University of Nevada

Reno

Fusulinid Paleontology and Paleoecology of Eastern Nevada

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Geology

by

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ABSTRACT

Paleontological and paleoecological studies in White Pine and Eureka Counties, Nevada, revealed 24 fusulinid taxa. The optimum environment for fusulinids appears to have been shallow (10-50 m), light-penetrated, marine waters of about 35 ppm salinity. The schwagerinids and triticitids are more numerous in the limestones containing about 20 per cent terrigenous materials. The parafusulinids show a wide tolerance of impurities by species, but more individuals occur in the purer limestones. The smaller fusulinids appear not to be restricted by environment.

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INTRODUCTION

Location and Accessibility

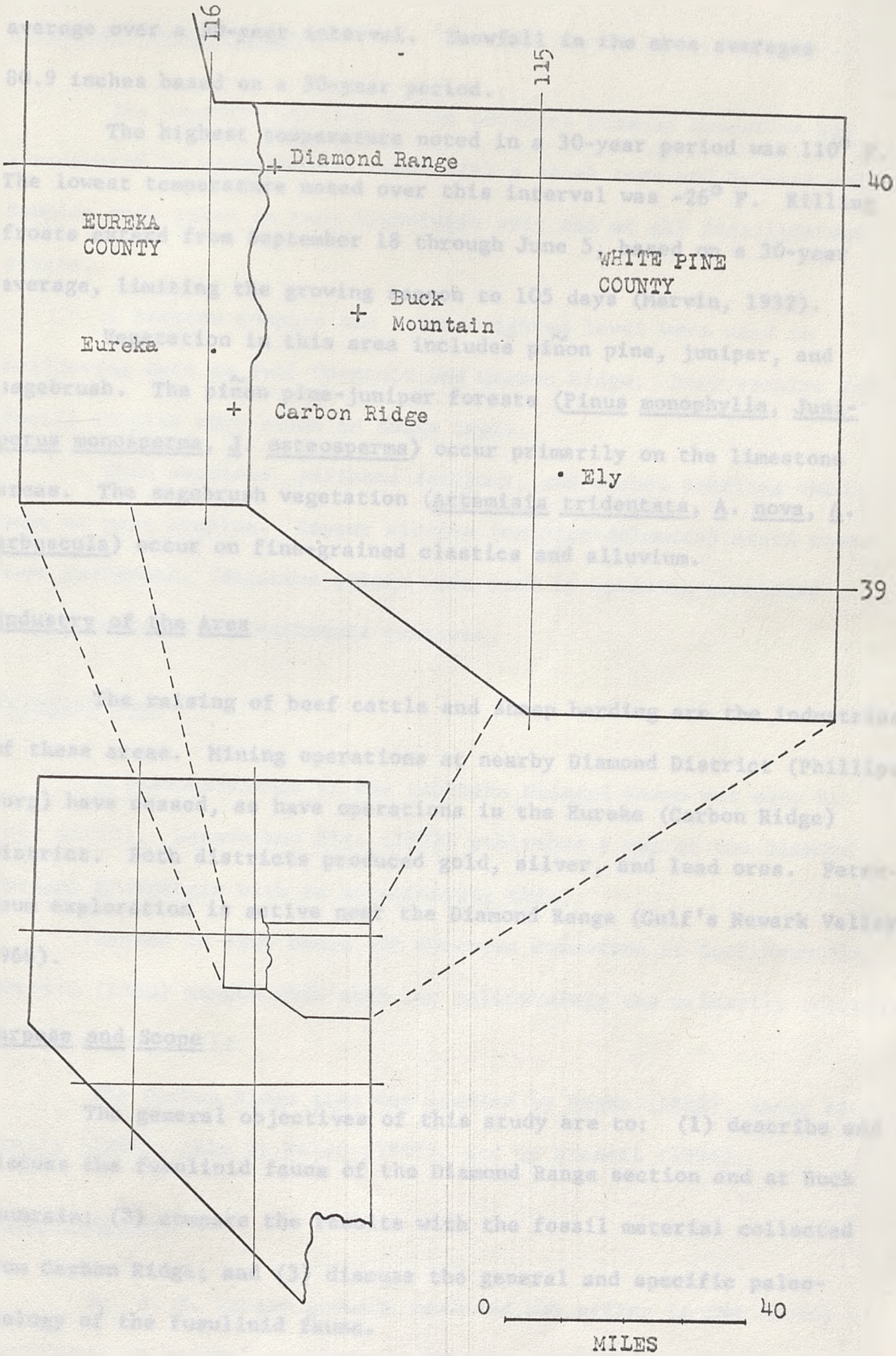
The areas studied are located in the northern part of the Diamond Range, the southern part of Buck Mountain, western White Pine County, and at Carbon Ridge in eastern Eureka County, Nevada. See Figure 1 and 15-minute topographic sheets in pocket.

The measured section in the Diamond Range is located in T24N, R55E, and T25N, R55E, and that at Buck Mountain in Sections 30 and 31, T17N, R53E.

Access to these areas is best accomplished in a vehicle of moderate to high ground clearance. The Diamond Mountain location can best be reached over a paved and gravel road extending along the eastern flank of the Diamond Mountains. This road begins approximately 15 miles east of Eureka on U. S. Highway 50. Access to the Buck Mountain location is best over the Barrel Springs Road, which crosses U. S. 50 approximately 26 miles east of Eureka. The Carbon Ridge turnoff from U. S. 50 is located approximately 9.5 miles east of Eureka.

Climate and Vegetation

The climate of the investigated area is semiarid. Records of precipitation in nearby Eureka show a 12.09-inch yearly rainfall



(modified from Riva)

Figure 1.--Location.

average over a 50-year interval. Snowfall in the area averages 80.9 inches based on a 30-year period.

The highest temperature noted in a 30-year period was 110° F. The lowest temperature noted over this interval was -26° F. Killing frosts extend from September 18 through June 5, based on a 30-year average, limiting the growing season to 105 days (Marvin, 1932).

Vegetation in this area includes piñon pine, juniper, and sagebrush. The piñon pine-juniper forests (_Pinus monophylla_, _Juniperus monosperma_, _J. osteosperma_) occur primarily on the limestone areas. The sagebrush vegetation (_Artemisia tridentata_, _A. nova_, _A. arbuscula_) occur on fine-grained clastics and alluvium.

Industry of the Area

The raising of beef cattle and sheep herding are the industries of these areas. Mining operations at nearby Diamond District (Phillipsburg) have ceased, as have operations in the Eureka (Carbon Ridge) District. Both districts produced gold, silver, and lead ores. Petroleum exploration is active near the Diamond Range (Gulf's Newark Valley, 1966).

Purpose and Scope

The general objectives of this study are to: (1) describe and discuss the fusulinid fauna of the Diamond Range section and at Buck Mountain; (2) compare the results with the fossil material collected from Carbon Ridge; and (3) discuss the general and specific paleoecology of the fusulinid fauna.

Method of Investigation

The measured section in the northern Diamond Mountains was constructed by measurements taken with a steel tape and Brunton compass. Samples were taken in each lithologic unit and at all fossiliferous strata.

A Brunton compass and a hand-sighted level were used in collecting data on Buck Mountain and Carbon Ridge. Rock samples and fossil samples were taken in these areas.

Thin sections, polished sections, and etched sections were made of most samples. Copper nitrate (calcite-dolomite) stain tests were performed. Negative prints were used in studying sectioned fossil material and carbonate textures.

Previous Work

A reconnaissance of the northern Diamond Range was made by Dott (1955). Larson and Riva (1963) published a map of the Diamond Springs Quadrangle with an accompanying text.

Lawson in 1906 named the Arcturus Formation at Buck Mountain. Merrill (1960) mapped this area but paleontology was primarily restricted to the macrofossils.

The Carbon Ridge area was studied by Hague (1892), later by Steele (1960), then by Nolan (1962), and by Bissell (1964).

Acknowledgments

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GEOLOGICAL SETTING

Stratigraphy

Northern Diamond Mountains

In the northern Diamond Mountain area, Mississippian through Permian marine and Cenozoic continental sediments are present. The unit underlying the measured section is the Chaetetes-bearing Pennsylvanian Ely Limestone. This medium dark gray limestone with chert concretions is about 1,300 feet thick throughout this area. Dott (1955) assigned an age of upper Springeran through lower Atokan to the Ely Limestone.

The Permian rock in this area has been divided into seven units by Riva (1957). Larson and Riva (1963) assigned upper Wolfcampian through Guadalupian ages to these units and have recognized Parafusulina-bearing beds on the western flank of the Diamond Mountains as Leonardian in age.

The measured section consists of 1,621.3 feet of middle Wolfcampian limestone. This section is correlated with Bissell's Riepe Springs Limestone and Riepetown Formation (lower part) because of the presence of *Schwagerina aculeata* Thompson and Hazzard and *Schwagerina elkoensis* Thompson and Hansen. See Figure 6.

The unit overlying the measured section is composed of dusky red quartz arenite and mudstones with chert pebble conglomerates. Larson and Riva (1963) assigned these sediments to the Guadalupian.

Buck Mountain Area

In the Buck Mountain area stratigraphic units range from middle Devonian through middle Permian (Findley, 1960). Cenozoic volcanics and Quaternary pluvial material also occur. The unit underlying the studied area is the Ely Limestone of Atokan age. The Permian Arcturus Formation is about 3,500 feet of limestone, siltstones, and sandstones. The only fusulinid-bearing portion is the uppermost limestones; this fusulinid outcropping is 22.4 feet thick. The fusulinids date this portion of the Arcturus Formation as upper Leonardian.

Overlying the Parafusulina-bearing beds are tuffs, welded tuffs, and tuffaceous sandstones of Miocene ? or Pliocene age (Merrill, 1960).

Carbon Ridge

Sediments adjacent to the studied area range from upper Mississippian through middle Permian in age. Overlying these sediments are tuffs and pumice of Cenozoic age (Hague, 1892). The Permian consists of 965 feet of Wolfcampian limestone. The Riepe Springs Limestone is correlative with the measured section, and the Riepetown Formation is present at this locality. The presence of Pseudoschwagerina arta Thompson and Hazzard and Schwagerina youngqusti Thompson and Hansen place the Riepetown Formation stratigraphically higher than the measured section; however, the zone of Schwagerina elkoensis Thompson and Hansen in the measured section suggests correlation with the lower portion of the Riepetown Formation.

Structure

The structure of the general area is of the typical Basin and Range type; the individual ranges are disturbed only to a minor degree. The Diamond Range is essentially a northward-trending asymmetrical syncline with a vertical or slightly overturned western limb. Small asymmetrical anticlines and synclines are present on both flanks of the ridges (Larson and Riva, 1963).

Buck Mountain is structurally a shallow, roughly symmetrical syncline with the axis parallel to the range.

The controlling structure at Carbon Ridge is the Conical Hill anticline (Nolan, 1962). The area studied is essentially an eastward-tilted block.

SYSTEMATIC PALEONTOLOGY

General Statement

Specimens described are from the northern Diamond Range and Buck Mountain, White Pine County, Nevada, and Carbon Ridge, Eureka County, Nevada. Specimens are labeled DR 1-26, BM 1-11, and CR 1-16, for the respective areas.

The thin sections are deposited at the University of Nevada, Geology Department. The terminology, method of description, and measurements are based on those of Dunbar and Skinner (1937). The measurements, given in Table 4, include the outside diameter of the proloculus, the radius vector, the half length, the form ratio (ratio of volution length to volution width), tunnel angle, and wall thickness.

Systematic Descriptions, Discussions, and Occurrences

Superfamily Fusulinacea von Möller 1878

Family Fusulinidae von Möller 1878

Subfamily Schubertellinae Skinner 1931

Genus Schubertella Staff and Wedekind 1910

Schubertella kingi Dunbar and Skinner

Plate 1, Figures 1 and 2

Schubertella kingi Dunbar and Skinner, 1937, Univ. Texas Bull. no. 3701, v. 3, pt. 2, p. 610, pl. 45, figs. 10-15.

Description.--Shells are minute, attaining about five volutions, with a length of 1.0 to 1.1 mm at maturity; rather thickly fusiform, with bluntly rounded polar extremities.

The proloculus is very small, 20 to 30 microns in diameter, rarely as much as 35 microns. The first two volutions consist of a well-defined endothyroid juvenarium with a maximum diameter of 100 to 125 microns. These whorls are narrow, similar to those of Endothyra, and are coiled at approximately right angles to the adult whorls. The first whorl includes about 8 subspherical chambers, and the second includes 11 or 12.

Near the end of the second whorl there is a tersion and an abrupt lengthening of the chambers as a fusulinid character is assumed. The form ratio then gradually increases from about 1.5 in the third volution to 3.0 in the fifth.

Chomata appear to be lacking in the juvenarium, but are prominent, though narrow, in the fusiform whorls. The tunnel is well defined but rather low. The tunnel angle increases from about 20° in the third whorl to about 40° in the last.

The spiral wall is very thin and consists of a tectum and diaphanotheca. Wall thickness is about 10 microns in the fourth volution and 15 microns in the fifth. This thinness allows the septa to be seen through the spirotheca in wet, whole specimens.

The septa are plane; therefore, no septal loops appear in the axial sections.

Discussion.--The only North American form closely resembling this species is Schubertella melogica. S. kingi is differentiated by its higher form ratio, thinner wall, and larger juvenarium. The forms studied fit well the original description.

Occurrence.--This species is found at Carbon Ridge, Eureka County, Nevada. It is found in association with Pseudoschwagerina arta Thompson and Hazzard and P. needhami ? Thompson.

Genus Pseudofusulinella Thompson 1951

Pseudofusulinella sp.

Plate 1, Figure 7

Description.--The shell is 1.52 mm long and .62 mm wide for shells of about four volutions. This small shell has a form ratio of 2.45. The lateral surfaces are slightly concave, the polar ends are pointed, and the axis of coiling is straight.

The proloculus is small, 120 microns, and spherical. The shell is rather tightly coiled throughout. Chamber height is about equal throughout the length of the shell.

The spirotheca is composed of an outer tectorium, a tectum, diaphanotheca, and an inner tectorium. The spirotheca is thin, ranging from 20 microns in the first volution to 32 microns in the fourth volution.

The septa are fluted in the polar ends only.

The tunnel is straight with an angle of about 20° in the inner volutions. The chomata are very large and massive, extending from the tunnel to the polar ends.

Discussion.--This form resembles no described species of Pseudofusulinella. The general shell shape and massive chomata distinguish this form. This species rather closely resembles Yangchienia haydeni Thompson from Afghanistan. Yangchienia occurs at the same stratigraphic level as Pseudofusulinella sp. but has not been reported from the western hemisphere.

Occurrence.--Pseudofusulinella sp. is found in the late Leonardian portion of the Arcturus Formation at Buck Mountain, White Pine County, Nevada.

Subfamily Schwagerininae Dunbar and Henbest 1930

Genus Oketaella Thompson 1951

Oketaella waldripensis Thompson

Plate 1, Figure 6

Oketaella waldripensis Thompson, 1954, American Wolfcampian Fusulinids, Protozoa Art. 5, Univ. Kansas Paleont. Contrib., p. 35, pl. 6, figs. 4-11.

Description.--The shell of Oketaella waldripensis is minute and inflated fusiform, with narrowly rounded to bluntly pointed poles, straight axis of coiling, and convex lateral slopes. Mature shells, three to four volutions, are 0.69 to 1.03 mm long and 0.35 to 0.58 mm wide, giving a form ratio of 1.4 to 2.2. All parts of the shell are involute. The first volution is almost spherical. The axis of coiling in later volutions increases in length rather slowly. Average form ratios are 1.2, 1.6, 1.8, and 1.8.

The thin spirotheca is composed of a tectum and a lower, much less dense layer that shows fine alveoli in the last part of the shell. Spirothecal thickness is about 18 microns in the fourth volution. The proloculus wall measures about 10 microns.

Septa are widely spaced and plane throughout the shell. Septal counts average 10, 14, and 17 for the first to third volutions, respectively.

The proloculus is relatively large with a diameter of 58 to 107 microns. Proloculus average diameter is 81 microns. The shell is loosely coiled throughout. Average chamber heights of the first to fourth volutions are 33, 50, 73, and 94 microns, respectively.

The tunnel is narrow and elliptical in cross section. Chomata are distinct throughout the shell and are massive in the outer part of the shell. The chomata sides are slightly steeper tunnelward. The tunnel angle varies considerably.

Discussion.--Oketaella waldripensis Thompson differs from O. fryei Thompson in having a thinner spirotheca, shorter shell, and slightly more inflated shell. The great variety in this genus may mean the specific designations for the members of this genus are invalid. This form best fits O. waldripensis but is assigned with some doubt. The lateral slopes of this form do not fit the original description very well.

Occurrence.--Oketaella waldripensis Thompson is found at the top of the section in the Diamond Range. The holotype is from an area near Rockwood, Texas.

Oketaella campensis Thompson

Plate 1, Figure 5

Oketaella campensis Thompson, 1954, Protozoa Art. 5, Univ. Kansas Paleont. Contrib., p. 36, pl. 6, figs. 14, 18, 25-33.

Description.--The shell of Oketaella campensis is short and inflated fusiform, with a straight axis of coiling, sharply pointed poles, and steep but slightly convex lateral slopes. Larger specimens of 2 1/2 to 4 volutions are 0.42 to 0.88 mm long and 0.29 to 0.48 mm wide, giving form ratios of 1.4 to 2.1 The shell is symmetrical throughout. The major change in shell shape with growth is a slight increase in axial length. Average form ratios of the first to third volutions are 1.2, 1.6, and 1.9, respectively.

The proloculus is relatively large, having an outside diameter of about 70 to 85 microns. Average chamber heights above the tunnel in the first to fourth volutions are 32, 40, 63, and 92 microns, respectively.

The spirotheca is moderately thick in the outer volutions and is composed of the tectum and a much thicker inner layer.

The septa are rather widely spaced and are plane throughout most, if not all, the shell. There is a slight indication of irregularity in the extreme polar ends of some specimens that may be septal fluting.

The tunnel is narrow with a straight path. The tunnel angle averages 22° to 25° in the second and third volutions. The chomata are very high and wide in all parts of the shell, except the last few volutions. They have steep tunnel sides and low lateral slopes. In most parts of the shell they are half as high as the chambers and extend almost to the polar ends. Axial fillings are very thin if present.

Discussion.--Oketaella campensis is similar to O. cheneyi but is distinguished by its shorter shell, tighter coiled outer volutions, more massive chomata, and narrower tunnel angle. It is distinguished from O. waldripensis by its more uniformly fusiform shell, tightly coiled outer volutions, and sharply pointed polar ends. There is uncertainty in the distinctions between O. campensis, O. waldripensis, and O. cheneyi. Variations in individuals might overlap the criteria used in species designation. This form best fits the description of O. campensis Thompson.

Occurrence.--Oketaella campensis Thompson is found at the top of the section in the Diamond Range 20 feet above the Schwagerina elkoensis Thompson and Hansen zone.

Genus Triticites Girty 1904

Triticites meeki (Möller)

Plate 3, Figure 2

Fusulina cylindrica var. ventricosa Meek and Hayden, 1858, Acad. Nat. Sci. Philadelphia Proc., 1858, v. 10, p. 261.

Fusulina cylindrica Meek and Hayden, 1865, Smithsonian Contrib. Knowl., v. 14, pp. 14-15, pl. 1, fig. 6a (not figs. 6d-6g).

Fusulina ventricosa var. meeki Möller, 1879, Acad. Imp. Sci. St. Petersburg Mem., VII3 ser., tome 27, no. 5, pp. 4-6.

Triticites ventricosus Dunbar and Condra, 1928, Nebraska Geol. Surv. Bull. 2, 2nd ser., pp. 84-91, pl. 1, fig. 2, (?) pl. 3, fig. 1, pl. 4, fig. 4.

Triticites meeki (Möller) Thompson, 1954, Protozoa Art. 5, Univ. Kansas Paleont. Contrib., p. 39, pl. 12, figs. 1-11, pl. 13, figs. 1-12, pl. 16, figs. 1-3.

Description.--Shell is highly elongate fusiform with convex to slightly concave lateral slopes, pointed poles, and is loosely coiled. Specimens of 7 to 8 1/2 volutions are 9.3 to 11.9 mm long and 3.0 to 3.9 mm wide, giving form ratios of 2.8 to 3.1. The first volution is short with bluntly pointed poles; the axis of coiling becomes extended in the remaining volutions. Average form ratios, first to eighth volutions, are 1.7, 2.0, 2.1, 2.2, 2.3, 2.6, 2.8, and 2.9, respectively.

Proloculus is large, measuring 181 to 333 microns, averaging 234 microns. Proloculus is spherical, but ellipsoidal or irregular shapes occur. The shell increases in width uniformly. Chamber height is uniform in the central two-thirds of the shell, but increases rapidly in the extreme polar ends.

The spirotheca is thick and coarsely alveolar. The keriotheca extends down both sides of the septa for short distances producing uneven wall thicknesses adjacent to the septa. Thickness of the proloculus wall averages about 24 microns.

The septa are strongly fluted in the extreme polar regions but appear unfluted above the tunnel. Average septal counts, first to seventh volutions, are 13, 21, 22, 24, 27, 28, and 31, respectively. Septal pores can be seen throughout the shell.

Tunnel angles average 21^{o}, 21^{o}, 23^{o}, 27^{o}, 38^{o}, 48^{o}, 53^{o}, and 58^{o} for the first to eighth volutions, respectively.

Discussion.--Triticites meeki resembles T. ventricosus (Meek and Hayden), but is distinguished by its loosely coiled shell, larger proloculus, larger form ratio, less inflated central area, and the septa are less intensely fluted.

Occurrence.--Triticites meeki (Möller) occurs at Carbon Ridge in the early to middle Wolfcampian age sediments.

Genus Pseudoschwagerina Dunbar and Skinner 1936

Pseudoschwagerina arta Thompson and Hazzard

Plate 3, Figures 5, 6, and 8

Pseudoschwagerina arta Thompson and Hazzard, 1946, Geol. Soc. America Mem. 17, p. 49, pl. 18, figs. 1-3.

Description.--The shell is large, highly inflated fusiform, with straight axis of coiling, steep lateral slopes, and sharply pointed poles. Specimens six to seven volutions are 9.4 to 11.4 mm long and 6.1 to 7.5 mm wide, giving a form ratio of 1.53 to 1.64. Form ratio decreases slowly with growth of the individual from the third volution outward.

The proloculus is small, ranging up to 216 microns. Inner 3 to 3 1/2 volutions are tightly coiled, next outer volution increases in height rapidly, and the outer volutions are highly inflated. Average heights of the first to seventh volutions are 72, 117, 162, 474, 902, 744, and 581 microns, respectively.

Septa are thin, closely spaced in the inner three or four volutions, but in the fourth to seventh volutions the septa are widely spaced. Average septal count for the first to seventh volutions is 13, 19, 22, 25, 20, 21, and 30, respectively. Septal fluting forms closed chamberlets in the polar regions only.

The tunnel forms a straight path throughout the shell. The tunnel is low and narrow in the inner three to four volutions, but widens rapidly outward from the fourth to about 48°. Chomata are well developed in the inner volutions but are low to discontinuous in the outer volutions.

Discussion.--Pseudoschwagerina arta is a typical form of the genus. The uniform profile, numerous septa, development of the juvenarium, and sharply pointed poles distinguish this species.

Occurrence.--Pseudoschwagerina arta Thompson and Hazzard occurs at Carbon Ridge, denoting the upper Wolfcampian sediments, and associated with Schwagerina elkoensis Thompson and Hansen.

Pseudoschwagerina needhami ? Thompson

Plate 3, Figure 7

Pseudoschwagerina needhami ? Thompson, 1954, Protozoa Art. 5, Univ. Kansas Paleont. Contrib., pp. 72-73, pl. 47, figs. 7, 8, 11-17.

Description.--The shell of Pseudoschwagerina needhami is medium sized, inflated fusiform, with a straight axis of coiling, sharply pointed poles, and broadly convex lateral slopes. Specimens of seven volutions are 6.9 mm long and 3.0 mm wide, with a form ratio of about 2.3. The first volution is ellipsoidal, but beyond the second volution the poles become more pointed. Beyond the fifth volution the shell becomes quite robust. Average form ratios of the first to seventh volutions are 1.6, 1.9, 2.3, 2.6, 2.6, 2.4, and 2.1, respectively.

The proloculus is small with an outside diameter of 115 to 165 microns. Chamber height increases rapidly beyond the fourth volution.

The spirotheca is thin, averaging 15, 26, 42, 66, 76, 87, and 85 microns in the first to seventh volutions, respectively.

The septa are thin and closely spaced in the inner volutions, but more widely spaced beyond the third or fourth volutions. Septal fluting is well defined in the polar regions and extends to the top of the chambers of the outermost volutions. Septal counts, first to fifth volutions, are 13, 19, 23, 28, and 26, respectively.

The tunnel is narrow in the inner volutions, but wides rapidly beyond the fourth volution. Average tunnel angles, first to seventh volutions, are 16°, 19°, 22°, 22°, 34°, 50°, and 42°, respectively. The chomata are broad and high in the inner four volutions and are narrow and low in the outer volutions.

Discussion.--Pseudoschwagerina needhami can be distinguished from P. morsei Needham by its small shell, more uniform expansion, and larger chomata. P. needhami can be distinguished from P. rhodesi Thompson by its more uniform expansion, more massive chomata, and thicker spirotheca. P. needhami also resembles P. beedi Dunbar and Skinner in general shell size. The holotype is from the Wolfcampian Hueco Limestone in the San Andres Mountains, New Mexico.

Occurrence.--Pseudoschwagerina needhami ? Thompson occurs at Carbon Ridge in the rocks of middle Wolfcampian age. This form is also reported from the Ferguson Mountain area in the Toana Range, Elko County, Nevada (Slade, 1961).

Genus Schwagerina Möller 1877

Schwagerina aculeata Thompson and Hazzard

Plate 2, Figure 1

Schwagerina aculeata Thompson and Hazzard, 1946, Permian Fusulinids of California, GSA Mem. 17, p. 45, pl. 12, figs. 1-8.

Description.--Shell is large, uniformly fusiform, with sharply pointed poles and low lateral slopes. Mature specimens of seven to eight volutions are 3.8 to 4.3 mm wide and 10 to 11 mm long. Form ratios of mature specimens are 2.3 to 3.1. Average form ratio of mature specimens is about 2.6. Beginning with the third to fourth volution, general shape of shell and its form ratio remain very nearly constant throughout growth to maturity. Axis of coiling is essentially straight in most specimens, but in a few the axis becomes irregular in the polar regions of the outer volutions.

Proloculus is small, outside diameter of 126 to 216 microns, averaging 172 microns. Inner three volutions are tightly coiled, the following three volutions increase in height rapidly, and the outer volutions remain about the same height.

Septa are narrowly fluted in basal parts throughout the length of the shell; fluting in the lower part of the septa forms chamberlets throughout the length of the shell. The septa are only weakly fluted immediately over the tunnel.

Tunnel is straight in the inner volutions and irregular in the outer volutions. Chomata are absent in the outer volutions. Axial fillings are poorly developed and present in the third to sixth volutions only.

The spirotheca is thick, composed of a tectum and keriotheca with coarse alveoli. Average thickness of the spirotheca for the third to seventh volutions is 36, 50, 79, 101, and 109 microns, respectively.

Discussion.--This species is characterized by its highly fluted septa, essentially uniform profile, sharply pointed poles, and closely coiled volutions. Schwagerina aculeata resembles S. thompsoni Needham from the Hueco Limestone of Texas. S. aculeata is larger at maturity, has thinner outer spirotheca, a tightly coiled youthful stage which involves more volutions, and expansion rates of the volutions differ. The specimens from the Diamond Range fit well the original description. Axial fillings in the Diamond Range forms are slightly higher than in the paratypes.

Occurrence.--Schwagerina aculeata Thompson and Hazzard occurs in the northern Diamond Range at the very top of the measured section. This form is common in the Wolfcampian Bird Springs Formation in the Providence Mountains of southern California.

Schwagerina elkoensis Thompson and Hansen
Plate 2, Figures 2 and 3

Schwagerina elkoensis Thompson and Hansen, 1954, Protozoa Art. 5, Univ. Kansas Paleont. Contrib., p. 63, pl. 35, figs. 1-9, ? 14-20.

Description.--The shell of Schwagerina elkoensis is highly consistent in most of its measurable features. It is subellipsoidal in profile, with blunt polar ends, straight axis of coiling, and convex lateral slopes. Large specimens of five to six volutions are

3.7 to 5.7 mm long and 1.6 to 2.7 mm wide, giving form ratios of 2.0 to 2.7. The first half volution has an axis of coiling that is shorter than the diameter of the proloculus. The following one or two volutions have sharply pointed poles and elongate fusiform shape. Beyond the second or third volution the shell becomes ellipsoidal and its polar area rounded. Average form ratios of the first to fifth volutions are 2.1, 2.3, 2.4, 2.4, and 2.3, respectively.

The proloculus of most specimens is rather large and spherical, but in some it is irregular. Its outside diameter measures 186 to 310 microns, averaging 234 microns. The shell is rather loosely coiled throughout all volutions. Average height of chambers in the first to fifth volutions is 64, 101, 165, 216, and 298 microns, respectively. The chambers are lowest above the tunnel, increasing in height very slowly and uniformly poleward.

The spirotheca is rather thick and contains coarse alveoli. It is very thin in the first 1 to 1 1/2 volutions but increases in thickness throughout the remaining volutions. It is thickest above the tunnel but remains of closely similar thickness throughout the length of the shell, decreasing only slowly and slightly poleward. Average thickness of the spirotheca above the tunnel of the first to fifth volutions is 22, 32, 48, 66, and 90 microns, respectively. The proloculus wall is thin, averaging about 21 microns.

The septa are narrowly fluted throughout their length, especially along their basal margins, and are widely spaced. Strong fluting in the end thirds of the shells affects septa to the tops of the chambers. Septal counts of the first to the fifth volutions average 9, 14, 16, 17, and 18, respectively. Phrenotheca are common in most specimens but are confined to the lower parts of the chambers.

The tunnel widens rapidly as the shell expands. The tunnel path is about straight. In some specimens it increases in width at first and then decreases as maturity is approached. Average tunnel angles of the first to the fifth volutions are 25^{o}, 32^{o}, 38^{o}, 41^{o}, and 48^{o}, respectively. Chomata are distinct only in the innermost volutions, where they are low, narrow, and asymmetrical. They occur as irregular deposits on the septa and spirotheca in the outer volutions. Thin axial fillings occur in the extreme polar ends of most specimens.

Discussion.--The small ellipsoidal, loosely coiled shell of this species distinguishes it from most other American forms of the genus. It bears a close resemblance to Schwagerina guembeli Dunbar and Skinner and to S. crassitectoria Dunbar and Skinner from the Leonardian of Texas. It closely resembles S. eolata Thompson and S. neolata Thompson. S. elkoensis differs from S. guembeli in a more loosely coiled shell, septa are wider and less highly fluted, and the axial fillings are less massive. The above forms all show a similar development of phrenothecae, suggesting a close biological relationship. S. elkoensis resembles S. bellula but is distinguished by its larger proloculus and more loosely coiled shorter shell.

Occurrence.--Schwagerina elkoensis Thompson and Hansen is common in the Diamond Range at 20 feet and 35 feet below the top of the measured section. This species is also found at Carbon Ridge in the middle Wolfcampian sediments associated with Pseudoschwagerina arta Thompson and Hazzard.

Schwagerina wellsensis Thompson and Hansen
Plate 2, Figures 4 and 5

Schwagerina wellsensis Thompson and Hansen, 1954, Protozoa Art. 5, Univ. Kansas Paleont. Contrib., p. 64, pl. 34, figs. 1-12.

Description.--The shell of Schwagerina wellsensis is large, inflated fusiform, with about straight axis of coiling, sharply pointed poles, and slightly convex lateral surfaces. Large specimens of five to seven volutions are 8.0 to 13.0 mm long and 2.7 to 3.6 mm wide, giving form ratios of 2.7 and 3.6. The first volution is elongate fusiform, and the shell remains of closely similar shape throughout its growth. Average form ratios of the first to sixth volutions are 2.2, 2.6, 2.5, 2.6, 2.6, and 3.4, respectively.

The proloculus is large, with an outside diameter of about 200 to 325 microns, averaging 281 microns. The shell remains loosely coiled throughout. The chambers remain about uniform in height in the central third of the shell but become slightly higher as the poles are approached. Average height of the spirotheca above the tunnel in the first to sixth volutions is 66, 126, 211, 273, 330, and 346 microns, respectively. The spirotheca is irregular along the lateral slopes, making slight variations in height of a given chamber as seen in an axial section.

The spirotheca is thick and coarsely alveolar. The spirotheca is thickest above the tunnel and thins gradually poleward. Average thickness of the spirotheca in the first to sixth volutions is 23, 36, 56, 75, 93, and 97 microns, respectively. The proloculus wall has a thickness of about 28 microns.

The septa are closely spaced and highly fluted throughout the length of the shell. The fluting brings the septa in contact with each other for about half their height, and the fluting is distinct to the tops of the chambers. Septal counts of the first to fifth volutions average 11, 18, 21, 25, and 27, respectively.

The tunnel is narrow with slightly irregular path. The intense fluting of the septa makes the tunnel sides difficult to identify in all specimens. Average tunnel angles in the second to sixth volutions are 30°, 38°, 31°, 32°, and 30°, respectively. The chomata are very slight. In the inner volutions they are minute and asymmetrical, but in the outer ones they occur as small irregular deposits on the septa and spirotheca. Large areas of the axial regions in all volutions, except for the first volution and outer part of the last volution, are completely filled with dense axial deposits.

Discussion.--Schwagerina wellsensis can be distinguished from most other American forms of the genus by its inflated shell, loosely coiled volutions, pointed polar ends, and massive axial fillings.

Schwagerina wellsensis is distinguished from S. eolata Thompson and S. neolata Thompson by its longer and more slender shell and spirotheca. The forms studied in the Diamond Range show less dense axial deposits than mentioned in the original description.

Paratypes from one locality near Wells, Nevada, also show less dense axial fillings.

Occurrence.--Schwagerina wellsensis Thompson and Hansen is common in the Diamond Range 35 feet and 45 feet from the top of the section, and also at the extreme top of the section. This form was also found at Carbon Ridge in the middle Wolfcampian sediments associated with S. elkoensis Thompson and Hansen and with Pseudoschwagerina arta Thompson and Hazzard.

Schwagerina campensis Thompson

Plate 2, Figure 6

Schwagerina campensis Thompson, 1954, Protozoa Art. 5, Univ. Kansas Paleont. Contrib., p. 57, pl. 26, figs. 1-15.

Schwagerina cf. S. longissimoidea Thompson, 1951, Cushman Foundation Foram. Research Contrib., v. 2, pp. 86-91, pl. 10, figs. 1-3, text fig. 1.

Description.--The shell of Schwagerina campensis is large and highly irregular, broadly arched, or straight axis of coiling, low and slightly irregular to almost parallel lateral slopes, and bluntly pointed to rounded polar ends. Large shells of five to seven volutions are 8.8 to 10.7 mm long and 2.1 to 2.7 mm wide, giving form ratios of 3.7 to 4.4. The first three to four volutions are inflated fusiform, with sharply pointed polar ends, but outer volutions show sharp increases in height of chambers in polar areas, resulting in a subcylindrical mature shape. Average form ratios of the first to seventh volutions are 1.9, 2.2, 2.7, 3.2, 3.7, 3.9, and 3.8, respectively.

The proloculus is moderate in size, having an outside diameter of about 150 to 220 microns, averaging 180 microns. The chambers are lowest immediately above the tunnel. In the inner volutions they increase in height only slightly as the polar ends are approached, but in the outer ones they increase rapidly poleward. Average height of the chambers above the tunnel in the first to seventh volutions is 67, 97, 131, 203, 264, 297, and 344 microns, respectively.

The spirotheca is moderately thick and coarsely alveolar. Its thickness is fairly uniform across the central third of the shell and decreases gradually toward the poles. Average thickness of the spirotheca above the tunnel in the first to seventh volutions is 19, 27, 35, 55, 74, 88, and 86 microns, respectively. The proloculus wall is thick, about 20 to 40 microns, averaging 28 microns. The septa are narrowly fluted throughout the length of the shell, with fluting extending to the tops of the chambers. Closed chamberlets are formed for about half the height of the chambers above the tunnel and for almost three-fourths the height of chambers in the polar third of the shell. Average septal counts of the first to sixth volutions are 12, 23, 24, 27, and 29, respectively.

The tunnel is wide with the path about straight. Average tunnel angles in the third to seventh volutions are 23°, 30°, 39°, and 54°, respectively. Chomata occur throughout all except the last few chambers. In the inner volutions they are narrow and only slightly asymmetrical, with steep to vertical tunnel sides and steep poleward slopes. They are half as high as the chambers in the outer volutions and spread up the sides of the septa to the tops of the chambers and laterally along the sides of the septa. Axial fillings occur throughout most of the shell but are relatively most massive in the inner four or five volutions.

Discussion.--Schwagerina campensis can be distinguished from most Wolfcampian forms of this genus by its larger size, highly elongate slender shell, nearly parallel lateral surfaces, and relatively tightly coiled shell. It differs from the holotype and what are considered to be conspecific specimens of S. longissimoidea (Beede) by its more highly and narrowly fluted septa, heavier axial fillings, smaller proloculus, and more tightly coiled inner volutions.

Schwagerina campensis is closely similar to S. pinosensis Thompson, and can be distinguished from the latter principally by its smaller, more slender shell, shorter early volutions, and seemingly heavier axial fillings. It is judged, however, that S. campensis is closely related biologically to S. pinosensis, S. turki, and S. longissimoidea. The difference noted among some of these may be due to local variations, possibly representing subspecies developed in different environmental conditions. The specimens obtained at Carbon Ridge fit the description of S. campensis well.

Occurrence.--Schwagerina campensis Thompson occurs at Carbon Ridge in association with Pseudoschwagerina needhami ? Thompson.

Schwagerina crassitectoria Dunbar and Skinner

Plate 2, Figure 7

Schwagerina crassitectoria Dunbar and Skinner, 1937, Univ. Texas Bull. no. 3701, v. 3, pt. 2, p. 641, pl. 65, figs. 1-15.

Description.--A fusiform species of about seven volutions, attaining a length of about 8.0 to 8.5 mm and a thickness of 3.0 to 3.5 mm. The axial profile is evenly elliptical and the poles nearly rounded.

The form ratio is generally about 2.5 and remains near this figure in growth following the second volution. The proloculus is of moderate size and thin walled and often irregular. The expansion of the volutions is progressive.

The septal count ranges from about 12 to 25 or 30 in the first to sixth volutions. Tunnel angles are about 40° in the second volution and 50° to 60° in the sixth. Chomata are not developed, but secondary deposits border the tunnel area. These deposits thicken the septa and may result in partial or complete filling of the chambers.

Discussion.--This species may be gradational with *Schwagerina guembeli*. The thicker walls and the slender and elliptical profile distinguish this form as *S. crassitectoria*. The spirothecal thicknesses in the Buck Mountain, Nevada, forms are slightly higher than the Texas forms. Specimens from the Pequop Mountains also show thicker wall structure in the late Leonardian sediments (Robinson, 1961).

Occurrence.--*Schwagerina crassitectoria* Dunbar and Skinner is found at Buck Mountain. This species has been found in the Pequop Mountains, Elko County, Nevada, and the Leonard Formation in the Glass Mountains of Texas.

Schwagerina subinflata Knight

Plate 2, Figure 8

Schwagerina subinflata Knight, 1956, Jour. Paleont., v. 30, no. 4, p. 783, pl. 84, figs. 8, 9.

Description.--Tests of this species are moderately large, thickly fusiform, have convex lateral slopes, a slightly curved axis of coiling and pointed poles. Specimens six to seven volutions are 7.5 mm long and 2.75 to 2.9 mm wide. The form ratios are near 2.0 until the fourth volution. After the fourth volution it increases rapidly to between 2.5 and 3.0. There is no striking change in the outline throughout the shell development.

The outside diameter of the subspherical to spherical proloculus varies from 325 to 400 microns. The shell expands uniformly and gives a rather loosely coiled appearance in axial section. There is a slight increase in height poleward.

The spirotheca is 25 to 40 microns thick in the first volution, 85 to 100 microns in the fifth, and 80 to 90 microns in the sixth and the seventh volutions. The spirotheca is composed of a tectum and a coarsely alveolar keriotheca.

Twenty to 25 septa are present in the second whorl and 30 to 36 in the fifth. Folding extends the entire length of the shell, forming high, wide axial loops in the outer volutions. Elongate chamberlets are seen in tangential slices, but the tips are not excavated.

Very small chomata border the moderately wide but irregular tunnel in the first three volutions. Secondary filling is concentrated in the poles of all but the last two volutions. The secondary fillings are not strongly developed.

Discussion.--Schwagerina subinflata resembles S. crassitectoria Dunbar and Skinner. It differs from that form in being shorter, having a much larger proloculus, and having much sharper poles than does S. crassitectoria. No central cylindrical portion is developed.

Occurrence.--Schwagerina subinflata Knight occurs at Buck Mountain in association with Parafusulina sellardsi Dunbar and Skinner. The holotype is from the late Leonardian portion of the Arcturus Formation at Moorman Ranch, White Pine County, Nevada.

Genus Parafusulina Dunbar and Skinner 1931

Parafusulina communis Knight

Plate 2, Figure 10

Parafusulina communis Knight, 1956, Jour. Paleont., v. 30, no. 4, p. 786, pl. 86, figs. 4-7.

Description.--Shells of Parafusulina communis are large, elongate fusiform to subcylindrical, possess evenly convex lateral slopes, a straight axis of coiling, and bluntly rounded poles. Mature specimens of 6 to 6 1/2 volutions are 8.5 to 9.0 mm long and 2.5 to 3.0 mm wide. Their form ratio is 1.5 to 2.0 in the second volution and increases to 3.0 in the last whorl.

The proloculus averages about 300 microns in outside diameter, through a variation of 250 to 375 microns. Proloculus shape is spherical but appears to be irregularly crushed in most specimens. The shell is loosely coiled after the first whorl and expands uniformly. Chamber height increases moderately poleward.

A distinct tectum is present along with a coarsely alveolar keriotheca. The spirotheca is about 25 microns thick at the first volution and reaches a maximum of 105 to 120 microns in the fifth volution.

Folding extends the entire length of the shell, and cuniculi are developed in at least the outer two or three volutions. Phrenothecae are well developed in the outer whorls, but no pattern is followed as to the location of these features.

The tunnel is narrow, when observable, and is not bounded by chomata. Axial filling is not strong and is largely located in the poles of the inner three volutions.

Discussion.--The shape of the shell of Parafusulina communis resembles Fusulina subcylindria Deprat but has a smaller form ratio. The proloculus of Buck Mountain forms was irregular although not always due to crushing.

Occurrence.--Parafusulina communis Knight occurs at Buck Mountain associated with Schwagerina crassitectoria Dunbar and Skinner.

Parafusulina shaksgamensis crassimarginata Knight

Plate 2, Figures 9 and 11

Parafusulina shaksgamensis crassimarginata Knight, 1956, Jour. Paleont., v. 30, no. 4, p. 787, pl. 87, figs. 1-3.

Description.--Shells of this species are of moderate size, elongate fusiform to cylindrical in shape, with evenly convex lateral slopes. Shells of six to seven volutions are from 9.0 to 11.0 mm long and 3.0 to 3.5 mm wide. The form ratio increases gradually during growth from approximately 2.0 to 3.0 in the sixth volution. Throughout growth the axial profile is predominantly a sharply pointed ellipse, although the last two whorls may become cylindrical through the middle portion.

The thin-walled proloculus, 25 to 30 microns thick, ranges in size from 275 to 425 microns and averages 350 microns. The shell is loosely coiled and expands uniformly. Chamber heights are uniform in the first four volutions, after which there is a gradual increase from the equator to the pole.

The tectum and keriotheca are well developed, and the spirotheca increases in thickness to 75 to 140 microns in the outer whorls.

Septa are numerous with about 15 per whorl at first and increasing to a value near 40 per whorl. Folding is high and extends the length of the shell. Cuniculi are formed in at least the three outer whorls.

The tunnel is narrow in all stages of growth. Axial fillings are present in the ends of all volutions, except the outer two.

Discussion.--This variety differs from the typical Parafusulina shaksgamensis in having lighter axial fillings, a much thicker spirotheca at maturity, and is shorter. This species resembles Schwagerina franklinensis Dunbar and Skinner, but the presence of cuniculi differentiates it. The holotype of this variety is from Moorman Ranch, White Pine County, Nevada.

Occurrence.--Parafusulina shaksgamensis crassimarginata Knight occurs at the Buck Mountain fusulinid outcroppings in the late Leonardian portion of the Arcturus Formation.

Parafusulina subrectangularis Kling

Plate 2, Figure 12

Parafusulina subrectangularis Kling, 1960, Jour. Paleont., v. 34, no. 4, p. 654, pl. 82, figs. 2-5.

Description.--Mature individuals of seven to eight volutions attain a length of 13.0 to 17.0 mm and a width of 3.0 to 5.0 mm, giving a form ratio of 1.5 to 2.3 for the first volution, and 3.5 to 4.1 for the last volution. Early volutions are distinctly elongate with sharply pointed poles, but the outer three volutions become greatly expanded at the poles which are rounded to nearly rectangular. This results in a subrectangular axial profile in mature specimens. The axis of coiling is straight.

Outside diameter of the proloculus ranges from 245 to 435 microns, averaging 334 microns.

Septal counts average 12, 22, 25, 28, 32, and 34 for the first through sixth volutions, respectively. The septa are regularly and intensely fluted. Closely spaced, high septal loops are seen in the inner and middle volutions, but often fail to appear in the outer volutions because the septa are widely spaced. Well-developed cuniculi can be observed in tangential sections.

The spirotheca consists of a thin tectum and thick keriotheca with a relatively coarse alveoli. Spirothecal thickness is approximately

20 to 50 microns for the first volution and 70 to 120 microns for the last volution.

Tunnel angle averages 34°, 37°, 35°, 36°, 39°, 48°, and 50° for the first seven volutions, respectively.

No chomata are observed. Secondary deposits are lacking or inconspicuously confined to a narrow axial zone in the inner three or four volutions.

Discussion.--Parafusulina subrectangularis is similar to P. sapperi Dunbar but is somewhat smaller, has a smaller proloculus, and has less axial fillings.

Parafusulina subrectangularis is similar in shape to P. sellardsi Dunbar and Skinner of the Word Formation of Texas. The latter is, however, larger, has a larger proloculus, and has more numerous septa in corresponding volutions.

Distinctive features of this species are its long, narrow inner and middle volutions with sharply pointed poles and outer volutions with unusually blunt poles. The holotype was described by Kling (1960) from the middle of the Chochal Limestone at Purulhá, Guatemala.

Occurrence.--Parafusulina subrectangularis Kling occurs at Buck Mountain in the late Leonardian portion of the Arcturus Formation. This species has also been reported from the Pequop Formation in Elko County, Nevada.

Parafusulina bosei Dunbar and Skinner

Plate 2, Figure 13

Parafusulina bosei Dunbar and Skinner, 1937, Geology of Texas, v. 3, pt. 2, p. 679, pl. 73, figs. 1-9.

Description.--A fusiform species of about seven volutions, 10.0 to 11.0 mm long and 3.5 to 4.0 mm wide. The form ratio of 2.7 to 3.6 commonly changes little throughout growth. The lateral slopes are convex with well-rounded polar ends. The axial profile is subelliptical.

The proloculus is large and commonly flattened or irregular. The first whorl or two are low, but the expansion is progressive and the outer volutions appear rather loosely coiled. The spirotheca is approximately 30 to 40 microns thick in the first volution and about 100 microns in the outer volutions.

The septa are intensely fluted with well-developed cuniculi. The tunnel angle is about 30^{o} in the first whorl, increasing to 50^{o} to 55^{o} in the fourth. Chomata are lacking, but a slight amount of secondary deposit coats the septa for some distance on each side of the tunnel and partly fills the chambers of the end zones of the early whorls.

Discussion.--Parafusulina bosei is distinguished from the associated species, P. splendens Dunbar and Skinner, by its more bluntly rounded ends, lower and less crowded septal loops, larger proloculus, and the lightness of its secondary deposits. Holotype is from the Word Formation, Glass Mountains, Texas.

Occurrence.--Parafusulina bosei is found at Buck Mountain, White Pine County, Nevada, in the late Leonardian portion of the Arcturus Formation. P. bosei has been reported in the Pequop Formation, Elko County, Nevada.

Parafusulina sellardsi Dunbar and Skinner
Plate 2, Figure 14

Parafusulina sellardsi Dunbar and Skinner, 1937, Univ. Texas Bull. no. 3701, v. 3, pt. 2, p. 688, pl. 78.

Description.--A large, subcylindrical species of eight to nine volutions, 16.0 to 18.0 mm long and 4.0 to 5.0 mm wide. The shell is slightly thicker at the middle, its lateral slopes are gently convex, and the poles are bluntly rounded. The axis of coiling is slightly curved.

The proloculus is large and thick walled and is commonly irregular in shape. The wall consists of a thin tectum and a well-developed keriotheca of 100 to 125 microns thick in the outer whorls. The septa are very numerous, numbering over 20 in the first volution, 30 in the second, and increasing to more than 50 in the outer whorls. They are intensely fluted, and the tips of the folds form arches over the basal foramina. Septal pores are rather coarse in the outer whorls.

The tunnel is rather wide, increasing from 25° to 30° in the early whorls to 50° to 60° in the outer whorls. There are no chomata at any stage of growth, but there is a moderate amount of secondary deposition in the form of axial fillings in the first four or five whorls.

Discussion.--Parafusulina sellardsi resembles P. rothi Dunbar and Skinner but attains a larger size, has a smaller form ratio, and has much more numerous septa. In axial section the septal loops appear more closely crowded than P. rothi. P. wordensis Dunbar and Skinner is a similarly shaped form but is twice as large and relatively more elongate. Holotype is from the Word Formation, Glass Mountains, Texas.

Occurrence.--Parafusulina sellardsi Dunbar and Skinner is found at Buck Mountain in the late Leonardian portion of the Arcturus Formation.

Parafusulina sp.

Plate 2, Figure 15

Description.--A large subcylindrical species of seven to eight volutions attaining a length of 14.0 to 15.0 mm and a width of 1.7 to 2.0 mm, giving a form ratio of about 2.1 in the first volution to 3.9 in the seventh volution. The axis of coiling is slightly curved, the lateral slopes are highly irregular, and the polar ends are sharply pointed in all but the outer two volutions.

The proloculus is spherical and about 250 microns in outside diameter. Chamber height increases progressively, resulting in loosely coiled outer volutions.

The septa are intensely fluted, resulting in crowded septal loops in axial section with vesicular fluting in the polar ends. The spirothecal thickness ranges from about 30 microns in the first volution to 140 microns in the outer volution. A tectum and well-developed keriotheca comprise the spirotheca.

The tunnel angle is about 24° in the first volution and 44° in the fourth volution. No chomata are developed, but secondary deposits are seen on the spirotheca in the tunnel area on the inner volutions and on the septa adjacent to the tunnel in the outer volutions. The innermost whorls show slight to moderate axial fillings.

Slight prenothecal development is noted in the outermost volutions.

Discussion.--Only one good axial section of this form was obtained. Oblique tangential sections adjacent to this form show cuniculi well developed; however, these could not be positively related to the illustrated form. This may be one of the later *Schwagerina* species such as *S. setum* Dunbar and Skinner. The axial section more closely resembles *Parafusulina sellardsi* Dunbar and Skinner and *P. rothi* Dunbar and Skinner because of the closely crowded septa. This form differs from the described *Parafusulina* species in the irregular lateral slopes and pointed polar ends in the inner and middle volutions.

Occurrence.--*Parafusulina sp.* is found in the late Leonardian portion of the Arcturus Formation at Buck Mountain, White Pine County, Nevada.

Genus Pseudofusulina Dunbar and Skinner 1931

Pseudofusulina loringi Thompson

Plate 3, Figure 1

Pseudofusulina loringi Thompson, 1954, Protozoa Art. 5, Univ. Kansas Paleont. Contrib., p. 69, pl. 41, figs. 1-10.

Description.--The shell of Pseudofusulina loringi is large and elongate subcylindrical, with nearly parallel lateral slopes in the central half of the shell and broadly convex surfaces in the end quarters, bluntly rounded polar ends, and irregular to broadly curving axis of coiling. Specimens of 5 1/2 to 7 volutions are 10.8 to 11.0 mm long and 2.8 to 3.7 mm wide, giving form ratios of 3.0 to 3.7. The polar ends of the first two to three volutions have sharply pointed polar ends and inflated central areas. The polar ends become rounder after the third volution. Average form ratios are 1.8, 2.3, 2.7, 3.4, 3.6, and 3.4 for the first to sixth volutions, respectively.

The proloculus varies in size from 179 to 368 microns. The shell is loosely coiled throughout. Average heights of chambers are 27, 114, 170, 217, 287, 353, and 405 microns in the first to seventh volutions. Chamber height increases rapidly as the extreme polar ends are approached.

The spirotheca is thick and distinctly alveolar, decreasing in thickness toward the polar ends. Average thickness of the first to seventh volutions is 23, 40, 46, 62, 72, 87, and 88 microns. The proloculus wall is about 29 microns thick.

The septa are thin and highly fluted throughout the length of the shell, but are irregular and discontinuous. Septal counts average 13, 22, 27, 29, 34, and 35 for the first to seventh volutions.

The tunnel is high and wide with a straight path. Average tunnel angles are 23°, 27°, 30°, 45°, and 56° in the second to sixth volutions, respectively. The chomata are small and nearly symmetrical in the inner four volutions and are discontinuous in the outer volutions. Axial fillings are very thin if present.

Discussion.--The forms studied best fit Pseudofusulina loringi Thompson. The development of prenotheca in the outer whorls was not observed in the holotype, yet Thompson (1948) stated in Protozoa Article 1, University of Kansas Paleontological Contributions, that prenotheca occur in all known species of this genera, and that P. loringi may not be closely related to other members of this genera.

Occurrence.--Pseudofusulina loringi Thompson is found in the Diamond Range at the top of the measured section and 20.5 feet below the top of the section.

Pseudofusulina retusa Skinner and Wilde

Plate 3, Figure 3

Pseudofusulina retusa Skinner and Wilde, 1965, Protozoa Art. 6, Univ. Kansas Paleont. Contrib., p. 61, pl. 18, figs. 13-17, pl. 19, fig. 1.

Description.--The shell is small, fusiform, with bluntly rounded poles. Adult specimens have 4.5 to 5 volutions and measure 6.95 to 7.7 mm in length and 2.8 to 3.2 mm in width, giving a form ratio of 2.17 to 2.53. Spirotheca is composed of a tectum and a moderately coarse keriotheca 94 to 114 microns in the fourth whorl. "Rugosity" is formed by closely spaced indentations of the tectum. Septa are strongly and irregularly fluted throughout the shell. Septa number 10 to 12 in the first volution, 17 to 20 in the second, 21 to 27 in the third, 27 to 28 in the fourth, and about 32 in the fifth. Septal folds are narrow and high, extending to the tops of the septa. Septal furrows are moderately deep. The proloculus is very large; its outside diameter is 336 to 450 microns. The tunnel is low and narrow, with an angle of 26° to 34° in the fifth whorl. Chomata are weak, present only on the proloculus.

Discussion.--Pseudofusulina retusa is similar to P. solita Skinner and Wilde. The latter, however, is slightly smaller, has more sharply pointed poles, a smaller proloculus, and a wider tunnel. One of the specimens from the Diamond Range shows quite clearly the "rugosity" caused by tectal indentation. Holotype is from the Wolfcampian McCloud Limestone, California.

Occurrence.--Pseudofusulina retusa Skinner and Wilde is found in the Diamond Range, 720 feet above the base of the section in association with Schwagerina aculeata Thompson and Hazzard.

Pseudofusulina sp.

Plate 3, Figure 4

Description.--Pseudofusulina sp. is of moderate size, 8.0 to 9.4 mm long and 2.8 to 3.4 mm wide for specimens of five volutions. Form ratios are approximately 2.0 to 2.7. Lateral surfaces are convex. The polar ends are rounded; the axis of coiling is slightly curved.

The proloculus is quite large, from 350 to 460 microns, and is spherical with a thin prolocular wall. The shell is loosely coiled throughout, with chamber height increasing poleward.

The spirotheca is moderately thick, ranging from 22 to 32 microns in the first volution to 110 to 128 microns in the fifth volution.

The septa are highly fluted throughout the length of the shell, becoming almost vesicular in the polar areas.

The tunnel is wide in the outer volutions, about 48^{o} in the third volution. The chomata are small and well developed but occur only on the proloculus. Light axial fillings occur in the innermost volutions of one specimen, and are absent in another.

Discussion.--This species is referred to the genus Pseudofusulina Dunbar and Skinner because of the large proloculus, loosely coiled nature of the shell, and the thick spirotheca. These forms are lacking the rugose spirotheca stated by Skinner and Wilde (1965) as a criterion in the identification of Pseudofusulina. Under the criteria listed by Skinner and Wilde this form may belong to the genus Schwagerina Möller. These specimens do not resemble any described form of the genus Schwagerina, nor do they resemble any species of the genus Parafusulina.

Occurrence.--Pseudofusulina sp. occurs in the Diamond Range at the top of the section.

THE SEDIMENTS

The Energy Index Classification

The classification of Plumley et al. (1962) for limestones has been incorporated into this paper. This classification was selected because of its primarily genetic basis.

The classification is genetic and provides a basis for the interpretation of depositional environments of limestones. The inferred degree of water agitation in the depositional environment is of primary consideration in the genetic grouping of limestones. The Energy Index (EI) system of limestone classification is based on the degree of water agitation.

Textural and compositional data are used to group the limestones into genetic categories. The textural data are size, sorting, roundness of granular particles, and matrix nature. The textural data are of primary consideration, whereas the compositional data are supplemental. Compositional data include mineralogy, fossil types, abundance, and associations.

Five major limestone types which constitute a grading spectrum between quiet water and strongly agitated water are assigned in this classification. The major types are quiet water (Type I), intermittently agitated water (Type II), slightly agitated water (Type III), moderately agitated water (Type IV), and strongly agitated water (Type V). The boundaries are arbitrarily determined by semiquantitative and qualitative analysis of primary textural properties (Plumley et al., 1962).

The major limestone types (Types I-V) are divided into three subtypes, designated as I_1, I_2, I_3, II_1, etc. These subtypes indicate (1) genetic similarities among limestones with different textural properties, and (2) genetic differences among limestones with similar textural properties. The complete classification is shown in Table 1.

The Energy Index classification does not necessarily imply water depth. A back-reef limestone, for example, may be of low EI in shallow water due to the sheltering action of the reef. The fore-reef limestone, at the same depth, may be subject to strong wave action resulting in a high EI limestone.

Carbonate Types

Limestones from the Diamond Range show intermittently agitated (Type II) to strongly agitated (Type V) Energy Indexes. The column, Figure 6, shows the changing conditions in the lower part of the section with the gradual decrease in energy in the upper part of the column.

Table 3 shows the limestone types observed plus supplemental information concerning impurities, diagenesis, and fossil types.

In the Carbon Ridge section the Energy Index of the limestones remains close to a Type II_1, with an occasional III level reached.

The Buck Mountain limestones range from EI I_1 to EI III_1, in the fusulinid outcroppings. The low EI fusulinid limestones are between limestones comprised of Dictyoclostus ivesi White, a spined

Limestone Type According to Energy Index	*Limestone Sub-Types*	*Mineralogy*	*Texture*			*Fossil Abundance and Complexity*	*Characteristic Fossils*[1] *Fossil Associations* *Fossil Preservation*
			Size	*Sorting*	*Roundness*		
QUIET I Deposition in quiet water	I_1	Calcite Clay (15 to 50%) Detrital quartz (<5%)	Microcrystalline carbonate (<0.06 mm) or any size fossil fragments in a microcrystalline carbonate matrix (matrix <50%)	Matrix—good Fossils—poor	Original fossil shapes; angular fragments if broken	Barren to moderately fossiliferous Simple assemblages	Crinoids; echinoids; bryozoans (fragile branching types); solitary corals; ostracodes: thin-shelled brachiopods, pelecypods, and gastropods; Foraminifera; sponge spicules; tubular, encrusting, and sediment-binding algae; fecal pellets of bottom scavengers. Common fossil associations are crinoid-bryozoa assemblages, bivalve shell assemblages, Foraminifera assemblages (predominantly planktonic). Many fossils are whole and unbroken and are not mechanically abraded. Any fragmentation of fossil material probably is due to disarticulation upon death, to predatory (boring, opening, and breaking) activity and scavenger activity, or to solution.
	I_2	Calcite (predominant) Clay (<15%) Detrital quartz (<5%)					
	I_3		Any size fossil fragments in microcrystalline matrix (matrix <50%)	Matrix—good Fossils—moderate to good		Moderately to abundantly fossiliferous Simple assemblages (coquinoid limestone)	
INTERMITTENTLY AGITATED II Deposition alternately in agitated water and in quiet water	II_1	Calcite (predominant) Clay (<25%) Detrital quartz (<50%)	Microcrystalline matrix (>50%). Micrograined to medium-grained clastic carbonate and terrigenous material	Matrix—good Clastic material—poor to good	Clastic carbonate material subangular to rounded. Roundness of terrigenous clastics is principally a function of size. Oolites may be present	Barren to moderately fossiliferous. Moderately simple assemblages	Characteristic fossils and fossil associations are similar to Type I limestones. Fossil materials are more fragmental than those in Type I limestones and also may be more or less rounded by wave action. Scattered fragments of fossils from rougher water environments may be present.
	II_2		Microcrystalline matrix (>50%). Coarse- to very coarse-grained clastic carbonate and terrigenous material				
	II_3		Interbedded microcrystalline carbonate and any size clastic. Microscale rhythmic bedding	Sorting good within individual lamina		Barren to moderately fossiliferous. Moderately complex assemblages	
SLIGHTLY AGITATED III Deposition in slightly agitated water	III_1	Calcite (predominant) Detrital quartz (up to 50%)	Micrograined clastic carbonate (<0.06 mm) predominates	Matrix—good Clastic material—moderate to good	Clastic material subrounded to well rounded. Fine-grained oolites may be present	Barren to sparsely fossiliferous Simple assemblages	Echinoderm, bryozoan, and bivalve shell debris; Foraminifera; encrusting algae. Common fossil associations are Foraminifera-abraded bivalve shell fragment assemblages. Fossil materials comminuted from larger fossil structures are well abraded by wave and current action.
	III_2		Very fine-grained clastic carbonate (0.06 to 0.125 mm) predominates			Barren to moderately fossiliferous Simple assemblages	
	III_3		Fine-grained clastic carbonate (0.125 to 0.25 mm) predominates	Matrix—poor Clastic material—moderate to good		Barren to abundantly fossiliferous Simple to moderately complex assemblages	
MODERATELY AGITATED IV Deposition in moderately agitated water	IV_1	Calcite (predominant) Detrital quartz (up to 50%)	Medium-grained clastic carbonate (0.25 to 0.5 mm) predominates	Matrix—poor Clastic material—moderate to good	Clastic material subrounded to well rounded. Oolites may be present	Moderately to abundantly fossiliferous Simple to moderately complex assemblages	Crinoids, echinoids, bryozoans, brachiopod and pelecypod shell fragments, colonial coral fragments, stromatoporoid fragments (Silurian and Devonian predominantly); tubular algal fragments, colonial algal fragments (rare), encrusting algae. Common fossil associations are similar to associations of Types I, II, and III, or they are mixtures of these associations. Fossil materials are generally broken and abraded.
	IV_2		Coarse-grained clastic carbonate (0.5 to 1.0 mm) predominates				
	IV_3		Very coarse-grained clastic carbonate (1.0 to 2.0 mm) predominates			Moderately to abunantly fossiliferous Moderately complex to complex assemblages	
Limestone Type According to Energy Index	*Limestone Sub-Types*	*Mineralogy*	*Texture*			*Fossil Abundance and Complexity*	*Characteristic Fossils*[1] *Fossil Associations* *Fossil Preservation*
			Size	*Sorting*	*Roundness*		
STRONGLY AGITATED V Deposition and growth in strongly agitated water	V_1	Calcite (predominant) Clay (<5%) Detrital quartz (<25%)	Gravel-size clastic carbonate (rock fragments and fossil material >2.0 mm) predominates	Matrix—poor Clastic material—poor to moderate	Clastic material subrounded to well rounded. Pisolites may be present	Sparsely to moderately fossiliferous Complex assemblages	Crinoids; echinoids; encrusting bryozoans; thick-shelled brachiopods, pelecypods, and gastropods; colonial coral fragments; stromatoporoid fragments (Silurian and Devonian predominantly); colonial algal fragments; rudistid fragments (Cretaceous predominantly). Fossil associations are similar to Type IV associations. Fossil materials are generally broken and abraded.
	V_2		Gravel-size conglomeratic or brecciated carbonate (>2.0 mm) Tectonic breccias excluded	Matrix—poor Clastic material—poor	Clastic material angular to well rounded	Barren to sparsely fossiliferous Complex assemblages	
	V_3	Calcite	Not applicable	Not applicable	Not applicable	Abundantly fossiliferous Simple assemblages (fossil colonial growth in place)	Colonial corals, stromatoporoids, colonial algae (principally the Rhodophyta or red algae and some genera of the Cyanophyta or blue-green algae).

TABLE 1.--Carbonate Classification (from Plumley *et al.*, 1962)

brachiopod in which the fragile spines are semiattached. The position of the spines seems to substantiate the low energy environment indicated in the EI assignment of these limestones.

PALEOECOLOGY

Fusulinid paleoecology is somewhat more uncertain than most paleoecological studies, those of Tertiary Foraminifera. The Tertiary forms can be closely related to genetically related living forms for comparison of habitats. The geologic range of the fusulinids is from Chesteran (middle Mississippian) to Ochoan (upper Permian). Although no forms genetically related to the fusulinids exist today, there is a foraminiferal family somewhat isomorphous in general shape, the Alveolinidae. Figure 2 shows an alveolinid, Alveolinella quoyi D'Orb,

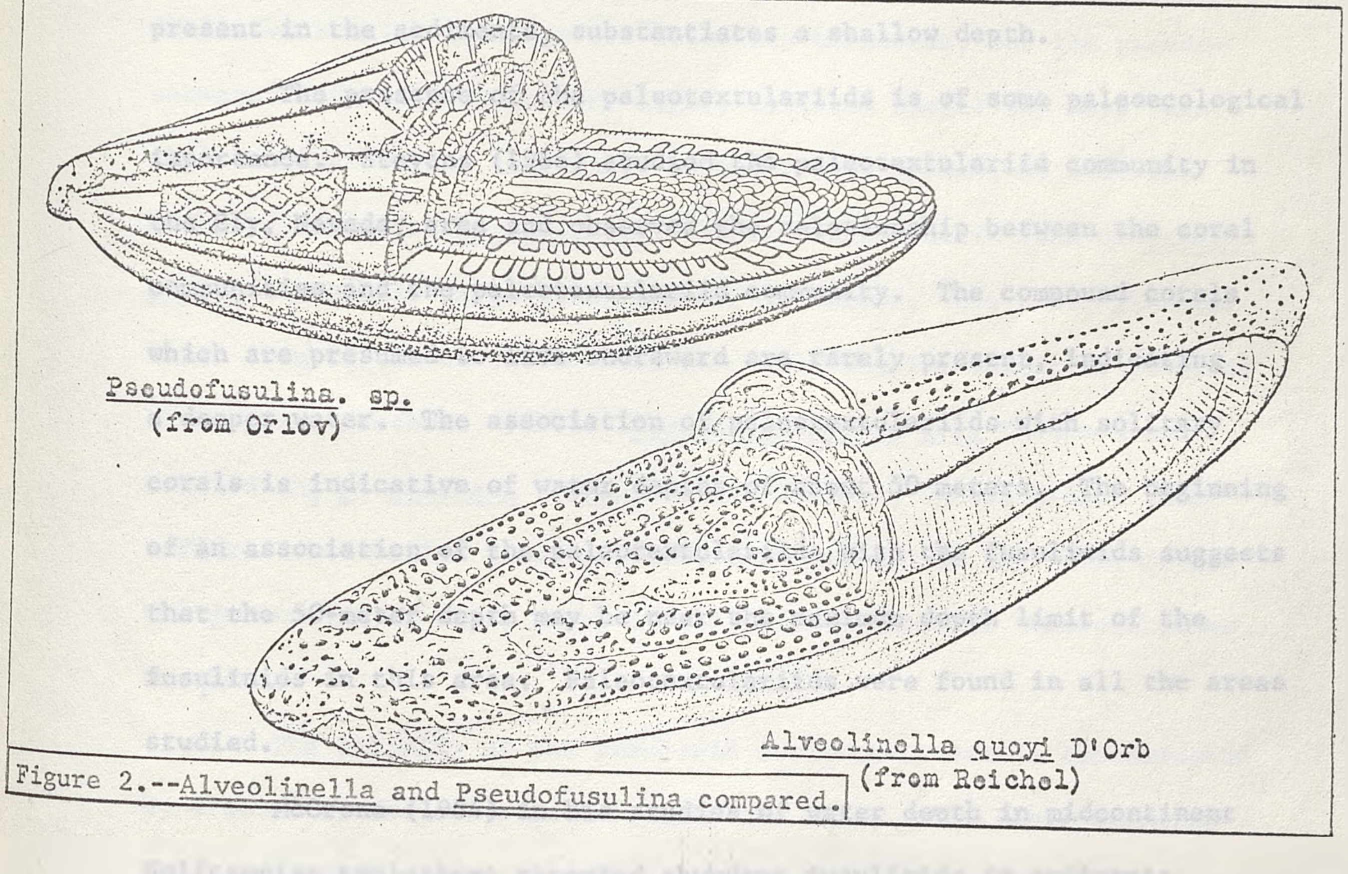


Figure 2.--Alveolinella and Pseudofusulina compared.

and a fusulinid, Pseudofusulina sp. The similarity of the shell structure is apparent. Two genera of the Alveolinidae, Borelis and Alveolinella, are Recent forms. Alveolinella quoyi D'Orb most closely resembles the Permian fusulinids of Nevada. A. quoyi is native to the equatorial Indopacific. This littorial form is very abundant along the coral coast of the area. The depth preference of this form is observed to be between 10 and 80 meters and rarely at shallower depths (Reichel, 1937). Also, most of the larger living benthonic Foraminifera favor water less than 60 to 70 feet in depth, although they can survive at greater depths (McCrone, 1964). The depth of water in which the Permian forms lived is assumed to be similar to these ranges. The occurrence of light-requiring algae, Epimastopora sp., which is present in the sediments, substantiates a shallow depth.

The presence of the paleotextulariids is of some paleoecological importance. Stevens (1966) studied the paleotextulariid community in the Ely, Nevada, area and observed the relationship between the coral communities and the paleotextulariid community. The compound corals which are presumed to live shoreward are rarely present, indicating a deeper water. The association of paleotextulariids with solitary corals is indicative of water depths of about 50 meters. The beginning of an association of the paleotextulariids with the fusulinids suggests that the 50-meter depth may be near the maximum depth limit of the fusulinids in this area. Paleotextulariids were found in all the areas studied.

McCrone (1964) in his studies of water depth in midcontinent Wolfcampian cyclothems reported abundant fusulinids in sediments deposited in waters of less than 60 feet. The occurrence of fusulinids in eastern Nevada in slightly agitated to moderately agitated water also suggests a shallow habitat. This depth of water is much less than that proposed by the earlier workers, such as Rauser-Chernousova in the Pre-Urals of Russia and Elias in the Kansas Big Blue Group. Both suggested depths greater than 100 feet as minimums; Elias proposed 160 to 180 feet as minimum water depth. Rauser-Chernousova based the depths on algae which she mentioned as thriving at 120 to 150 feet. Most present-day marine calcareous algae thrive at depths much less than 120 feet (McCrone, 1964).

Kahler and Kahler (in Dunbar, 1957) stated that the habitat of some fusulinid forms is uncertain. The forms which weighted their shells with axial fillings are evidently benthonic, but the pseudoschwagerinids with their very light, inflated shells may have been able to float during some stage in their life cycles, as does the modern foraminifer Tremtoplalus. In the microspheric form of Tremtoplalus a peculiar large final chamber is formed. The thin, globular inner chamber can be filled with gas, allowing the animal to float to the surface (Cushman, 1950). Pseudoschwagerina arta Thompson and Hazzard and P. needhami ? Thompson are found at Carbon Ridge; these inflated thin-walled forms may have been pelagic in the adult forms. The juvenarium of these forms is triticitid, which is interpreted as benthonic.

The salinity of the fusulinid environment can be approximated by studies of the associated stenohaline fauna. The Echinodermata, which are present either as plates or stem columnals, have a very narrow salinity tolerance. The salinity, measured from living echinoderms, is close to 35 ppm (Stevens, 1966). Echinodermata fragments are found in approximately 90 per cent of the thin sections of fusulinids. Studies in the Permian of the Texas-New Mexico area show lithologies grading from areas in which fusulinid fauna are abundant, into areas characterized by brackish water type fauna, and into dolomites and evaporites. The fusulinids disappear laterally in the sections long before the regions of evaporites occur. Fusulinids are not found with euryhaline fauna (Thompson, 1964).

Fusulinids are found in sediments formed in marine waters of about 10 to 50 meters in depth, in areas of light penetration, and in waters with a salinity of about 35 ppm.

PALEOECOLOGY AND FACIES

The relationship between the carbonate grain size, indicating an interface energy level, and detrital impurities, indicating the effect of the adjacent uplifted areas on fusulinid distribution, is shown in Figure 3. Specific identification of the numbers in this figure are given in Table 2.

The most favorable conditions appear to be those under which carbonate grains of about .09 to .29 mm in diameter are transported; and perhaps slightly more favorable when an influx of terrigenous material of about 8 to 20 per cent is indicated. The controlling factor appears to be carbonate grain size rather than the percentage of impurities for over-all fusulinid distribution. Number 6 (Schwagerina elkoensis Thompson and Hansen), for example, has a relatively narrow distribution in its relationship to carbonate grain size, but is found in limestones with a wide range of impurities. It is assumed that S. elkoensis Thompson and Hansen could live not only within the environmental conditions represented in the figure but also in any gradational environment between these two observed environments. This assumed environment is depicted, for this case, by dashed lines in the figure.

Generally recognizable from Figure 3 are certain environmental preferences. Although the schwagerinids seem to be tolerant of changes in impurity level, most individuals of this genus are found in the arenaceous limestones, that is, those with about 12 to 20 per cent terrigenous impurities. Schwagerina elkoensis Thompson and Hansen (6) and S. wellsensis Thompson and Hansen (7) show this type of distribution.

Schwagerina campensis Thompson (8) has a wider range of energy tolerances but appears to be restricted by impurities. No individuals of this species were found in sediments with greater than 1 per cent impurities.

The occurrence of the parafusulinids appears to be governed by interface energy rather than impurity content. These forms are represented throughout the range of from 1 to 20 per cent impurities. The least sensitive of these is Parafusulina loringi Thompson (20).

Pseudoschwagerinids are also energy controlled. These forms are found in the extremes of the impurity ranges, 1 per cent and 14 per cent. If these forms do become pelagic at some time in their life cycle, it would seem that their death in this habitat would cause a widespread distribution uncontrolled by either energy or impurities.

The triticitids are found only in highly impure limestones of about 30 per cent detrital quartz.

The smaller forms, the schubertellids, pseudofusulinids, staffellids, and oketaellids, are rather restricted by genera but as a group are distributed over a wide range of impurities and carbonate grain size. Distribution of genera and species of the other taxa may be taken from the figure.

Figure 4 shows frequency curve distributions of the represented genera.

Relationships between the maximum observed length of the fusulinids and the energy level at the depositional interface are shown in Figure 5. The most favorable energy levels, II and III, show an almost thirtyfold difference in length. This indicates a biocoensis, that is, an assemblage representing one of living forms rather than an assemblage transported and brought together after death. A well-sorted assemblage might indicate a death assemblage.

The general unabraded nature of the fusulinid shells, the poor quality of shell sorting, and the low EI limestones indicate that the fusulinids dealt with are representative of the life and the environments present during the lower Permian in eastern Nevada.

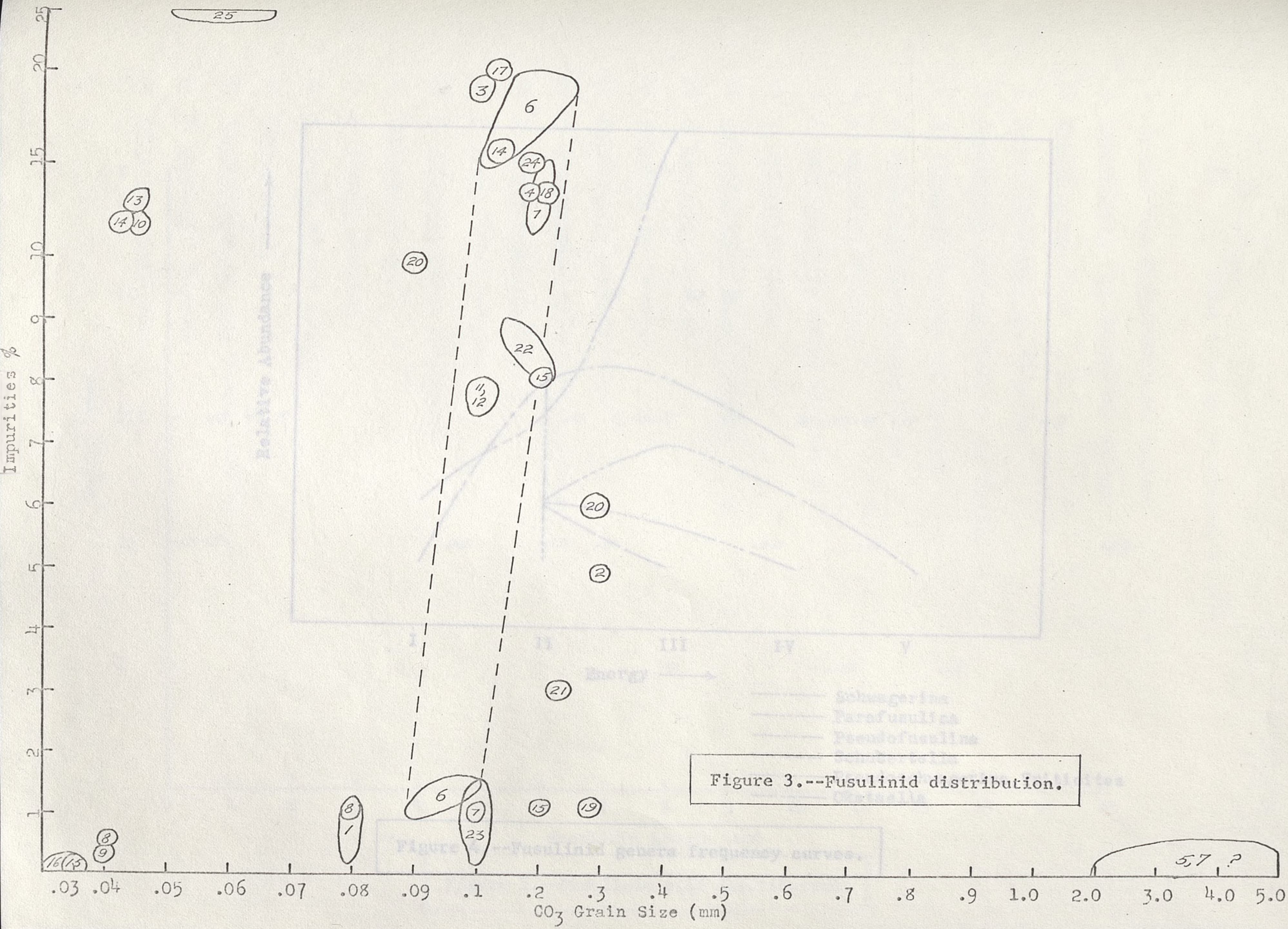


Figure 3.--Fusulinid distribution.

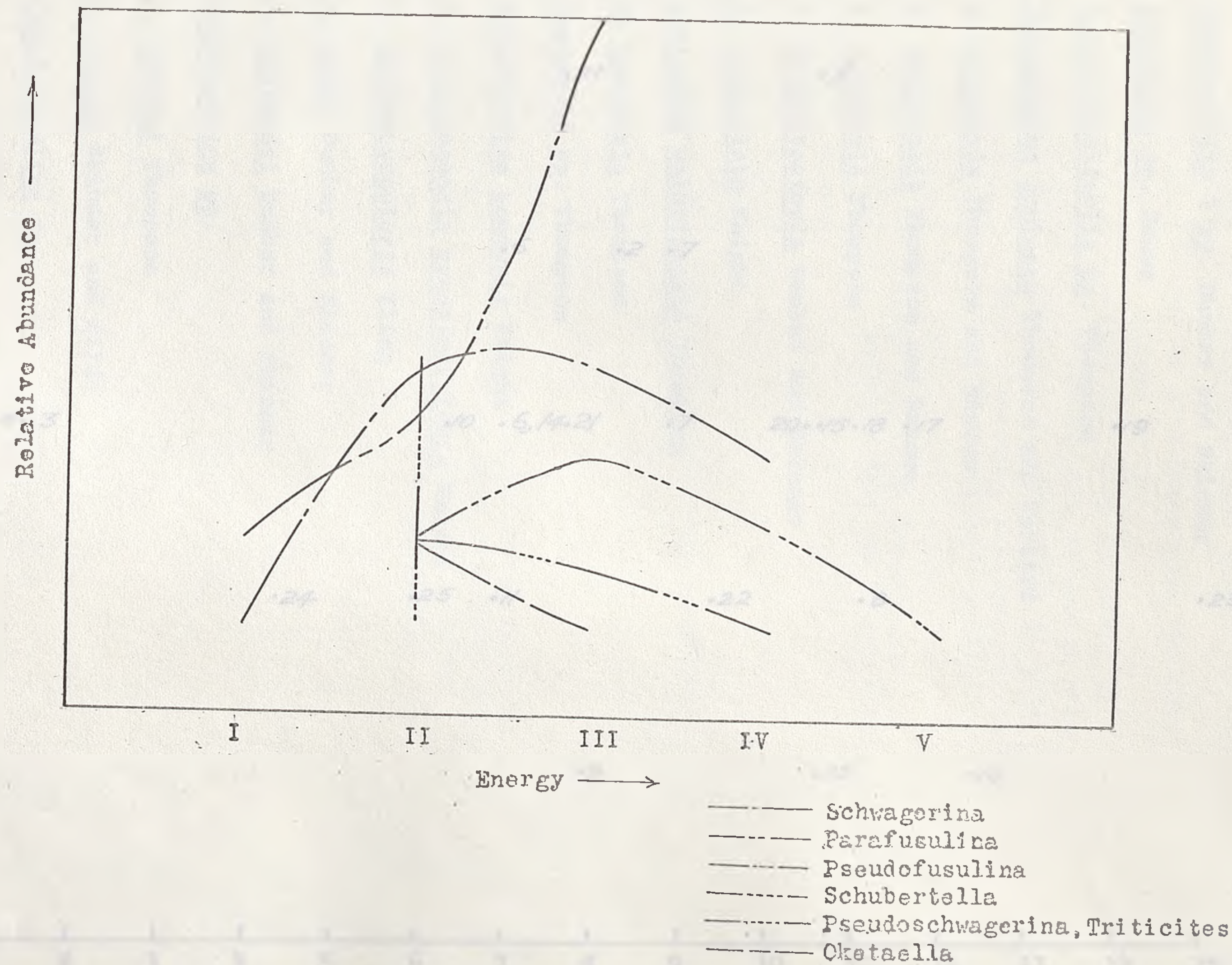


Figure 4.--Fusulinid genera frequency curves.

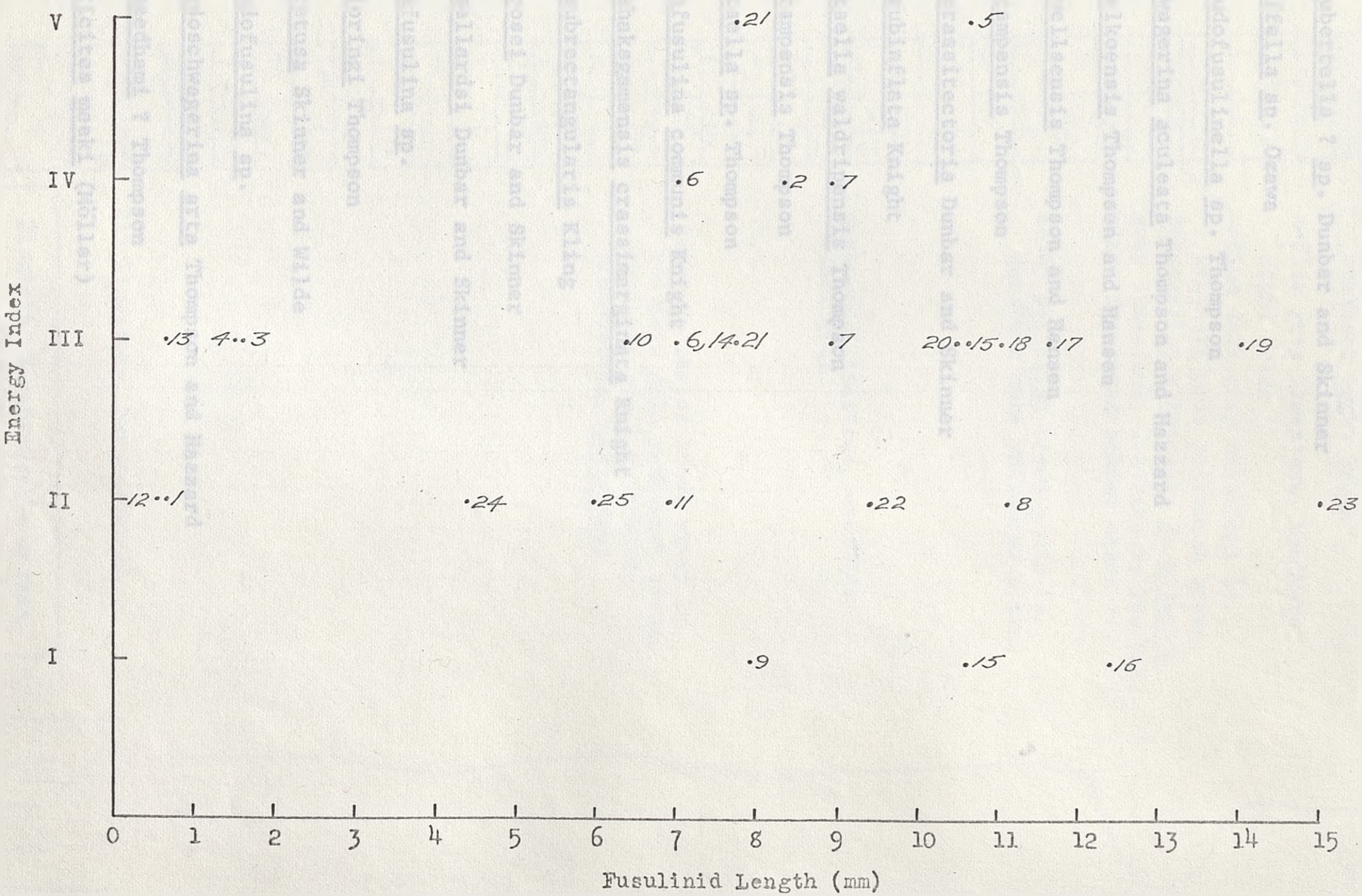


Figure 5.--Fusulinid size distribution.

TABLE 2.--A Key to Figures 3 and 5

1 Schubertella kingi Dunbar and Skinner

2 Schubertella ? sp. Dunbar and Skinner

3 Staffella sp. Ozawa

4 Pseudofusulinella sp. Thompson

5 Schwagerina aculeata Thompson and Hazzard

6 S. elkoensis Thompson and Hansen

7 S. wellsensis Thompson and Hansen

8 S. campensis Thompson

9 S. crassitectoria Dunbar and Skinner

10 S. subinflata Knight

11 Oketaella waldripensis Thompson

12 O. campensis Thompson

13 Oketaella sp. Thompson

14 Parafusulina communis Knight

15 P. shaksgamensis crassimarginata Knight

16 P. subrectangularis Kling

17 P. bosei Dunbar and Skinner

18 P. sellardsi Dunbar and Skinner

19 Parafusulina sp.

20 P. loringi Thompson

21 P. retusa Skinner and Wilde

22 Pseudofusulina sp.

23 Pseudoschwagerina arta Thompson and Hazzard

24 P. needhami ? Thompson

25 Triticites meeki (Möller)

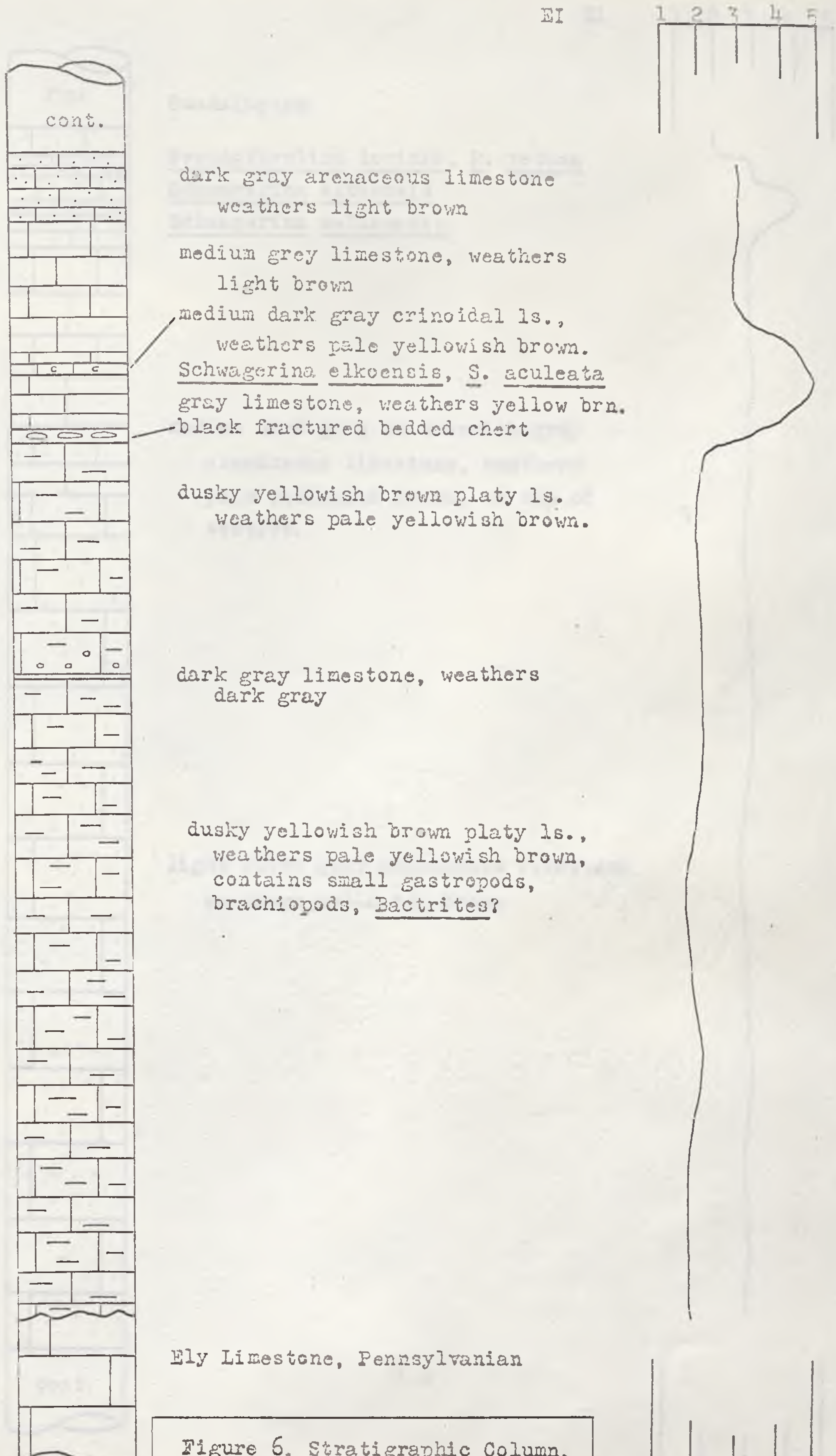
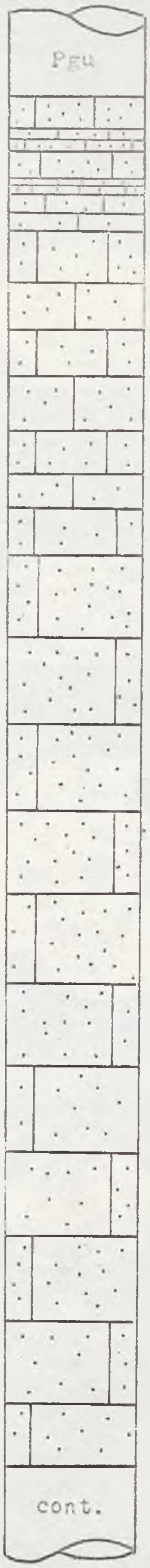


Figure 6, Stratigraphic Column,
Diamond Range
Scale
1"= 100'



Guadalupian

<u>Pesudofusulina loringi</u>, <u>P. retusa</u>
<u>Schwagerina elkoensis</u>
<u>Schwagerina wellsensis</u>

medium dark gray to brownish gray arenaceous limestone, weathers pale yellowish brown, to top of section.

light olive gray arenaceous limestone, weathers yellowish brown

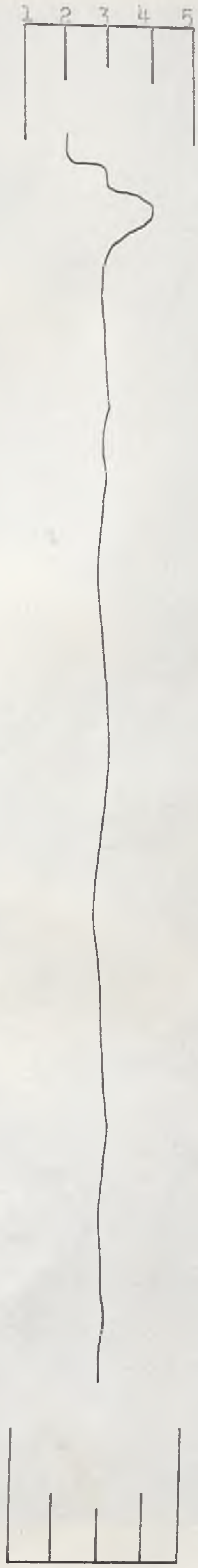


Figure 6, continued

PLATE 1

(About 125X)

1, 2 Schubertella kingi Dunbar and Skinner

3 Schubertella ? sp. Dunbar and Skinner

4 Staffella sp. Ozawa

5 Oketaella campensis Thompson

6 O. waldripensis Thompson

7 Pseudofusulinella sp.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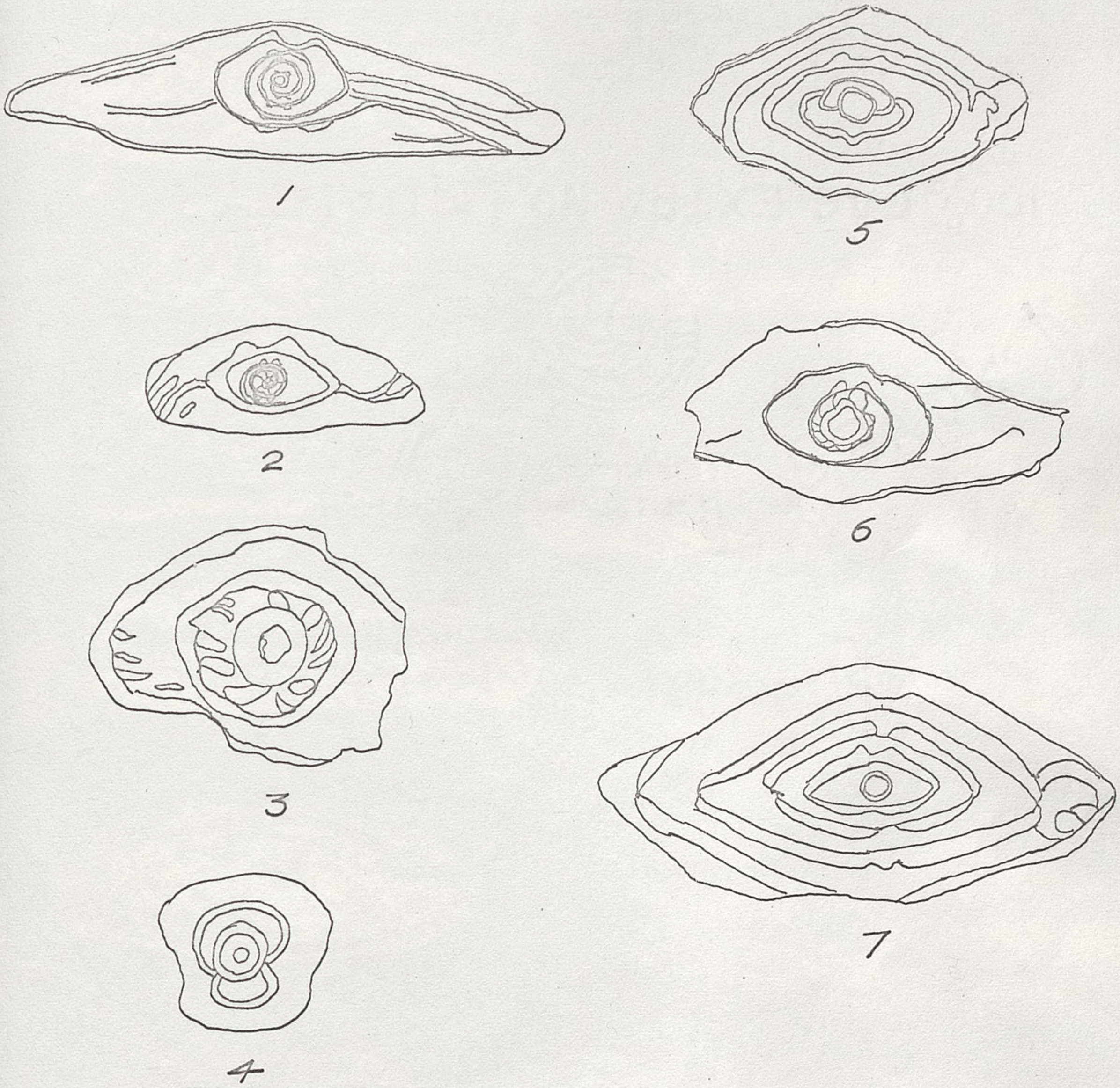

Figure 7.--Line drawings of smaller fusulinids.

Illipah

PLATE 2

(All 8.5X)

1	*Schwagerina aculeata* Thompson and Hazzard
2, 3	*S. elkoensis* Thompson and Hansen
4, 5	*S. wellsensis* Thompson and Hansen
6	*S. campensis* Thompson
7	*S. crassitectoria* Dunbar and Skinner
8	*S. subinflata* Knight
9, 11	*Parafusulina shaksgamensis crassimarginata* Knight
10	*P. communis* Knight
12	*P. subrectangularis* Kling
13	*P. bosei* Dunbar and Skinner
14	*P. sellardsi* Dunbar and Skinner
15	*Parafusulina sp.*

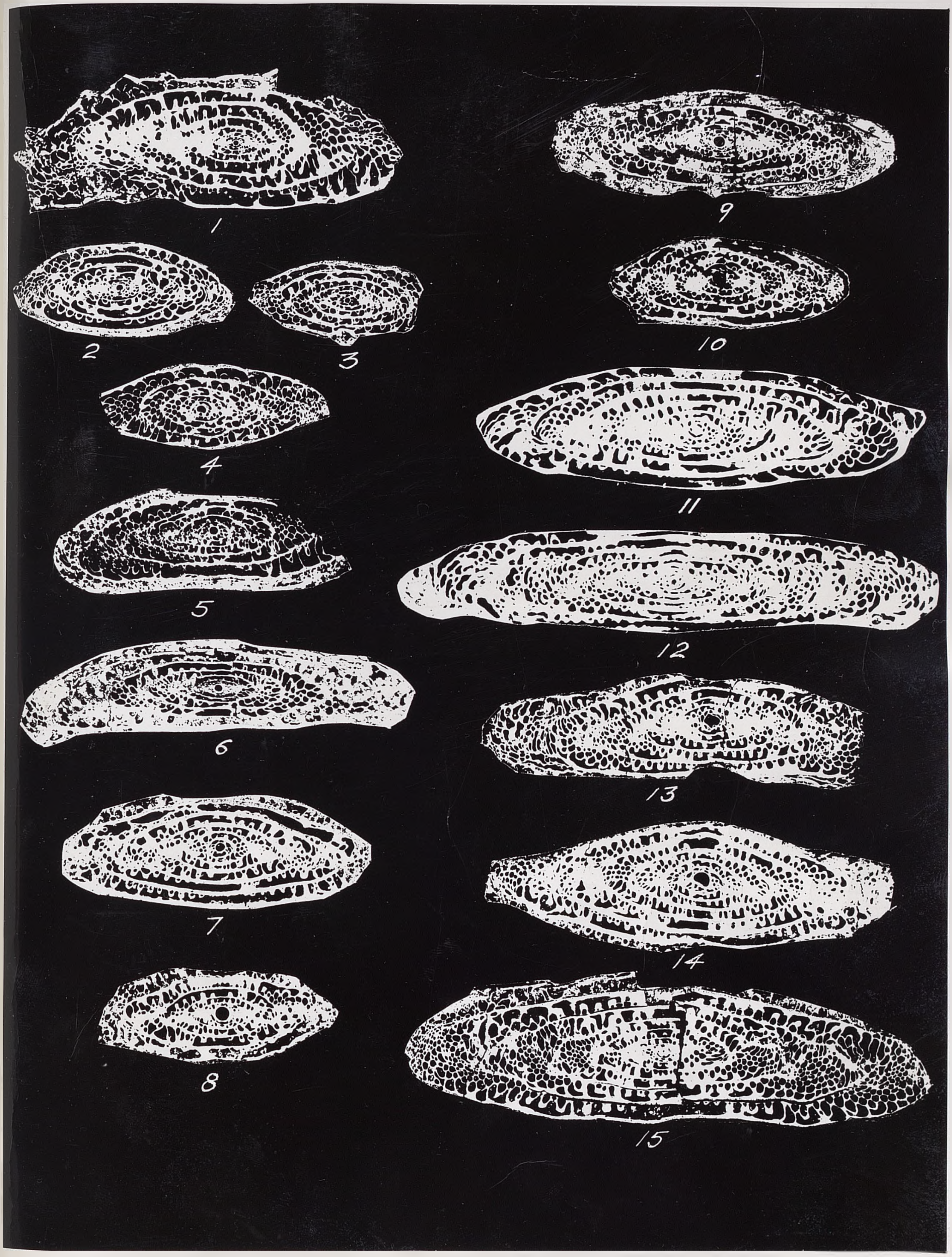
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PLATE 3

(All 8.5X)

1	*Pseudofusulina loringi* Thompson
2	*Triticites meeki* (Moller)
3	*Pseudofusulina retusa* Skinner and Wilde
4	*Pseudofusulina sp.*
5, 6, 8	*Pseudoschwagerina arta* Thompson and Hazzard
7	*Pseudoschwagerina needhami* ? Thompson

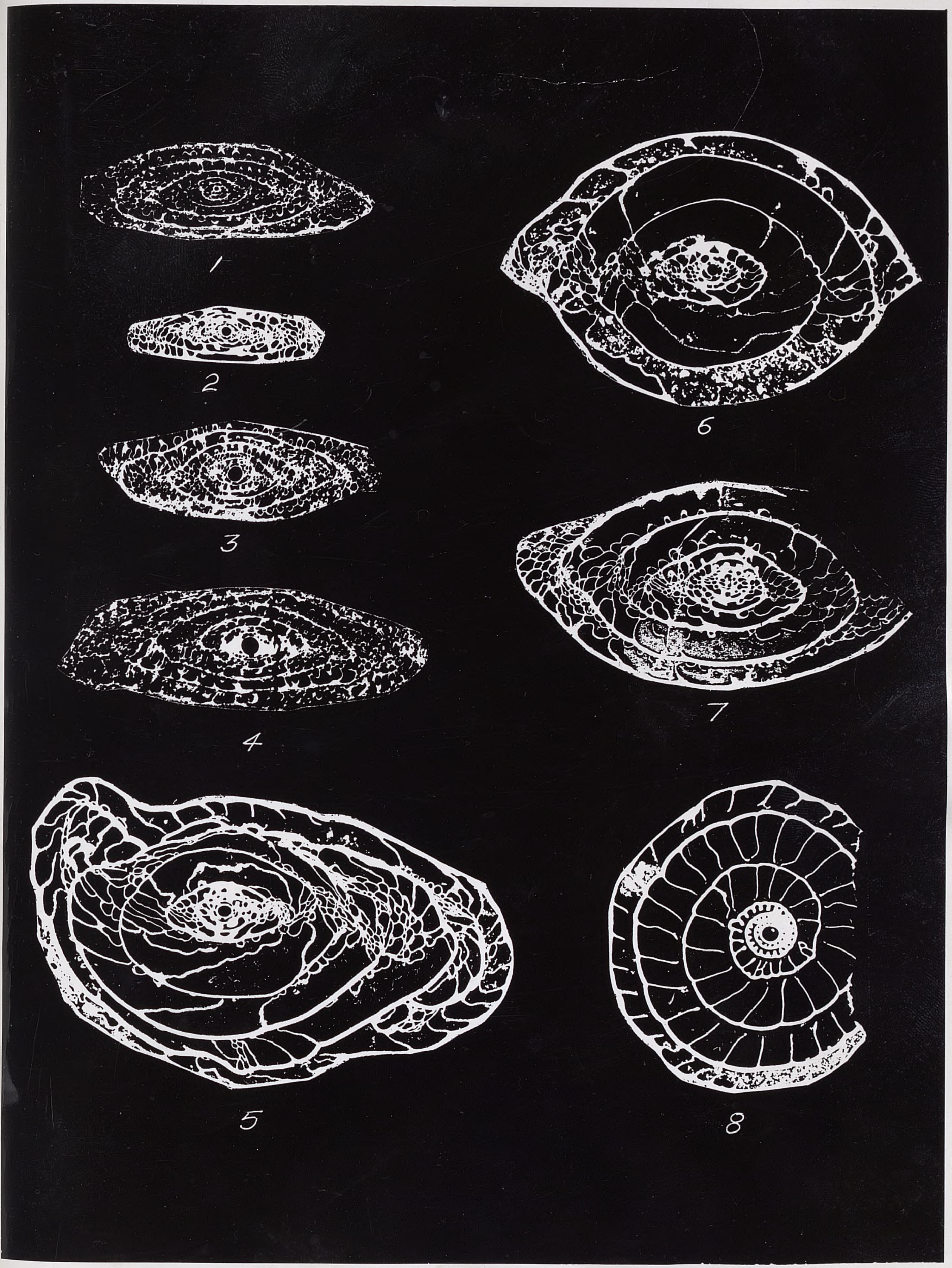
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TABLE 3.--Sediments of Studied Areas

Slide Number	Energy Index	Matrix	CO_3 Size (in mm)	Type	Percent-age	Impurities Size (in mm)	Diagenesis	Fossils
DR 1-5	V_2	-	2.0	-	-	-	Chert replace-ment	Pelmatazoan fragments, fusulinids
DR 6	IV_1	Scant	.4	Quartz	1%	.06	Chalcedony	Brachiopod fragments, algal fragments
DR 7	-	-	-	-	-	-	-	Chert spiculite
DR 8	III_3	Scant	.2	Quartz, chert	10	.04-.3	Chert, dolomite	Fusulinids, Bryozoa
DR 10-12	III_3	Scant	.2	Quartz	5-15	.04-.2	Chert	Bryozoa, fusulinids, algae
DR 13-14	IV_1	Scant	.3	Quartz, chert	5	.25	Chalcedony, dolomite	Echinodermata frag-ments, fusulinids, Bryozoa
DR 15-18	IV_1	-	.2	Quartz	5-20	.06-2.0	Silica, calcite	Bryozoa, fusulinids, paleotextulariids, pelmatazoan frag-ments
DR 19	III_3	30%	.16	Quartz	10	.04-.2	Quartz	Fusulinids, Gastropoda
DR 20-22	III_3	5	.2-.28	Quartz, chert	7	.04-.18	Trace dolomite	Echinodermata frag-ments, Bryozoa, fusulinids
DR 23	III_3	Scant	.2	Quartz, chert	10	.04-.3	Dolomite	Fusulinids, Echino-dermata, Bryozoa

TABLE 3--Continued

Slide Number	Energy Index	Matrix	CO_3 Size (in mm)	Type	Percent-age	Impurities Size (in mm)	Diagenesis	Fossils
DR 24	II_3	50% +	.18	Quartz	9%	.03-.2	Dolomite 25%, pyrite	Fusulinids, paleo-textulariids
DR 25-26	II_1	50 +	.1	Quartz	8	.06-.16	Quartz	Fusulinids
BM 1-5	III_1	Scant	.11-.2	Quartz	8-20	.14	Calcite	Fusulinids, paleo-textulariids, algae, Echinodermata plates, Porifera
BM 6-7	III_3	Scant	.2	Quartz	1	.9	Calcite, slight dolomite	Fusulinids, algae, Ostracoda
BM 8-11	I_1	50% +	-	Quartz	1	.04	Slight iron oxide, dolo-mite	Fusulinids, few Echinodermata fragments
CR 4-5	II_2	50 +	-	Quartz	15-20	.08	Chert	Fusulinids, pelmata-zoan fragments, all slightly abraded
CR 6-7	III_1	20	.08	Quartz	1	.07	Chert, chalcedony	Fusulinids, pelmata-zoan fragments, brachiopod spines, algae ? , Ostracoda
CR 8-10	II_1	50 +	-	Quartz	1	.05	Stains, iron	Fusulinids, Ostracoda
CR 11-16	II_1	50 +	-	Quartz	1-25	.08	Chert	Fusulinids

TABLE 4.--Table of Measurements (in mm)

Taxon	Number	Proloc-ulus	Radius Vector 1	2	3	4	5	6	7	Half Length 1	2	3	4	5	6	7
Schubertella kingi	CR 13b	.046	.071	.110	.160					.12	.24	.56				
	CR 15b	.037	.050	.084	.140					.061	.150	.330				
Schubertella ? sp.	DR 16b	.160	.18	.27						.22	.42					
Staffella sp.	BM 1c	.060	.59	.70						.40	.80					
Pseudofusulinella sp.	BM 5c	.120	.14	.22	.31					.34	.56	.76				
Schwagerina aculeata	DR 5b	.142	.29	.46	.68	1.07	1.30	1.77		.42	1.20	1.90	2.91	4.09	5.30	
S. elkoensis	DR 16	.184	.30	.39	.50	.75	.92			.68	1.00	1.47	1.81	2.50		
	DR 17	.212	.38	.57	.86	1.05	1.24?			.71	1.00	1.61	2.23	2.91		
	DR 20	.303	.32	.53	.75					.75	1.27	1.62?				
	CR 11b	.370		.38	.73	.99				.60	1.07	1.75	2.52			
	CR 12	.261	.36	.51	.80	1.24				.79	1.26	2.30	3.50			
S. wellsensis	DR 11	.234	.33	.50	.80	1.10				.52	.85	1.60	2.90			
	DR 18	.278	.41	.60	.87	1.21	1.49			.50	1.36	2.38	3.59	4.18		
	CR 10	.298	.38	.56	.86	1.52					.81	1.84	3.10	4.10		
	DR 1	.39?	.44	.77	1.1	1.4	1.8			.70	1.5	2.8	4.2	?		
	DR 2		.40	.60	.84	1.3				1.1	1.6	2.3	3.3			
	DR 3			.78	1.2	1.7					1.3	2.5	3.4			
	DR 5		.45	.74	.95	1.3	1.8			.77	1.2	2.0	3.0	3.5		
S. campensis	CR 9	.128	.26	.39	.50	.74	.95	1.25		.51	1.27	1.89	2.91	4.5	5.61	
	CR 6		.24	.30	.62	.83				.50	.96	1.68	3.22			
S. guembeli	BM 8	.297	.28	.49	.68	.89	1.26	1.57		.41	.76	1.49	2.02	3.36	3.97	
S. subinflata	BM 2b	.402	.48	.71	.97	1.20				.98	1.69	2.19	3.12			
Oketaella campensis	DR 26b	.090	.078	.135	.204					.120	.230	.341				

Form Ratio							Wall Thickness							Tunnel Angle (in degrees)						
1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
							.011	.014	.014					16°	38°					
							.009	.009	.012					12	22					
1.22	1.55						.019	.039						36	36					
.68	1.14						.007	.016												
							.020	.039	.032					20	20					
1.45	2.60	2.80	2.72	3.14	2.99		.026	.034	.042	.068	.082	.084		28	28	32°				
2.27	2.56	2.94	2.42	2.72				.040	.056	.068	.074	.072			20	26	38°	36°		
1.87	1.71	1.81	2.21	2.35			.026	.076	.076	.084					22	38	42			
2.34	2.40	2.18?																		
1.58	1.48	1.77	1.98				.028	.067	.078	.072										
2.19	2.47	2.88	2.82				.032	.050	.060	.084										
1.57	1.70	2.00	2.63				.032	.040	.058	.084				20	22	26	30			
1.22	2.27	2.74	2.96	2.78			.038	.046	.084	.046	.100			20	24	28				
	2.14	3.08	3.60	2.70			.028	.042	.072	.080										
1.7	2.2	2.5	3.0				.04	.08	.11	.12	.12	.12		18	24	29				
2.3	2.7	2.6	2.7				.04	.05	.90	.80					28	31	36			
1.7	2.1	2.0					.04	.07	.07	.80				10	12	22				
1.7	1.6	2.1	2.4				.05	.05	.05	.08	.11									
1.91	3.26	3.78	3.94	4.74	4.49		.024	.022	.056	.078	.080	.092		22	30	34	41			
2.08	3.20	2.70	3.88				.030	.052	.058	.100	.096	.106								
1.46	1.55	2.19	2.27	2.66	2.53		.052	.062	.086	.114	.126	.084?		22	22	44	42			
2.04	2.38	2.26	2.60				.024	.040	.062	.090				20	22	26				
1.54	1.70	1.67					.018	.019	.020					8	24	30				

TABLE 4--Continued (in mm)

Taxon	Number	Proloculus	Radius Vector 1	2	3	4	5	6	7	Half Length 1	2	3	4	5	6	7
taella ? sp.	BM 2b	.150	.12	.17						.22	.35					
afusulina communis	BM 1	.340-.420	.39	.63	.78	1.07				.64	1.14	1.92	2.87	3.50		
shaksgamensis rassimarginata	BM 5b	.351	.33	.45	.66	.87	1.25			.56	1.06	1.84	3.07	4.15		
	BM 6	.296		.48	.69	.97	1.40				1.26	1.96	2.25	4.23	4.74	
	BM 10	.280+	.24	.49	.60	.94	1.23	1.52		.98	1.61	1.93	2.23	4.33	5.84	
subrectangularis	BM 11a															
	BM 11b	.322	.31	.46	.65	.88	1.13	1.33		.64	1.09	1.79	2.46	4.10	6.20	
bosei	BM 4	.380	.49	.72	.83	1.16	1.50			.76	1.75	3.50	4.24	5.88		
sellardsi	BM 2a		.43	.62	.88	1.12	1.42			.76	1.28	1.90	2.62	3.31		
	BM 3	.464	.49	.59	.77	1.09	1.48	1.74		.55	.93	1.77	2.72	3.76	5.49	
afusulina sp.	BM 7	.240+	.28	.46	.71	.96	1.30	1.68		.59	1.04	1.84	2.98	4.75	6.60	7.09
udofusulina pringi	DR 9	.210?	.49	.61	.90	1.21	1.52			.76	1.46	2.60	3.78	5.25		
	DR 23	.196	.51	.72	1.02	1.23				.74	1.83	2.59	3.76			
retusa	DR 5a	.39	.40	.65	.94	1.44				.91	1.55	2.04	2.54?			
	DR 10	.42	.40	.51	.77	1.1	1.3			.50	1.75	1.70	2.80	3.88		
udofusulina sp.	DR 25	.350	.58	.82	1.07	1.40				.72	1.10	1.81	2.86	3.98		
	DR 26	.460	.50	.77	1.19	1.50	1.73?			.72	1.26	2.50	3.71	4.68		
udoschwagerina rta	CR 11a	.340	.26	.51	.76	2.25	3.35	3.84	4.34	.49	.97	1.50	3.18	4.24	5.89	7.50
	CR 13	.360	.38	.49	.93	2.50	3.50			.42	1.00	1.51	3.08	5.25		
	CR 17	.480														
aeedhami ?	CR 15a	.175	.26	.37	.48	.76				.51	.82	1.26	2.21			
ticites meeki	CR 5	.281	.31	.49	.59	.78				.35	1.52	2.08	2.76			
	CR 14	.230	.31	.50	.74	1.00				.64	.99	1.35	1.83	2.92		

Form Ratio							Wall Thickness							Tunnel Angle (in degrees)						
1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
							.017	.018						16°	20°					
1.64	1.81	2.46	2.68				.020	.048	.074	.092	.120									
1.69	2.38	2.88	3.52	3.32										19	39	50°	92°?			
	2.62	2.84	2.32	3.02			.018	.024	.060	.064	.096			22	44	78?				
	2.00	2.68	2.06	2.62	2.85			.040	.072	.096	.140	.100		28	28	55	76?			
2.06	2.37	2.76	2.80	3.62	4.65		.068	.094	.086	.082	.104									
1.55	2.43	4.22	3.66	3.92			.044	.058	.068	.080	.122			14	20	38	42			
1.77	2.06	2.16	2.34	2.33										23	28	34	48			
1.12	1.58	2.30	2.49	2.54	3.16		.032	.060	.085	.080	.140	.140		24	30	31	36			
2.11	2.26	2.59	3.05	3.65	3.93		.028	.036	.058	.074	.102	.140		24	30	42	44			
1.55	2.44	2.89	3.12	3.45			.040	.054	.088	.100	.102			22	26	45				
1.45	2.54	2.54	3.06				.040	.070	.088	.082				22	28					
	2.27	2.38	2.17	1.77?			.040	.068	.085	.11				14	18	26				
1.25	2.26	2.21	2.54	2.98			.040	.056	.064	.062	.102			14	18	22	32			
1.24	1.34	1.69	2.05				.032	.040	.062	.088	.128			20	24	48				
1.44	1.62	2.10	2.47	2.71?			.022	.040	.066	.106	.110			21	25	46				
1.88	1.90	1.97	1.41	1.30	1.53	1.73	.051	.075	.076	.055	.100	.120	.080							
1.10	2.02	1.95	1.23	1.50			.040	.079	.060	.071	.129									
							.061	.061	.079	.082	.119	.104								
1.96	2.22	2.62	2.91				.029	.028	.037	.078				20	21	24	25	27°		
1.13	3.10	3.52	3.54				.024	.038	.038	.060	.068			20	22	32	34			
2.06	1.98	1.83	1.83				.030	.037	.050	.077	.071			16	22	28				

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APPENDIX A

GLOSSARY

allogenic--Generated elsewhere; applied to those constituents that came into existence outside of the rock of which they are now a part.

alveolus (pl. alveoli)--Minute blind cavity in keriothecal layer of the shell wall.

antetheca--Final septal face.

aperture--Opening or openings from the chamber of the test to the exterior.

authigenic--Generated on the spot; the constituents that came into existence with or after the formation of the rock of which they are a part.

axial fillings--Deposits of dense calcite developed in the axial regions of some fusulinaceans.

axial section--Slice bisecting test in plane coinciding with axis of coiling and intersecting proloculus.

axial septulum (pl. septula)--Secondary or tertiary septum located between primary septa, its plane approximately parallel to axis of coiling.

axis--Imaginary line around which spiral or cyclical shell is coiled, transverse to plane of coiling.

benthos--The bottom-dwelling organisms.

biocoensis--A biological community in an environment conducive to animal growth and development of organisms.

carbonate rocks--Rocks composed of more than 50 per cent, by weight, carbonate minerals; for practical microscopic work area percentages are used.

cement--Clear crystalline material occurring in the interstices between grains and matrix material.

chamber--Test cavity and its surrounding wall; the fundamental unit of the foraminiferal test.

chamberlet--Subdivision of chamber produced by axial or transverse septula.

chomata (sing. choma)--Revolving ridgelike deposit of dense shell substance delimiting tunnel.

clastic carbonate particles--Grains that have been transported mechanically by current of wave action.

clastic textured--Having a texture that shows evidence, such as size sorting or cross stratification of particles, of mechanical deposition.

cuniculus (pl. cuniculi)--Tunnel-like continuous cavity formed by strong septal fluting, serving to connect adjoining chambers from one foramen to next.

depositional interference--The interface between the water and the bottom where sediments are deposited in relation to the energy level at the interface.

diamorphism--Occurrence in single species of two distinct forms; megalospheric and microspheric tests.

diaphanotheca--Relatively thick, light-colored to transparent layer of spirothecal wall next below tectum in fusulinids.

dolomitic--Refers to those rocks that contain 10-50 per cent of the mineral dolomite.

ecology--The relations of an organism to its environment.

energy level--The kinetic energy that exists in the water at the depositional interface and a few feet above, due to either wave or current action.

environment--The total of external conditions surrounding an organism.

epitheca--Dark secondary deposit in inner wall of some fusulinids; tectorium.

eupelagic sediments--Sediments derived entirely from the open sea, containing no terrigenous material.

euryhaline--Animal with a wide salinity tolerance or able to withstand rapid salinity changes.

foramen (pl. foramina)--Opening between chambers located at base of septa.

fusiform--Spindle-shaped, tapering at each end.

juvenarium--Proloculus and first few chambers of foraminiferids; embryonic apparatus.

keriotheca--Relatively thick shell layer with honeycomblike structure in wall of some fusulinids, occurring next below tectum and forming part of spirotheca.

loculus--Chamber.

matrix--Microcrystalline or granular material in which any sedimentary particle is embedded.

mechanical--Pertaining to particles of sediment brought to their place of final deposition by agents such as water currents, wind current, or gravity.

megalospheric test--Small exoskeleton with large proloculus, secreted by the asexual foraminiferids.

micrite--Consolidated or unconsolidated ooze or mud of either chemical or mechanical origin.

microcrystalline carbonate--Carbonate particles less than 0.06 mm diameter that cannot be recognized as clastic. Produced by precipitation or postdepositional recrystallization of carbonate mud.

micrograined carbonate--Distinct carbonate particles of silt-size range which can be interpreted as clastic grains.

microspheric test--Large exoskeleton with small proloculus, secreted by the sexual foraminiferids.

nekton--The swimming organisms.

neritic--The zone of the sea over the continental shelf, from 0 feet to approximately 400 feet in depth.

nonclastic textured--Texture showing no evidence that the sediment was deposited mechanically.

nonskeletal grains--Carbonate grains, ranging from silt size through sand size, and composed of homogeneous microcrystalline carbonate the genesis of which is unknown.

parachomata--Ridges of dense calcite developed between adjacent foramina in tests having multiple foramina, in some fusulinaceans.

parallel section--Slice through test in plane normal to axis of coiling, but not through proloculus.

pellet--A grain composed of micritic material, lacking significant internal structure and generally oöid in shape.

phrenotheca--Thin, dense, diaphramlike partitions that extend across chambers of tests at various angles and in various parts of the chamber.

polymorphism--Morphologically different forms of same species which may be result of different generations.

primary septulum--Major partition of chamberlet; includes primary axial and primary transverse septula.

proloculus (pl. proloculi)--Initial chamber of foraminiferal test.

proloculus pore--Single circular opening in proloculus leading to next-formed chamber of test.

protheca--Primary elements of fusulinid wall, comprising diaphanotheca and tectum.

pycnotheca--Dense layer of wall penetrated by septal pores, wedged between tectum and keriotheca of septal face (antetheca) of some fusulinids.

sagittal section--Slice through test perpendicular to axis of coiling and passing through proloculus (equivalent to equatorial section).

secondary septulum (pl. septula)--Minor partition of chamberlet reaching downward (adaxially) from spirotheca.

septal fluting--Folding or corrugation of septum (and antetheca) transverse to axis of coiling, generally strongest in lower (adaxial) part of septum and toward poles.

septal furrow--Shallow meridianal grooves dividing outer surface of fusuline test into melonlike lobes.

septal pore--A connecting pore through the septum.

septulum (pl. septula)--Ridge extending downward adaxially, from lower surface of spirotheca so as to divide chambers partially.

septum--A partition or wall dividing the test interiorly into chambers.

skeletal--Pertaining to debris derived from organisms that secrete hard material around or within organic tissue; bioclastic.

sparry--Refers to clear, transparent, or translucent, readily cleavable, crystalline particles generally having an interlocking mosaic texture.

spirotheca--Outer or upper wall of test.

stenohaline--Animal with narrow salinity tolerance or sensitive to changes in salinity content.

tangential section--Slice through part of test parallel to axis of coiling or growth, but not through proloculus.

tectorium (pl. tectoria)--Internal lining of chamber, composed of dense calcite formed at or near the same time as that in which tunnel in test is excavated.

tectum--Thin, dense outer layer of spirotheca.

test--The excreted exoskeleton.

thanatocoensis--An assemblage brought together after death.

tunnel--Resorbed area at base of septa in central part of test in many fusulinids, facilitating communication between adjacent chambers.

tunnel angle--Angle formed by the edges of chomata in axial sections.

wave base--That water depth below which the movement of the water caused by surface waves does not move the sediments; a variable factor.

APPENDIX B

PHOTOGRAPHIC TECHNIQUE

A camera was used only in copying the composite plates. The individual fusulinid prints were made by inserting a standard rock thin section, 3 microns in thickness, into a photographic enlarger by means of a 35-mm negative holder. Care must be taken not to crack or break the slide due to uneven pressures during entry. Once the thin section was in place a test strip of Kodabromide F3 paper was exposed over various time intervals by shadowing with an opaque object. The best exposure time was seen on this test strip after developing with Dektol developer and fixing with hypo. This exposure time was used in all subsequent prints.

This rapid method eliminated the use of a camera and the development of film. The individual fusulinid prints were cut out with scissors and a scalpel and glued to a completely exposed and developed sheet of photographic paper. This composite plate was then photographed on 3 x 5-inch film and copies were printed in the normal manner.