea, I am not sure whether this layering represents a genetically distinct feature or just better preservation of the dark, granular, homogeneous walls of other species.

Occurrence.—Morrow (BS 5, BS 7) Bird Spring Formation at Arrow Canyon Range. Morrow (E 3) Ely Limestone at Moorman Ranch.

Globivalvulina sp. E

Plate 10, figures 10, 11

Measurements.—(based on 2 specimens) Apparent diameter (1 specimen): 0.30 mm. Shell thickness last volution: 0.015 mm.

Description.—Test is small. All the volutions are not visible in these sections but are probably planispirally coiled. Chambers of the last volution are almost unrolled and grow with a steady and moderate expansion. Septa are straight or slightly curved in side view, and one septum contains two ridge-like deposits, possibly remnants of a former aperture. The peripheral outline is smooth. Wall is two-layered with a darker, coarse granular, outer zone and an inner hyaline layer, best developed on the lower side of the septa. Funnel and lamina are indistinct.

Discussion.—These specimens are not well oriented but are figured to show the inner hyaline layer which differentiates them from *G.* species B. They appear similar to *G. mosquensis* Reitlinger, 1950 except for the more erect coiling but there is not enough material to define clearly the relationship between the two.

Occurrence.—Morrow (BS 6) Bird Spring Formation at Arrow Canyon Range.

Globivalvulina sp. F

Plate 10, figures 12, 13

Measurements.—(based on 2 specimens) Number of volutions: about 1½–2. Number of biserial chamber pairs in last volution: 7–8. Apparent diameter: 0.33–0.36 mm. Shell thickness last chamber: 0.015–0.020 mm.

Description.—Test is small. Coiling is planispiral, and the chambers are in a tight arc. The last three pairs of chambers are greatly inflated relative to the preceding ones. Septa are slightly curved; periphery is smooth or slightly lobate. Wall is dark, granular calcite. Apertural face is broadly concave in one specimen. The funnel is well developed.

Discussion.—This species differs from *G.* species B in its tighter coil and unsteady rate of chamber inflation.

The two figured specimens have quite differently shaped final chambers. But the coiling, deep funnel and rate of chamber expansion are similar so that the chamber shape may be a function of the angle of section rather than a true morphological difference.

Occurrence.—Morrow (BS 7) Bird Spring Formation at Arrow Canyon Range. Morrow (E 3) at Moorman Ranch.

Family QUASIENDOTHYRIDAE

Rozovskaya, 1961

The following description is translated from Rozovskaya (1963, p. 59):

> The shell is flatly discoidal or lenticular, involute in the early stage and commonly evolute in the adult. The enrollment of the coil is asymmetrical in the early stages, planispiral in the adult, or the early and adult [stages] of the coil are oriented in different planes at an angle of 90 degrees. The wall is finely and commonly uniformly granular, sometimes porous, or with a clear fibrous layer. The aperture is simple, basal, rarely

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EXPLANATION OF PLATE 9

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	2. Tangential section, approaching axial; holotype (UCM 28162). Sample BW 5, Battleship Wash Formation, Arrow Canyon Range.	
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	4. Near sagittal section (UCM 28161b). Sample BW 5, Battleship Wash Formation, Arrow Canyon Range.	
	5. Diagonal section (UCM 28161c). Sample BW 5, Battleship Wash Formation, Arrow Canyon Range.	
	6. Tangential section, approaching axial (UCM 28160b). Sample BW 4, Battleship Wash Formation, Arrow Canyon Range.	
7–10.	*Asteroarchaediscus rugosimilis* n. sp. × 125.	62
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	11. Tangential section, approaching axial (UCM 28168b). Sample BS 2, Bird Spring Formation, Arrow Canyon Range.	
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15. Near sagittal section (UCM 28168d). Sample BS 2, Bird Spring Formation, Arrow Canyon Range.

16–25. *Neoarchaediscus incertus* (Grozdilova and Lebedeva), 1954. × 100. 63
16. Tangential section, approaching axial (UCM 28169L). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
17. Axial section (UCM 28161d). Sample BW 5, Battleship Wash Formation, Arrow Canyon Range.
18. Tangential section, approaching axial (UCM 28169m). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
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20. Tangential section, approaching axial (UCM 28169o). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
21. Diagonal section (UCM 28169p). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
22. Axial section (UCM 28169q). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
23. Axial section (UCM 28169r). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
24. Axial section (UCM 28169s). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
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26, 27. *Planospirodiscus*? *altiluminis* n. sp. × 75. 64
26. Sagittal section (UCM 28169u). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
27. Axial section; piece of shell wall missing at top; holotype (UCM 28171). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.

28–34. *Planospirodiscus* cf. *P. minimus* (Grozdilova and Lebedeva), 1953. × 75. 65
28. Tangential section, approaching axial (UCM 28169v). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
29. Axial section (UCM 28169w). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
30. Near sagittal section (UCM 28169x). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
31. Tangential section, approaching axial (UCM 28169y). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
32. Tangential section, approaching axial (UCM 28169z). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
33. Tangential section, approaching axial (UCM 28169aa). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
34. Tangential section, approaching axial (UCM 28169bb). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.

35–37. *Planospirodiscus sulculus* n. sp. × 125. 65
35. Tangential section, approaching axial (UCM 28160d). Sample BW 4, Battleship Wash Formation, Arrow Canyon Range.
36. Tangential section, approaching axial; holotype (UCM 28164). Sample BW 5, Battleship Wash Formation, Arrow Canyon Range.
37. Sagittal section (UCM 28161e). Sample BW 5, Battleship Wash Formation, Arrow Canyon Range.

38. *Quasiarchaediscus*? sp. A. × 125. 67
38. Tangential section, approaching axial (UCM 28167b). Sample BS 1, Bird Spring Formation, Arrow Canyon Range.

39, 40. *Globivalvulina* sp. A. × 75. 67
39. Tangential section (UCM 28168e). Sample BS 2, Bird Spring Formation, Arrow Canyon Range.
40. Tangential section (UCM 28168f). Sample BS 2, Bird Spring Formation, Arrow Canyon Range.


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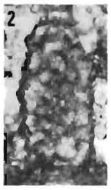
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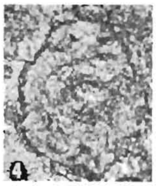
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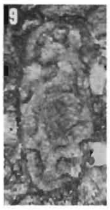
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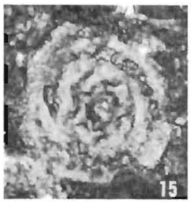
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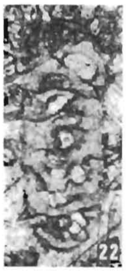
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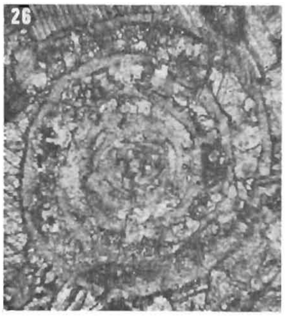
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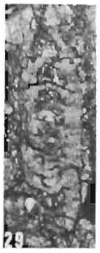
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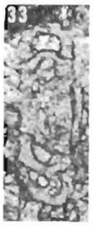
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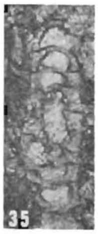
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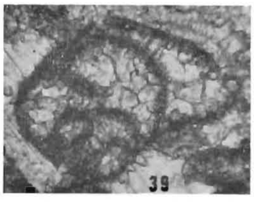
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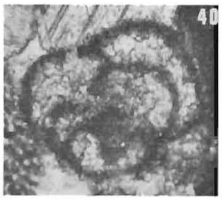
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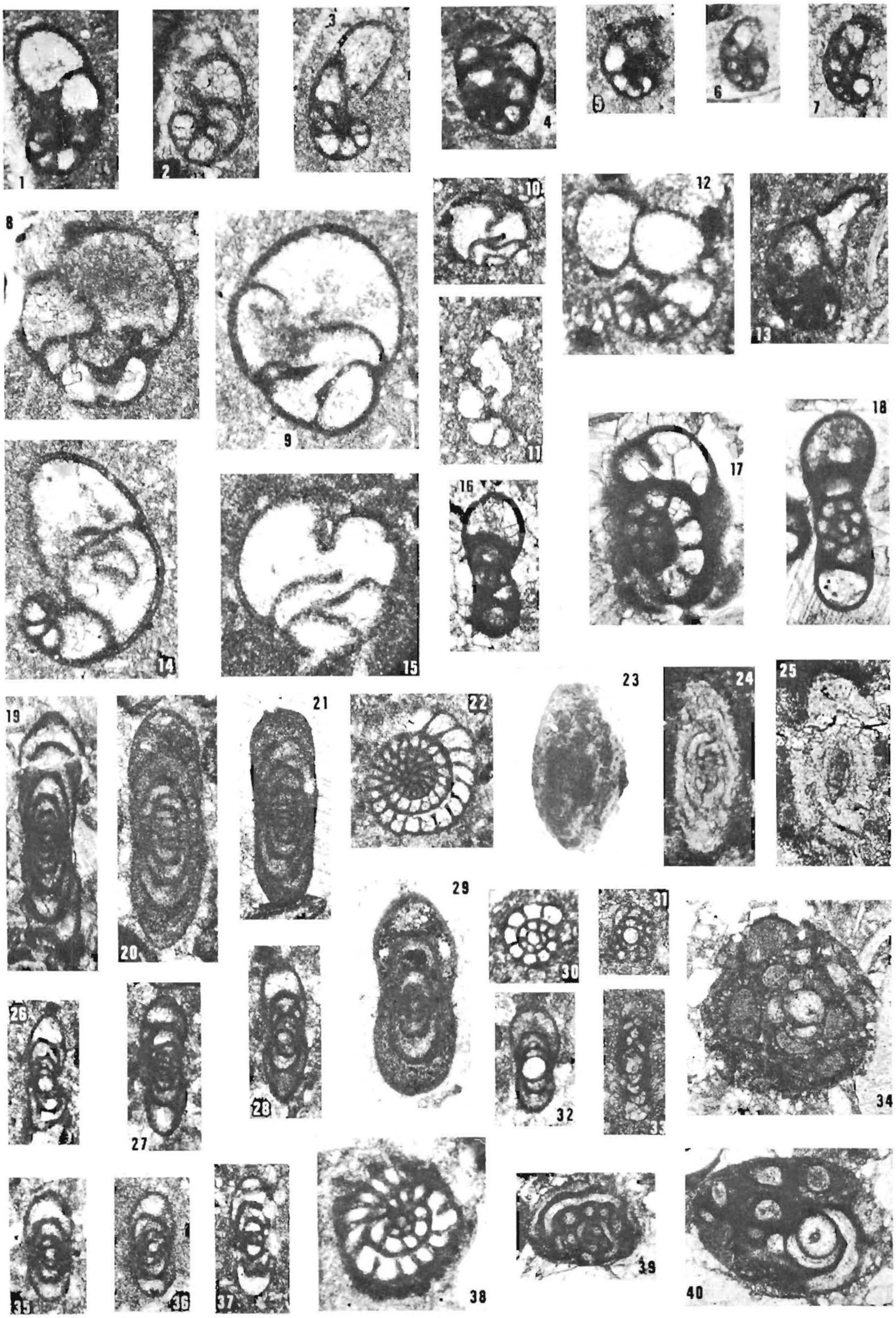
BRENCKLE: CALCAREOUS FORAMINIFERS FROM NEVADA



BRENCKLE: CALCAREOUS FORAMINIFERS FROM NEVADA

EXPLANATION OF PLATE 10

FIGS. PAGE

1–5. *Globivalvulina* sp. B. × 75. 67

- 1. Tangential section, approaching sagittal (UCM 28175a). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.
- 2. Tangential section (UCM 28168g). Sample BS 2, Bird Spring Formation, Arrow Canyon Range.
- 3. Tangential section, approaching sagittal (UCM 28175b). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.
- 4. Tangential section (UCM 28186h). Sample E 3, Ely Limestone, Moorman Ranch.
- 5. Tangential section, approaching sagittal; juvenile (UCM 28175c). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.

6, 7. *Globivalvulina* sp. C. × 75. 68

- 6. Sagittal section (UCM 28168i). Sample E 3, Ely Limestone, Moorman Ranch.
- 7. Sagittal section (UCM 28172a). Sample BS 4, Bird Spring Formation, Arrow Canyon Range.

8, 9, 14, 15. *Globivalvulina* sp. D × 75. 68

- 8. Tangential section (UCM 28175d). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.
- 9. Tangential section (UCM 28175e). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.
- 14. Tangential section, approaching sagittal (UCM 28175f). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.
- 15. Tangential section (UCM 28173a). Sample BS 5, Bird Spring Formation, Arrow Canyon Range.

10, 11. *Globivalvulina* sp. E. × 75. 68

- 10. Tangential section (UCM 28174a). Sample BS 6, Bird Spring Formation, Arrow Canyon Range.
- 11. Tangential section (UCM 28174b). Sample BS 6, Bird Spring Formation, Arrow Canyon Range.

12, 13. *Globivalvulina* sp. F. × 75. 69

- 12. Tangential section, approaching sagittal (UCM 28186j). Sample E 3, Ely Limestone, Moorman Ranch.
- 13. Tangential section, approaching sagittal (UCM 28175g). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.

16–18. *Planoendothyra aljutovica* (Reitlinger), 1950. × 60. 73

- 16. Axial section (UCM 28169cc). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
- 17. Diagonal section (UCM 28169dd). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.
- 18. Axial section (UCM 28169ee). Sample BS 3, Bird Spring Formation, Arrow Canyon Range.

19. *Millerella* sp. A. × 60. 74

- 19. Axial section (UCM 28168h). Sample BS 2, Bird Spring Formation, Arrow Canyon Range.

20, 21. *Millerella* cf. *M. designata* D. Zeller, 1953. × 60. 74

- 20. Axial? section (UCM 28168i). Sample BS 2, Bird Spring Formation, Arrow Canyon Range.
- 21. Tangential section, approaching axial (UCM 28168j). Sample BS 2, Bird Spring Formation, Arrow Canyon Range.

22, 26–28. *Millerella* cf. *M. bigemmicula* Igô, 1957. × 60. 73

- 22. Diagonal section (UCM 28186k). Sample E 3, Ely Limestone, Moorman Ranch.
- 26. Axial section (UCM 28186L). Sample E3, Ely Limestone, Moorman Ranch.
- 27. Tangential section, approaching axial (UCM 28186m). Sample E 3, Ely Limestone, Moorman Ranch.
- 28. Axial section (UCM 28186n). Sample E 3, Ely Limestone, Moorman Ranch.

23–25. *Eosigmoilina* Ganelina, 1956. × 125. 76

- 23. Whole specimen, side view (UCM 28165d). Sample IS 1, Indian Springs Formation, Arrow Canyon Range.
- 24. Tangential section (UCM 28167c). Sample BS 1, Bird Spring Formation, Arrow Canyon Range.
- 25. Broken tangential section, approaching sagittal (UCM 28167d). Sample BS 1, Bird Spring Formation, Arrow Canyon Range.

29. *Eostaffella* cf. *E. pinguis* (Thompson), 1944. × 75. 75
    29. Axial section (UCM 28187d). Sample Bu 1, Ely Limestone, Butte Mountains.
30–32. *Eostaffella* sp. A. × 75. 75
    30. Sagittal section (UCM 28174c). Sample BS 6, Bird Spring Formation, Arrow Canyon Range.
    31. Near sagittal section (UCM 28186o). Sample E 3, Ely Limestone, Moorman Ranch.
    32. Axial section (UCM 28186p). Sample E 3, Ely Limestone, Moorman Ranch.
33. *Brunsia* Mikhailov, 1939. × 125. 76
    33. Axial section (UCM 28175h). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.
34, 39, 40. *Glomospira* Rzehak, 1885. × 60. 76
    34. Diagonal section (UCM 28189a). Sample Bu 3, Ely Limestone, Butte Mountains.
    39. Tangential section (UCM 28189b). Sample Bu 3, Ely Limestone, Butte Mountains.
    40. Diagonal section (UCM 28189c). Sample Bu 3, Ely Limestone, Butte Mountains.
35–38. *Eostaffella* cf. *E. tortula* (D. Zeller), 1953. × 75. 75
    35. Axial section (UCM 28175i). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.
    36. Axial section (UCM 28175j). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.
    37. Tangential section, approaching axial (UCM 28174d). Sample BS 6, Bird Spring Formation, Arrow Canyon Range.
    38. Diagonal section (UCM 28175k). Sample BS 7, Bird Spring Formation, Arrow Canyon Range.

> in the middle of the septal face or cribrate in the final stage of growth. Additional deposits are in the form of chomata, pseudochomata or thickenings which cover the sides and floors of the chambers.
>
> We shall ascribe six genera to this family. . .
>
> Age: Devonian-Carboniferous.

The six genera include *Dainella* Brazhnikova, 1962; *Endostaffella* Rozovskaya, 1961; *Loeblichia* Cummings, 1955; *Paraendothyra* Chernysheva, 1940; *Quasiendothyra* Rauzer-Chernousova, 1948; and *Planoendothyra* Reitlinger, 1950. Only the last genus is found in this study.

Genus **Planoendothyra** Reitlinger, 1959

Type species: *Endothyra aljutovica* Reitlinger, 1950.

Description.—Test is discoidal, compressed laterally in axial view and umbilicate. Commonly the first volution is skewed at an angle of 90° to the later, essentially planispiral whorls. The initial volution may be involute, but the remaining whorls are evolute. Septa are straight, and the periphery is lobate. Secondary deposits include continuously thickened floors, lateral deposits in the corners of the chambers and, commonly, pseudochomata. Wall is fine grained, homogeneous calcite. Aperture is a basal opening.

Discussion.—I have only a few well oriented specimens of this genus and cannot write an adequate description. Moreover, Reitlinger's generic description (*in* Rauzer-Chernousova and Fursenko, eds., 1959, p. 194) is very incomplete. The above description, therefore, is a synthesis of the original description of *Endothyra aljutovica* and of the generic descriptions of *Planoendothyra* in Rozovskaya (1963, pp. 60–61), Conil and Lys (1964, p. 153) and Bogush and Yuferev (1962, pp. 123–124 and 1966, p. 143). Contrary to the others, Conil and Lys restrict the genus to almost completely planispiral forms.

My specimens differ from the above description primarily in the absence of pseudochomata. However, few published figures that I have seen have clearly defined pseudochomata, and this deposit may actually be poorly developed in the genus.

Planoendothyra differs from *Novella* Grozdilova and Lebedeva, 1950 in having initial coiling skewness, secondary floor coverings, lateral chamber fillings and no chomata. It differs from *Quasiendothyra* Rauzer-Chernousova, 1948 in having lateral chamber fillings and lacking chomata and an inner, clear fibrous wall layer. *Endostaffella* Rozovskaya, 1961 is distinguished from the present genus in having a greater number of skew volutions (commonly two to three) in the juvenile stage, and involute coil and poor development of lateral chamber fillings and floor thickenings. Pseudochomata are not always present in *Endostaffella* either.

Rozovskaya (1963, pp. 36, 60) reports *Planoendothyra* from the Lower to middle Upper Carboniferous (Tournaisian to Moscovian stages). My specimens are restricted to the Lower Pennsylvanian.

Planoendothyra aljutovica (Reitlinger), 1950

Plate 10, figures 16–18

Endothyra aljutovica REITLINGER, 1950, p. 34, pl. 5, figs. 4–6.

Planoendothyra aljutovica (Reitlinger). ROZOVSKAYA, 1963, p. 61; BOGUSH and YUFEREV, 1966, p. 147, pl. 10, fig. 1.

Measurements.—(based on 5 specimens) Number of volutions (4 specimens): 3–3½. Diameter: 0.35–0.50 mm. Width (3 specimens): 0.13–0.20 mm. Width/diameter (3 specimens): 0.36–0.43. Interior diameter of proloculus (4 specimens): 0.025–0.035 mm. Shell thickness last volution: 0.010–0.020 mm.

Description.—Test is small to medium in size, compressed laterally in axial view, almost completely evolute, and more deeply umbilicate on one side than the other. The first one to one and one-half volutions are skewed at an angle of 90° to the remaining, essentially planispiral whorls. The rate of expansion of the coil is steady and rapid. Septa are long, thin, straight, pointed slightly forward, and narrowly thickened at the septal join. Chambers are large but not very inflated between septal sutures, and the peripheral outline is almost smooth. Thick deposits line the floors and fill the corners of the chambers. The wall is mostly dark, microgranular, unlayered calcite. Some specimens appear to have a faintly layered wall. Aperture was not seen but is inferred to be low and basal.

Discussion.—The manner of coiling, secondary deposits, and axial shape of these organisms agree well with Reitlinger's forms. The specimen in Plate 10, figure 18 is almost identical with Reitlinger's holotype (1950, pl. 5, fig. 6). On the average, however, my specimens are smaller.

Conil and Lys' assignment (1964, p. 153, pl. 23, figs. 447–448) of completely planispiral forms to *P. aljutovica* var. *aljutovica* is questionable because of the lack of initial skewness characteristic of the species.

According to Reitlinger (1950, p. 35, translated in Ellis and Messina, supplement no. 1, 1958) the very similar species *Planoendothyra irinae* differs from this species in being less evolute, having more strongly developed secondary layering, a narrowly rounded periphery and fewer chambers.

Occurrence.—Morrow (BS 3) Bird Spring Formation at Arrow Canyon Range.

Superfamily FUSULINACEA Möller, 1878

Family OZAWAINELLIDAE

Thompson and Foster, 1937

Genus **Millerella** Thompson, 1942

Type species: *Millerella marblensis* Thompson, 1942.

Description.—Test is small to medium, umbilicate on both sides, discoidal and has a rounded to angular periphery. Specimens have three to six, mostly planispiral volutions, but some have a small initial coiling asymmetry. The inner whorls are involute, but the last one to two are partially evolute. The whorls expand moderately and steadily. Septa are numerous, thin, long and straight or slightly curved forward. The chambers are flat or slightly inflated between the septa; therefore, the peripheral outline is smooth to incipiently lobate. Small, narrow chomata bound the low tunnel. The wall is mostly homogeneous, dark, microgranular calcite, but some specimens appear to have a light colored tectum separating dark, inner and outer tectoria. Recrystallization probably obscures the three-layered *Profusulinella*-type wall reported as typical for this genus. Aperture is closed.

Discussion.—This genus differs from *Eostaffella* Rauzer-Chernousova, 1948 in the evolution of its last few whorls and generally more compressed axial shape. The genus *Novella* Grozdilova and Lebedeva, 1950 is distinguished from *Millerella* by its completely evolute coiling and open aperture which links it to the Endothyridae.

Millerella cf. **M. bigemmicula** Igô, 1957

Plate 10, figures 22, 26–28

Millerella bigemmicula IGÔ, 1957, p. 172, pl. 1, figs. 1–9, 15–17, 27.

Measurements.—(based on 4 specimens) Number of volutions: 3½–4. Number of chambers in last volution (1 specimen): about 19. Number of chambers in penultimate volution (1 specimen): about 18. Diameter: 0.30–0.36 mm. Width (3 specimens): 0.11–0.13 mm. Width/diameter (3 specimens): 0.33–0.37. Interior diameter of proloculus (2 specimens): 0.040 mm. Shell thickness last volution: 0.005–0.010 mm.

Description.—Test is small, discoidal, deeply to shallowly umbilicate on both sides and has a subrounded to angular axial periphery. The initial whorls are either planispiral or slightly skewed; the outer one to two are planispiral and partially evolute. The last volution expands rapidly, but the inner ones coil both moderately and steadily. Septa are long, mostly straight and pointed anteriorly. Inflation of the chambers causes a slightly lobate peripheral outline. Chomata are indistinct or small mounds. Tunnel is low. The wall is dark, microgranular calcite and poorly layered.

Discussion.—These specimens differ slightly from Igô's in having less anteriorly curved septa, smaller chomata and a poorly layered wall. The dimensions, however, are quite similar, and the lack of distinct wall layering may be a result of secondary alteration.

One of the axially oriented specimens of *Eostaffella acuta* Grozdilova and Lebedeva (1950, pl. 1, fig. 13) may be referable to this present species which it resembles in dimensions, angular periphery and coiling. The holotype of *E. acuta* is involute.

Millerella sp. D (Marshall, 1969, pp. 120–121, pl. 1, fig. 35) appears similar to the present specimens except for a larger diameter and proloculus, and a younger age (Desmoines).

Occurrence.—Morrow (E 3) Ely Limestone at Moorman Ranch.

Millerella cf. M. designata D. Zeller, 1953

Plate 10, figures 20, 21

Millerella designata D. ZELLER, 1953, p. 194, pl. 26, figs. 1–6.

Measurements.—(based on 2 specimens) Number of volutions: 5–5½. Diameter: 0.52–0.61 mm. Width: 0.18–0.20 mm. Width/diameter: 0.33–0.35. Shell thickness last volution: 0.015 mm.

Description.—Test is medium in size, shallowly umbilicate, almost straight sided and has a rounded to subrounded axial periphery. The axis of coiling oscillates slightly, causing the final volution to be partially evolute. The volutions expand moderately and steadily. Chomata are not well developed. The wall is mostly dark, microgranular calcite but appears faintly three-layered in places. No sagittal sections were seen.

Discussion. My specimens are slightly larger than D. Zeller's forms but are otherwise similar. However, sagittal sections are needed for a definite species assignment.

Occurrence.—Morrow (BS 2) Bird Spring Formation at Arrow Canyon Range.

Millerella sp. A

Plate 10, figure 19

Measurements.—(based on 2 specimens) Number of volutions: 5½–6. Diameter: 0.58–0.61 mm. Width (1 specimen): 0.18 mm. Width/diameter (1 specimen): 0.30. Interior diameter of proloculus: 0.25–0.30 mm. Shell thickness last volution (1 specimen): 0.010 mm.

Description.—Test is medium in size, compressed axially, very shallowly umbilicate and has a peaked axial periphery. The initial one to two whorls deviate slightly, but the rest are planispiral. The last two to three volutions are partially evolute. Expansion of the whorls is steady throughout. Chomata are low mounds, in some places indistinct, and the tunnel path is regular. The wall is dark, granular calcite discontinuously three-layered.

Discussion.—The compressed axial shape, angular axial periphery and large number of volutions distinguish this form from most other *Millerella* species. *Millerella elegantula* (Rauzer-Chernousova), 1951 *in* Brazhnikova *et al.* (1967, pl. 23, fig. 9) appears similar in size, angularity of periphery, compressed shape and number of volutions. Brazhnikova *et al.* provide no description with their figured specimen which, like mine, differs significantly in coiling from the specimens of *Eostaffella elegantula* described by Rauzer-Chernousova (1951, p. 64). The first volution of Rauzer-Chernousova's forms is rotated 90° to the following evolute whorls. In fact, the coiling appears more like that of the Quasiendothyridae rather than *Millerella.*

Occurrence.—Morrow (BS 2) Bird Spring Formation at Arrow Canyon Range. Morrow (E 3) Ely Limestone at Moorman Ranch.

Genus Eostaffella Rauzer-Chernousova, 1948

Paramillerella THOMPSON, 1951, pp. 115–116. Not *Paramillerella* Thompson, 1951, emended Anisgard and Campau, 1963, p. 102.

Type species: *Staffella (Eostaffella) parastruvei* Rauzer-Chernousova, 1948.

Description.—The test is small to medium, umbilicate on both sides, discoidal and has a rounded to subangular periphery. There are two to four, mostly planispiral, volutions, but a few specimens have initial coiling asymmetry. All whorls are involute or nearly so. The volutions expand steadily and moderately. Septa are thin, long, numerous and pointed slightly forward. The peripheral outline is probably smooth or slightly lobate, but more sagittal sections are needed to determine the shape. Chomata appear as small mounds in axial section; tunnel is low. The wall is mostly dark, microgranular calcite. One specimen exhibits a relict three-layered wall. Aperture, seen in only one species, appears closed.

Discussion.—In supporting the validity of *Paramillerella,* Anisgard and Campau (1963) consider *Eostaffella* synonymous with *Millerella.* They say that Rauzer-Chernousova's original generic description is incomplete in regard to the coiling and that the generoholotype of *Eostaffella* appears evolute. Reitlinger (1966) replies that the apparent evolute coiling of the generoholotype is probably caused by recrystallization or by a poor angle of section. Furthermore, she states that the name *Eostaffella* has been consistently used in the Soviet Union for primitive fusulinids with involute coiling, pseudochomata—chomata, a large width/diameter ratio, and, in some species, a skew-coiled juvenarium. Since the type species of *Paramillerella* (*Millerella*? *advena* Thompson, 1944)* has the above features, it belongs to *Eostaffella*.

Anisgard and Campau's emended description of *Paramillerella* is not considered synonymous with that of *Eostaffella* because it is partly based on the description of their new species *Paramillerella thompsoni* which belongs to *Eoendothyranopsis* (Reitlinger, 1966, pp. 57, 66; Skipp, 1969, p. 217; Mamet *in* Toomey and Mamet, 1969, p. 49).

Eostaffella cf. E. pinguis (Thompson), 1944

Plate 10, figure 29

Millerella pinguis THOMPSON, 1944, p. 425, pl. 1, figs. 18–20.

Paramillerella pinguis (Thompson). THOMPSON, 1951, p. 115.

Measurements.—(based on 1 specimen) Number of volutions: 4. Diameter: 0.41 mm. Width: 0.18 mm. Width/diameter: 0.44. Interior diameter of proloculus: 0.025 mm. Shell thickness last volution: 0.015 mm.

Description.—Test is medium in size, involute, umbilicate on both sides and has a rounded to subangular axial periphery. Coiling is planispiral. The interior whorl is tightly coiled, but the outer three are loose and expand steadily. Chomata are poorly developed. The wall is possibly three-layered although not well preserved.

Discussion.—My specimen has an axial shape, width/diameter ratio and number of whorls similar to Thompson's hototype (1944, pl. 1, fig. 18) but is smaller in size. Without sagittal sections, this present specimen can be assigned only tentatively to *E. pinguis.*

Occurrence.—Morrow (Bu 1) at Butte Mountains.

Eostaffella cf. E. tortula (D. Zeller), 1953

Plate 10, figures 35–38

Millerella tortula D. ZELLER, 1953, pp. 192–194, pl. 26, figs. 7–10, 12–21, 23–26.

Paramillerella tortula (D. Zeller). ZELLER, E. J., 1957, p. 703, pl. 75, figs. 4–8, 10–12; SKIPP, 1961, pp. C-242–C-243, fig. 236.3 G, H; ANISGARD and CAMPAU, 1963, p. 102.

Measurements.—(based on 6 specimens) Number of volutions: 3–4. Number of chambers in last volution (1 specimen): about 14. Number of chambers in penultimate volution (1 specimen): about 9. Diameter (5 specimens): 0.21–0.31 mm. Width (4 specimens): 0.09–0.15 mm. Width/diameter (4 specimens): 0.35–0.48. Interior diameter of proloculus (3 specimens): 0.020–0.025 mm. Shell thickness last volution: 0.005–0.015 mm.

Description.—Test is small, discoidal, involute, umbilicate on both sides and has a rounded axial periphery. The initial whorl is planispiral or slightly skewed; the remainder are planispiral. Expansion of the volutions is steady and moderate. Septa are long, gently tapered and slightly curved forward. Inflation of the chambers produces a mildly lobate periphery. Chomata are rudimentary or absent. The wall is dark, microgranular calcite except that the septa in the single sagittal section (Plate 10, figure 38) appear to be composed of a thick, light colored tectum flanked by the dark, outer and inner tectoria.

Discussion. The dimensions of these specimens agree well with those of D. Zeller. My specimens average fewer volutions, and have less pronounced initial skewness than in Zeller's typical forms, although she also figures specimens that are essentially planispiral throughout.

Occurrence. Morrow (BS 2, BS 6, BS 7) Bird Spring Formation at Arrow Canyon Range.

Eostaffella sp. A

Plate 10, figures 30–32

Measurements.—(based on 5 specimens) Number of volutions: 2–2½. Number of chambers in last volution (2 specimens): 9–11. Number of chambers in penultimate volution (1 specimen): about 7. Diameter: 0.12–0.22 mm. Width (3 specimens): 0.07–0.11 mm. Width/diameter (3 specimens): 0.44–0.50. Interior diameter of proloculus: 0.030–0.055 mm. Shell thickness: 0.005–0.010 mm.

Description.—Test is small, discoidal, involute, umbilicate on both sides and has a rounded axial periphery. Coiling is planispiral. The last volution inflates more rapidly than the inner one to one and one-half whorls. Septa extend to the base of the chamber and are perpendicular to the wall or pointed slightly forward. Chamber inflation is so small that the peripheral outline is almost smooth. Chomata are rudimentary or absent; tunnel was not visible in sagittal section. Wall is dark, microgranular calcite. Aperture appears closed.

Discussion.—The combination of small size, few chambers and volutions and planispiral coiling differentiates these specimens from other species of *Eostaffella* found in this study. But the large difference in size among the proloculi of such small specimens may indicate that these forms are not related. Instead, they may be the juvenaria of separate species, or, in the case of the specimens with large proloculi (pl. 10, fig. 32), they may be the megalospheric generation of another species. More specimens are needed.

Occurrence.—Morrow (BS 6) Bird Spring Formation at Arrow Canyon Range. Morrow (E 3) Ely Limestone at Moorman Ranch.

Suborder TEXTULARIINA
Delage and Hérouard, 1896
Superfamily AMMODISCACEA Reuss, 1862
Family AMMODISCIDAE Reuss, 1862
Subfamily AMMODISCINAE Reuss, 1862
Genus **Brunsia** Mikhailov, 1939
Plate 10, figure 33

Type species: *Spirillina irregularis* Möller, 1879.

Description.—Test is discoidal. The proloculus is surrounded by a single, tubular chamber which initially is skew coiled and partially involute and later planispiral and evolute. Wall is composed of dark, unlayered calcite grains. Aperture is a simple, terminal opening.

Discussion.—Material found in this study is too sparse and poorly preserved for speciation.

Occurrence.—Zone 15 (BW 2, BW 3) Battleship Wash Formation; Morrow (BS 7) Bird Spring Formation at Arrow Canyon Range.

Genus **Glomospira** Rzehak, 1885
Plate 10, figures 34, 39, 40

Type species: *Trochammina squamata* Jones and Parker var. *gordialis* Jones and Parker, 1860.

Description.—Test is free or encrusting, small to large and spherical to flattened in shape. The proloculus is followed by a non-septate, streptospirally coiled, tubular chamber which expands slowly in diameter throughout growth. In cross section the tubular chamber appears circular to semicircular in shape. Wall is composed of fine grained calcite commonly with inclusions of larger calcite crystals and appears reddish brown in transmitted light. Aperture is at the end of the tubular chamber.

Discussion.—This genus differs from *Glomospiranella* Lipina, 1953 in the absence of pseudosepta in the last volutions and by the presence of an agglutinated wall.

Material was not studied sufficiently for speciation.

Occurrence.—Morrow (Bu 3) at Butte Mountains.

Suborder MILIOLINA
Delage and Hérouard, 1896
Superfamily MILIOLACEA Ehrenberg, 1839
Family NUBECULARIIDAE Jones, 1875
Subfamily OPHTHALMIDIINAE Wiesner, 1920
Genus **Eosigmoilina** Ganelina, 1956
Plate 10, figures 23–25

Type species: *Eosigmoilina explicata* Ganelina, 1956.

Description.—Test is small, lenticular and compressed. In transverse-axial section the plane of coiling changes gradually to form a sigmoidal curve. Proloculus is followed initially by a tubular, non-septate chamber; later, thin septa divide each volution into two chambers. The calcareous wall is light colored and imperforate. Aperture is a simple opening at the end of the last chamber.

Discussion.—*Eosigmoilina* is distinguished from other similar genera in the "Discussion" of *Quasiarchaediscus*, a member of the Archaediscidae.

Specimens were recovered whole from the Indian Springs Formation as well as in thin section from the Bird Spring. They were not studied sufficiently for speciation.

Occurrence.—Zone 19 (IS 1, IS 2) Indian Springs Formation and (BS 1) Bird Spring Formation at Arrow Canyon Range.

REFERENCES CITED

AIZENVERG, D. E., BRAZHNIKOVA, N. E. and POTIEVSKAYA, P. D., 1968, Biostratigraphic separation of the Carboniferous deposits of the southern slope of the Voronezhsk Massif: Akad. Nauk Ukrain. S.S.R., Inst. Geol. Nauk, "Naukova Dumka," Kiev, 151 pp., 60 pls. (in Russian).

ANISGARD, H. W. and CAMPAU, D. E., 1963, *Paramillerella thompsoni*, n. sp., from Michigan and a redefinition of *Paramillerella*: Cushman Found. Foram. Research, Contrib., v. 14, pt. 3, pp. 99–108, pls. 9–11.

ARMSTRONG, A. K., 1958, Meramecian (Mississippian) endothyrid fauna from the Arroyo Peñasco formation, northern and central New Mexico: Jour. Paleont., v. 32, no. 5, pp. 970–976, pl. 127.

———, 1967, Biostratigraphy and carbonate facies of the Mississippian Arroyo Peñasco formation, north-central New Mexico: New Mexico Inst. Min. and Tech., State Bureau Mines and Mineral Resources, Memoir 20, 79 pp., 10 pls.

———, MAMET, B. L. and DUTRO, J. T., JR., 1970, Foraminiferal zonation and carbonate facies of Carboniferous (Mississippian and Pennsylvanian) Lisburne group, central and eastern Brooks Range, Alaska: Amer. Assoc. Petroleum Geologists Bull., v. 54, no. 5, pp. 687–698.

ARNOLD, C. A. and SADLICK, W., 1962, A Mississippian flora from northeastern Utah and its faunal and stratigraphic relations: Contrib. Museum Paleont., Univ. Michigan, v. 17, no. 11, pp. 241–263, 2 pls.

BIRINA, L. M., 1948, New species of calcareous Algae and Foraminifera from the Devonian and Carboniferous strata on the edge of the Sub-Moscow Basin: Soviet Geol., no. 28 (in Russian).

Bissell, H. J., 1964, Ely, Arcturus, and Park City groups (Pennsylvanian-Permian) in eastern Nevada and western Utah: Amer. Assoc. Petroleum Geologists Bull., v. 48, no. 5, pp. 565–636.

Bogush, O. I. and Yuferev, O. V., 1960, Some new species of Tournaisian Foraminifera from Karatau and the western spurs of Talasskiy Alatau: Paleont. Zhur., no. 4, pp. 16–27, 1 pl. (in Russian).

——— and ———, 1962, Foraminifera and stratigraphy of the Carboniferous deposits in Karatau and Talasskiy Alatau: Akad. Nauk S.S.S.R., Sibirskoe Otdel., Inst. Geol. i Geofiz., 234 pp., 9 pls. (in Russian).

——— and ———, 1966, Carboniferous and Permian Foraminifera of the Verkhoyansk Range: Akad. Nauk S.S.S.R., Sibirskoe Otdel., Inst. Geol. i Geofiz., Izdatal. "Nauka," Moskva, 208 pp., 14 pls. (in Russian).

Bowyer, B., Pampeyan, E. H. and Longwell, C. R., 1958, Geologic map of Clark County, Nevada, 1:200,000: U. S. Geol. Survey MF 138.

Brady, H. B., 1870, Notes on the Foraminifera of mineral veins and the adjacent strata, pp. 381–382: *in* Moore, C., Report on mineral veins in Carboniferous limestone and their organic contents: British Assoc. Adv. Sci., London, Rept. 39, Exeter Meeting 1869, pp. 360–382.

———, 1876, Carboniferous and Permian Foraminifera (the genus *Fusulina* excepted): Paleont. Soc., London, v. 30, pp. 1–166, pls. 1–12.

Brazhnikova, N. E., *et al.*, 1967, Microfaunal marker horizons of the Carboniferous and Permian deposits of the Dneprovsk-Donetsk Basin: Akad. Nauk Ukrain. S.S.R., Inst. Geol. Nauk, Izdatel. "Naukova Dumka," Kiev, 224 pp., 59 pls. (in Russian).

Brew, D. A., 1971, Mississippian stratigraphy, Diamond Peak area, Eureka County, Nevada: U.S. Geol. Survey Prof. Paper 661, 84 pp.

Brokaw, A. L., 1967, Geologic map and sections of the Ely quadrangle White Pine County, Nevada, 1:24,000: U.S. Geol. Survey GQ 697.

Bykova, E. V. and Polenova, E. I., 1955, Stratigraphic importance of Devonian Foraminifera and Radiolaria of the Volga-Ural region and central Devonian area: Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), Trudy, n.s., v. 87, 141 pp., 24 pls. (in Russian).

Bykova, N. K., *et al.*, 1958, New genera and species of Foraminifera: Mikrofauna S.S.S.R., Sbornik 9, Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), Trudy, v. 115, 81 pp., 12 pls. (in Russian).*

Carss, B. W. and Carozzi, A. V., 1965, Petrology of Upper Devonian pelletoidal limestones, Arrow Canyon Range, Clark County, Nevada: Sedimentology, v. 4, pp. 197–224, 2 pls.

Cassity, P. E. and Langenheim, R. L., Jr., 1966, Pennsylvanian and Permian fusulinids of the Bird Spring group from Arrow Canyon, Clark County, Nevada: Jour. Paleont., v. 40, no. 4, pp. 931–968, pls. 110–114.

Chernysheva, N. E., 1940, On the stratigraphy of the Lower Carboniferous Foraminifera in the Makarovski district of the south Urals: Soc. Nat. Moscou Bull., n.s., v. 48, Geol. Sec. v. 18, nos. 5–6, pp. 113–135, 2 pls. (in Russian with English summary).*

———, 1948, Some new species of Foraminifera from the Visean stage in the Makarovsk region (southern Urals): Akad. Nauk S.S.S.R., Inst. Geol. Nauk, Trudy, v. 62, Geol. Ser. no. 19, pp. 246–250, pl. 18 (in Russian).*

Chilingar, G. V. and Bissell, H. J., 1957, Mississippian Joana limestone of Cordilleran Miogeosyncline and use of Ca/Mg ratio in correlation: Amer. Assoc. Petroleum Geologists Bull., v. 41, no. 10, pp. 2257–2274.

China, W. E., 1965, Opinion 724, *Endothyra bowmani* Phillips, [1846] (Foraminifera): validated under the plenary powers: Bull. Zool. Nomencl., v. 22, pt. 1, pp. 37–39.

Conil, R., and Lys, M., 1964, Matériaux pour l'étude micropaléontologique du Dinantien de la Belgique et de la France (Avesnois). Parties 1–2: Algues et foraminifères. Louvain Univ., Inst. Geol., Memoires, v. 23, 296 pp., 42 pls.

——— and ———, 1966, Foraminifères et algues du Tournaisien supérieur et du Viséen de la Belgique: Annales de la Société Géologique de Belgique, v. 89, no. 6, pp. B207–B221, 3 pls.

——— and ———, 1968, Utilisation stratigraphique des Foraminifères du Dinantien: Annales de la Société Géologique de Belgique, v. 91, pp. 491–558, 11 pls.

Coogan, A. H., 1964, Early Pennsylvanian history of Ely Basin, Nevada: Amer. Assoc. Petroleum Geologists Bull., v. 48, no. 4, pp. 487–495.

Cummings, R. H., 1955, New genera of Foraminifera from the British Lower Carboniferous: Jour. Washington Acad. Sci., v. 45, no. 1, pp. 1–8.

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* New species or genera in this publication translated in Ellis and Messina, Catalogue of Foraminifera.

Dain, L. G. and Grozdilova, L. P., 1953, Fossil Foraminifera of the U.S.S.R., Tournayellidae and Archaediscidae: Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), Trudy, n.s., v. 74, 127 pp., 11 pls. (in Russian); excerpts from Assoc. Tech. Services, Inc., translation RJ-1557, pp. 1–21, 49, 67–79, 114–115.

Dott, R. H., Jr., 1955, Pennsylvanian stratigraphy of Elko and northern Diamond Ranges, northeastern Nevada: Amer. Assoc. Petroleum Geologists Bull., v. 39, pp. 2211–2305.

Douglass, W. B., Jr., 1960, Geology of the southern Butte Mountains White Pine County, Nevada: *in* Guidebook to the geology of eastcentral Nevada: Intermtn. Assoc. Petroleum Geologists, 11th Ann. Field Conf., pp. 181–185.

Drewes, H., 1967, Geology of the Connors Pass quadrangle, Schell Creek Range, east-central Nevada: U.S. Geol. Survey Prof. Paper 557, 93 pp.

Dunn, D. L., 1970, Conodont zonation near the Mississippian-Pennsylvanian boundary in the western United States: Geol. Soc. Amer. Bull., v. 81, pp. 2959–2974.

Durkina, A. V., 1959, Foraminifera of the Lower Carboniferous deposits of the Timan-Pechora Province: Mikrofauna S.S.S.R., Sbornik 10, Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), Trudy, v. 136, pp. 132–389, 27 pls. (in Russian).

Dvořák, J. and Conil, R., 1969, Foraminifères du Dinantien de Moravie: Bull. de la Société belge de Géologie, de Paléontologie, et d'Hydrologie, v. 77, no. 1, pp. 75–88, 3 pls.

Ellis, B. F. and Messina, A. R., 1940–1950, Catalogue of Foraminifera: New York, Amer. Museum Nat. History Spec. Pubs., 30 v. (and supplements).

Ganelina, R. A., 1956, Foraminifera of the Visean sediments of the northwest region of the Moscow syncline: Mikrofauna S.S.S.R., Sbornik 8, Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), Trudy, n.s., v. 98, pp. 31–159, 12 pls. (in Russian).*

———, 1966, Foraminifera of the Tournaisian and lower Visean deposits of some regions of the Kamsk-Kinel'sk Basin: Mikrofauna S.S.S.R., Sbornik 14, Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), Trudy, v. 250, pp. 64–175, 12 pls. (in Russian).

Golubtzov, V. K., 1957, Stratigraphy and Foraminifera of the Visean series of the Pripyat Arch: Paleont. i Strat. B.S.S.R., Akad Nauk Belorussia S.S.R., Inst. Geol. Nauk, Sbornik 2, Minsk, pp. 44–191, 9 pls. (in Russian).

Grozdilova, L. P. and Lebedeva, N. S., 1950, Some species of Staffellas from the Middle Carboniferous of the western slopes of the Ural Mountains: Sbornik 3, Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), Trudy, n.s., v. 50, pp. 5–46, pls. 1–5, (in Russian).*

——— and ———, 1954, Foraminifera of the Lower Carboniferous and Bashkirian stage of the Middle Carboniferous of the Kolva-Visherka Area: Mikrofauna S.S.S.R., Sbornik 7, Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), v. 81, 203 pp., 15 pls. (in Russian).*

——— and ———, 1960, Foraminifera from the Carboniferous deposits of the western slope of the Urals and Timan: Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), Trudy, n.s., v. 150, 264 pp., 33 pls. (in Russian).

Heath, C. P., Lumsden, D. N. and Carozzi, A. V., 1967, Petrography of a carbonate transgressive-regressive sequence: The Bird Spring group (Pennsylvanian), Arrow Canyon Range, Clark County, Nevada: Journ. Sed. Petrology, v. 37, no. 2, pp. 377–400.

Hewett, D. F., 1931, Geology and ore deposits of the Goodsprings quadrangle, Nevada: U.S. Geol. Survey Prof. Paper 162, 172 pp., 40 pls.

Hose, R. K., 1966, Devonian stratigraphy of the Confusion Range, west-central Utah: *in* Geological survey research 1966, chapter B: U.S. Geol. Survey Prof. Paper 550-B, pp. B36–B41.

——— and Repenning, C. A., 1959, Stratigraphy of Pennsylvanian, Permian, and Lower Triassic rocks of Confusion Range, west-central Utah: Amer. Assoc. Petroleum Geologists Bull., v. 43, no. 9, pp. 2167–2196.

Humphrey, F. L., 1960, Geology of the White Pine Mining District, White Pine County, Nevada: Nevada Bureau of Mines, Bull. 57, 119 pp., 2 pls.

Igô, H., 1957, Fusulinids of Fukuji, southeastern part of the Hida Massif, central Japan: Tokyo Kyoiku Daigaku, Sci. Rept., sec. C, v. 5, no. 47, pp. 153–246, pls. 1–15.

Kellogg, H. E., 1960, Geology of the southern Egan Range, Nevada: *in* Guidebook to the geology of east-central Nevada: Intermtn. Assoc. Petroleum Geologists, 11th Ann. Field Conf., pp. 189–197.

———, 1963, Paleozoic stratigraphy of the southern Egan Range, Nevada: Geol. Soc. Amer. Bull., v. 74, pp. 685–708, 4 pls.

Lane, B., 1960, The Ely limestone in the vicinity of Moorman Ranch, Nevada: *in* Guidebook to the geology of east-central Nevada:

Intermtn. Assoc. Petroleum Geologists, 11th Ann. Field Conf., pp. 114–116.

———, 1962, The fauna of the Ely group in the Illipah area of Nevada: Jour. Paleont., v. 36, pp. 888–911, pls. 125–128.

Langenheim, R. L., Jr., 1960, Early and Middle Mississippian stratigraphy of the Ely area: *in* Guidebook to the geology of east-central Nevada: Intermtn. Assoc. Petroleum Geologists, 11th Ann. Field Conf., pp. 72–80.

———, 1961, The Pilot shale, the West Range limestone, and the Devonian-Mississippian boundary in eastern Nevada: Illinois State Acad. Sci. Trans., v. 53, pp. 122–131.

———, 1962, Nomenclature of the Late Mississippian White Pine shale and associated rocks in Nevada: Illinois State Acad. Sci. Trans., v. 55, no. 2, pp. 133–145.

———, Carss, B. W., Kennerly, J. B., McCutcheon, V. A. and Waines, R. H., 1962, Paleozoic section in Arrow Canyon Range, Clark County, Nevada: Amer. Assoc. Petroleum Geologists Bull., v. 46, no. 5, pp. 592–609.

——— and Collinson, C., 1963, Upper Devonian Crystal Pass limestone of southern Nevada (abstract): Geol. Soc. Amer. Spec. Paper 73, p. 45.

Langenheim, V. A. M. and Langenheim, R. L., Jr., 1965, The Bird Spring group, Chesteran through Wolfcampian, at Arrow Canyon, Arrow Canyon Range, Clark County, Nevada: Illinois State Acad. Sci. Trans., pp. 225–240.

Lawson, A. C., 1906, The copper deposits of Robinson mining district, Nevada: Univ. Calif. Pub. Geol. Sci., v. 4, pp. 287–357.

Lebedeva, N. S., 1954, Lower Carboniferous Foraminifera of the Kuznetsk Basin: Mikrofauna S.S.S.R., Sbornik 7, Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), Trudy, v. 81, pp. 237–295, 12 pls. (in Russian).*

Lee, J. S., Chen, S. and Chu, S., 1930, Huanglung limestone and its fauna: Acad. Sinica, Nat. Res. Inst. Geol., Memoir no. 9, pp. 85–143, pls. 2–15.

Lipina, O. A., 1948, Foraminifera of the Chernyshinsk suite, Tournaisian stage, Lower Carboniferous, Moscow Basin: Akad. Nauk S.S.S.R., Inst. Geol. Nauk, Trudy, v. 62, Geol. Ser. no. 19, pp. 251–259, pls. 19–20 (in Russian).*

———, 1955, Foraminifera of the Tournaisian stage and uppermost Devonian of the Volga-Ural region and western slope of the central Urals: Akad. Nauk S.S.S.R., Inst. Geol. Nauk, Trudy, v. 163, Geol. Ser. no. 70, 96 pp., 13 pls. (in Russian)*; excerpts from Assoc. Tech. Services, Inc., Translation RJ-1555, pp. 3–17, 82–83.

———, 1965, Systematics of the Tournayellidae: Akad. Nauk S.S.S.R., Trudy, Geol. Inst., v. 130, Nauka Publ. Office, Moscow, 115 pp., 24 pls. (in Russian).

———, 1970, Evolution of two Early Carboniferous rectilinear foraminifers: Akad. Nauk S.S.S.R., Geol. Inst., Vopros. Mikropaleont., v. 13, pp. 3–29, 2 pls. (in Russian).

Loeblich, A. R., Jr., Tappan, H., *et al.*, 1964, Sarcodina, chiefly "Theocamoebians" and Foraminiferida, pt. C., *in* Moore, R.C., ed., Treatise on Invertebrate Paleontology, Protista 2: Geol. Soc. Amer. and Kansas Univ. Press, 2 v., 900 pp.

Longwell, C. R., 1928, Geology of the Muddy Mountain area, Nevada: Geol. Soc. Amer. Bull. 798, 152 pp., 17 pls.

———, Pampeyan, E. H., Bowyer, B. and Roberts, R. J., 1965, Geology and mineral deposits of Clark County, Nevada: Nevada Bureau Mines Pub., Bull. 62, 218 pp., 16 pls.

Malakhova, N. P., 1956a, Foraminifera of the Zhartimke River limestone of the southern Urals: Akad. Nauk S.S.S.R., Trudy, v. 24, pp. 26–71, 8 pls. (in Russian).

———, 1956b, Foraminifera from the Carboniferous rocks of the western slope of the northern and central Urals: Akad. Nauk S.S.S.R., Trudy, v. 24, pp. 72–155, 15 pls. (in Russian).

Mamet, B. L., 1968a, Foraminifera, Etherington formation (Carboniferous), Alberta, Canada: Canadian Petroleum Geology Bull., v. 16, no. 2, pp. 167–179.

———, 1968b, Sur une microfaune du Viséen supérieur de Terre-Neuve: Naturalist canadien, v. 95, no. 6, pp. 1357–1372.

———, 1968c, Sur les microfaciès calcaires du Viséen de la Montagne-Noir (France): Revue de Micropaléont., v. 11, no 3. pp. 121–136, 5 pls.

———, 1970, Carbonate microfacies of the Windsor group (Carboniferous) Nova Scotia and New Brunswick: Geol. Survey Canada, Dept. Energy, Mines, and Resources, Paper 70-21, 121 pp., 19 pls.

——— and Gabrielse, H., 1969, Foraminiferal zonation and stratigraphy of the type section of the Nizi formation (Carboniferous system, Chesteran stage), British Columbia: Geol. Survey of Canada, paper 69-16, 19 pp.

——— and Mason, D., 1968, Foraminiferal zonation of the Lower Carboniferous Connor Lakes section, British Columbia: Canadian Petroleum Geology Bull., v. 16, no. 2, pp. 147–166.

——— and Skipp, B., 1970, Lower Carboniferous calcareous Foraminifera—preliminary zonation and stratigraphic implications for the Mississippian of North America: Internat. Cong. on Carboniferous Stratigraphy and Geology, 6th, Sheffield, England, Sept. 1967, Compte rendu, pp. 1129–1145.

———, ———, Sando, W. J. and Mapel, W. J., 1971, Biostratigraphy of Upper Mississippian and associated Carboniferous rocks in south-central Idaho: Amer. Assoc. Petroleum Geologists Bull., v. 55, no. 1, pp. 20–33.

Marshall, F. C., 1969, Lower and Middle Pennsylvanian fusulinids from the Bird Spring formation near Mountain Springs Pass, Clark County, Nevada: Brigham Young Univ. Geol. Studies, v. 16, pt. 1, pp. 97–154, 4 pls.

McKay, W. and Green, R., 1963, Mississippian Foraminifera of the southern Canadian Rocky Mountains, Alberta: Research Council of Alberta, Bull. no. 10, 77 pp., 12 pls.

Mikhailov, A., 1939, On the characteristics of the genera of Lower Carboniferous Foraminifera: *in* Maliavkin, S. F., ed., The Lower Carboniferous deposits of the northwestern limb of the Moscow Basin: Leningrad, Geol. Admin., Symposium (Sbornik) no. 3, pp. 47–62, 4 pls. (in Russian with English summary).*

Miklukho-Maklai, A. D., 1956, New families and genera of invertebrates: Materialy p. Paleont., Vses. Nauchno-Issledov. Geol. Inst. (VSEGEI), Min. Geol. i Okhrana Nedr S.S.S.R., n.s., v. 12, pp. 9–15 (in Russian).

———, 1960, New Early Carboniferous Archaediscidae: *in* New species of ancient plants and invertebrates of the U.S.S.R.: Vses. Nauchno-Issledov. Geol. Inst. (VSEGEI), Min. Geol. i Okhrana Nedr S.S.S.R., pt. 1, pp. 149–151, pl. 25; Assoc. Tech. Services, Inc., translation 17P59R, pp. 7–9.

———, 1963, Stratigraphy of the Upper Paleozoic and the systematics and phylogeny of Foraminifera: *in* Upper Paleozoic of central Asia: Izdatel. Leningrad Univ., 328 pp. (in Russian).

Mollazal, Y., 1961, Petrology and petrography of Ely limestone in part of the eastern Great Basin: Brigham Young Univ. Geol. Studies, v. 8, pp. 3–35, 4 pls.

Omara, S. and Conil, R., 1965, Lower Carboniferous Foraminifera from southwestern Sinai, Egypt: Annales de la Société Géologique de Belgique, v. 88, no. 5, pp. B221–B242, 3 pls.

Pennebaker, E. N., 1932, Geology of the Robinson (Ely) mining district in Nevada: Mining and Metallurgy, v. 13, no. 304, pp. 163–168.

Petryk, A. A., Mamet, B. L. and MacQueen, R., 1970, Preliminary foraminiferal zonation, Rundle group and uppermost Banff formation (Lower Carboniferous), southwestern Alberta: Canadian Petroleum Geology Bull., v. 18, pp. 84–103.

Rauzer-Chernousova, D. M., 1948a, The Lower Carboniferous Endothyras of the group *Endothyra crassa* Brady and similar forms: Akad. Nauk S.S.S.R., Inst. Geol. Nauk, Trudy, v. 62, Geol. Ser. no. 19, pp. 166–175, pl. 4 (in Russian).*

———, 1948b, Some new species of Foraminifera from the Lower Carboniferous sediments in the Moscow Basin: Akad. Nauk S.S.S.R., Inst. Geol. Nauk, Trudy, v. 62, Geol. Ser. no. 19, pp. 227–238, pls. 15–16 (in Russian).*

———, 1948c, Foraminifera from the Carboniferous deposits of central Kazakhstan: Akad. Nauk S.S.S.R., Inst. Geol. Nauk, Trudy, v. 66, Geol. Ser. no. 21, pp. 1–25, 3 pls. (in Russian).*

———, Beljaev, G. M. and Reitlinger, E. A., 1936, Die Oberpalaeozoischen Foraminiferen aus dem Petschora-Lande (der Westabhang des Nord Urals): Akad. Nauk S.S.S.R., Po. Kom., Trudy, v. 126, Geol. Ser. no. 47, pp. 1–127, pls. 1–22 (in Russian with German summary).*

——— and Fursenko, A. V., 1937, A monographic study of the Foraminifera from the oilfields of the U.S.S.R.: Leningrad-Moskva, Glavnaya Redak., Gorno-Topliv., 315 pp. (in Russian).*

——— and ———, 1959, responsible eds.; Orlov, Yu.A., chief ed., Fundamentals of Paleontology, general part, Protozoa: Izdatel. Akad. Nauk S.S.S.R., 482 pp., 13 pls., translated into English and published for the Nat. Sci. Found., Washington, by the Israel Program for Sci. Translations, Jerusalem, 1962.

———, *et al.*, 1951, Middle Carboniferous fusulinids of the Russian Platform and adjoining regions: handbook and guide: Akad. Nauk S.S.S.R., Inst. Geol. Nauk, Min. Neft. Prom. S.S.S.R., 380 pp., 58 pls. (in Russian).*

Reichel, M., 1946, Sur quelques foraminifères nouveaux du Permien méditerranéen: Eclogae Geol. Helv., Lausanne, v. 38 (1945), no. 2, pp. 524–560, pl. 19.

Reitlinger, E. A., 1949, An account of the smaller Foraminifera in the lower part of the Middle Carboniferous in the central Ural and Kama regions: Akad. Nauk S.S.S.R., Izv., Geol. Ser. no. 6, pp. 149–164, 1 pl. (in Russian).

———, 1950, Foraminifera of the Middle Carboniferous formations of the central part of the Russian Platform (exclusive of the family Fusulinidae): Akad. Nauk S.S.S.R., Inst.

Geol. Nauk, Trudy, v. 126, Geol. Ser. no. 47, 127 pp., 22 pls. (in Russian).*

———, 1966, Some problems of classification and evolution of the Endothyrina and primitive Fusulinina: Akad. Nauk S.S.S.R., Geol. Inst., Vopros. Mikropaleont., v. 10, pp. 39–67, 3 pls. (in Russian).

RICH, M., 1967, *Donezella* and *Dvinella*, widespread Algae in Lower and Middle Pennsylvanian rocks in east-central Nevada and west-central Utah: Jour. Paleont., v. 41, no. 4, pp. 973–980, pls. 125–126.

———, 1970, The genus *Tuberitina* (Foraminiferida) in Lower and Middle Pennsylvanian rocks from the eastern Great Basin: Jour. Paleont., v. 44, no. 6, pp. 1060–1066, pls. 143–144.

ROZOVSKAYA, S. E., 1963, Ancient representative fusulinids and their ancestors: Akad. Nauk S.S.S.R., Trudy, Inst. Paleont., v. 97, 128 pp., 22 pls. (in Russian).

ST. JEAN, J., 1957, A Middle Pennsylvanian fauna from Dubois County, Indiana: Indiana Geol. Survey Bull. 10, 66 pp., 5 pls.

SANDBERG, C. A. and POOLE, F. G., 1970, Conodont biostratigraphy and age of West Range limestone and Pilot shale at Bactrian Mountain, Pahranagat Range, Nevada (abstract): Abstracts with Programs, Geol. Soc. Amer. Cordilleran Section, v. 2, no. 2, p. 139.

SANDO, W. J., MAMET, B. L. and DUTRO, J. T., JR., 1969, Carboniferous megafaunal and microfaunal zonation in the northern Cordillera of the United States: U.S. Geol. Survey Prof. Paper 613-E, pp. E1–E29.

SHLYKOVA, T. I., 1951, Foraminifera of the Visean and Namurian stages of the Lower Carboniferous of the western slope of the Moscow Basin: Vses. Neft. Nauchno-Issledov. Geol.-Razved. Inst. (VNIGRI), Trudy, n.s., v. 56, pp. 109–178, 6 pls. (in Russian).

SKIPP, B., 1961, Stratigraphic distribution of endothyrid Foraminifera in Carboniferous rocks of the Mackay quadrangle, Idaho: *in* Short papers in the geologic and hydrologic sciences: U.S. Geol. Survey Prof. Paper 424-C, pp. C239–C244.

———, 1969, Foraminifera: *in* McKee, E. D., and Gutschick, R. C., eds., History of the Redwall limestone of northern Arizona: Geol. Soc. Amer. Memoir 114, pp. 173–255, pls. 16–28.

———, HOLCOMB, D. L. and GUTSCHICK, R. C., 1966, Tournayellinae, calcareous Foraminifera, in Mississippian rocks of North America: Cushman Found. Foram. Research, Spec. Pub. no. 9, 38 pp., 7 pls.

——— and MAMET, B. L., 1970, Stratigraphic micropaleontology of the type locality of the White Knob limestone (Mississippian), Custer County, Idaho: *in* Geol. Survey Research 1970: U.S. Geol. Survey Prof. Paper 700-B, pp. B118–B123.

SOSIPATROVA, G. P., 1962, Foraminifera of the Upper Paleozoic of the Taimyr: Sbornik Stat. p. paleont. i biostrat., Nauchno-Issledov. Inst. Geol. Arkt., Min. Geol. i Okhrana Nedr S.S.S.R., v. 30, Leningrad, pp. 35–72, 5 pls. (in Russian).

———, 1966, Foraminifera of the Tiksinsk suite of the northern Kharaulakh Range: Uchen. Zapis., paleont. i biostrat., Nauchno-Issledov. Inst. Geol. Arkt., Min. Geol. S.S.S.R., v. 11, Leningrad, pp. 5–32, 3 pls. (in Russian).

SPENCER, A. C., 1917, The geology and ore deposits of Ely, Nevada: U.S. Geol. Survey Prof. Paper 96, 189 pp., 15 pls.

SPIVEY, R. C., 1954, The geology in the vicinity of Railroad Valley, Nevada: Pacific Petroleum Geologist, v. 8, no. 7, p. 1.

SPURR, J. E., 1903, Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: U.S. Geol. Survey Bull. 208, 229 pp., 8 pls.

STANTON, R. J., JR., 1967, Radiosphaerid calcispheres in North America and remarks on calcisphere classification: Micropaleont., v. 13, no. 4, pp. 465–472, 1 pl.

STEELE, G., 1960, Pennsylvanian-Permian stratigraphy of east-central Nevada and adjacent Utah: *in* Guidebook to the geology of east-central Nevada: Intermtn. Assoc. Petroleum Geologists, 11th Ann. Field Conf., pp. 91–113.

STENSAAS, L. J. and LANGENHEIM, R. L., JR., 1960, Rugose corals from the Lower Mississippian Joana limestone of Nevada: Jour. Paleont., v. 34, no. 1, pp. 179–188.

THOMPSON, M. L., 1944, Pennsylvanian Morrowan rocks and fusulinids of Kansas: Kansas State Geol. Survey Bull. no. 52, pt. 7, pp. 409–431, 2 pls.

———, 1951, New genera of fusulinid Foraminifera: Cushman Found. Foram. Research, Contrib., v. 2, pt. 4, pp. 115–119, pls. 13–14.

TOOMEY, D. F., 1961, *Endothyra scitula*, new name for *E. symmetrica* Zeller, preoccupied: Cushman Found. Foram. Research, Contrib., v. 12, pt. 1, p. 26.

——— and MAMET, B. L., 1969, Annotated bibliography of Paleozoic nonfusulinid Foraminifera, addendum 6: Cushman Found. Foram. Research, Contrib., v. 20, pt. 2, pp. 45–64.

———, MOUNTJOY, E. W. and MACKENZIE, W. S., 1970, Upper Devonian (Frasnian) Algae and Foraminifera from the Ancient Wall carbonate complex, Jasper National Park, Alberta, Canada: Canadian Jour. Earth Sciences, v. 7, pp. 946–981, 7 pls.

Vissarionova, A. Ya., 1948, Some species of the subfamily Tetraxinae Galloway from the Visean series of the European part of the Union: Akad. Nauk S.S.S.R., Inst. Geol. Nauk, Trudy, v. 62, Geol. Ser. no. 19, pp. 190–195, pl. 8 (in Russian).*

Waines, R. H., 1962, Devonian calcareous foraminifers from Arrow Canyon Range, Clark County, Nevada (abstract): San Francisco Program A.A.P.G.-S.E.P.M., p. 58.

Webster, G. D., 1969, Chester through Derry conodonts and stratigraphy of northern Clark and southern Lincoln Counties, Nevada: Univ. California Pub. Geol. Sci., v. 79, 105 pp., 8 pls.

——— and Lane, N. G., 1967, Mississippian-Pennsylvanian boundary in southern Nevada: *in* Essays in paleontology and stratigraphy, Raymond C. Moore commemorative volume: Kansas Univ. Press, pp. 503–522.

Woodland, R. B., 1958, Stratigraphic significance of Mississippian endothyroid Foraminifera in central Utah: Jour. Paleont., v. 32, no. 5, pp. 791–814, pls. 99–103.

Wray, J. L., 1967, Upper Devonian calcareous Algae from the Canning Basin, western Australia: Prof. Contrib. Colorado School of Mines, no. 3, 76 pp., 11 pls.

Zeller, D. E. N., 1953, Endothyrid Foraminifera and ancestral fusulinids from the type Chesteran (Upper Mississippian): Jour. Paleont., v. 27, no. 2, pp. 183–199, pls. 26–28.

Zeller, E. J., 1950, Stratigraphic significance of Mississippian endothyroid Foraminifera: Kansas Univ. Paleont. Contrib., Protozoa, Article 4, pp. 1–23, 6 pls.

———, 1957, Mississippian endothyrid Foraminifera from the Cordilleran Geosyncline: Jour. Paleont., v. 31, no. 4, pp. 679–704, pls. 75–82.

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