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Eocene Euthecosomatous Pteropoda (Gastropoda) of the Gulf and Eastern Coasts of North America

by

Kenneth A. Hodgkinson, Christopher L. Garvie, and Allan W. H. Bé

Paleontological Research Institution
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CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

EOCENE EUTHECOSOMATOUS PTEROPODA (GASTROPODA) OF THE GULF AND EASTERN COASTS OF NORTH AMERICA

by

KENNETH A. HODGKINSON[1]

CHRISTOPHER L. GARVIE[2]

AND

ALLAN W. H. BÉ[3]

ABSTRACT

Euthecosomatous pteropods of Early Tertiary seas were equally or more diverse than they are in present-day oceans, and probably as abundant. Twenty-eight new species (*Altaspiratella gracilens, Limacina adornata, Limacina aegis, Limacina canadaensis, Limacina convolutus, Limacina davidi, Limacina heatherae, Limacina helikos, Limacina labiata, Limacina planidorsalis, Limacina smithvillensis, Limacina stenzeli, Limacina texana, Limacina voluta, Limacina wechesensis, Skaptotion? reklawensis, Skaptotion spirale, Camptoceratops americanus, Cheilospicata repanda, Creseis cylindrica, Bucanoides basiannulata, Bucanoides divaricata, Bucanoides tenuis, Cuvierina gutta, Cuvierina lura, Loxobidens aduncus, Tibiella annulata,* and *Tibiella reflexa*) and three new genera (*Bucanoides, Cheilospicata,* and *Loxobidens*) are described from the Eocene of Texas, Louisiana, Alabama, Mississippi, and the Nova Scotian shelf. In addition, seven species that previously were not reported from North America were found in these localities. These 35 species plus 13 previously described North American Eocene pteropod species constitute a total of 48 species now known to occur in North America. All of these species are formally described here except for single specimens of *Hyalocylis* sp. A, *Creseis* sp. A, and *Praehyalocylis cretacea* (Blanckenhorn, 1889). The latter species has been described from the late Eocene of Oregon and Washington (Squires, 1989). It is basically a worldwide species with additional reported occurrences in Russia, Turkey, and Australia. The genera *Camptoceratops* and *Euchilotheca* are reported from North America for the first time.

INTRODUCTION

Pteropods are one of the most abundant and ubiquitous members of the plankton community in modern seas, and their skeletal remains are preserved in large quantities in some areas of the deep-sea floor. The shells of these small mollusks are often abundant enough to form pteropod oozes. These oozes occur in the Mediterranean Sea, Red Sea, Persian Gulf, Caribbean Sea, Gulf of Mexico, Blake Plateau, Bermuda Platform, and in parts of the Atlantic, Pacific, and Indian oceans. Fairbridge (1966) estimated that these oozes, together with those of foraminifers and coccolithophores, cover 128 million km^2, or about 35% of the ocean bottom. Sverdrup, Johnson, and Fleming (1942) estimated that pteropod oozes cover about 2 million km^2, or about 1% of the sea floor.

Pteropods are opisthobranch gastropods that have adapted to a planktonic existence. According to Bé and Gilmer (1977, p. 744), there are 28 modern euthecosomatous pteropod species, of which seven belong in the family Limacinidae (= Spiratellidae) and 21 in the family Cavoliniidae. Unlike the gymnosomatous and pseudothecosomatous pteropods, which have a shell in the larval stage but not in the adult, euthecosomatous pteropods possess aragonitic shells throughout their life cycle. The shells of the Limacinidae are sinistrally coiled [technically the coiling is hyperstrophic (Keen, 1971, p. 805)], but we follow most other authors in describing the coiling as sinistral. For a discussion of hyperstrophic coiling see p. 13. Most species belonging to the Cavoliniidae have bilaterally symmetrical, straight or slightly curved shells. Several North American creseid genera, like *Bovicornu* and *Camptoceratops,* have shells with a very loose spiral.

Euthecosomatous pteropods are abundant and widespread in the world's oceans, and range from polar to tropical regions. Twenty-one species inhabit the circum-global belt of tropical and subtropical waters, where the surface-water temperature is 18°C or higher. Only four species live in sub-Antarctic and/or Antarctic waters, of which three also occur in Arctic and/or sub-Arctic regions. Thus species diversity among pteropods follows a trend seen in many other marine invertebrates; namely, that species diversity is greater in lower latitudes and decreases toward the higher latitudes. For detailed discussions of the biogeography, taxonomy, and comparative anatomy of modern pteropods, see Boas (1886), Pelseneer (1888a, 1888b), Meisenheimer (1905, 1906a, 1906b), Schiemenz (1906), Bonnevie (1913), Tesch (1904, 1913, 1946, 1948), Vayssière (1915), Massy (1932), Morton (1954), and Pruvot-Fol (1954). More recent publications are those

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by McGowan (1960, 1968, 1971), Chen and Bé (1964a, 1964b), Spoel (1967, 1972), Rampal (1968, 1973, 1974, 1975), Herman (1978), Lalli and Wells (1978), Spoel and Pierrot-Bults (1979), Bé and Gilmer (1977), Rottman (1980), Stepien (1980), and Wormuth (1981). Abbott (1974) and Keen (1971) have also described and illustrated most of the Recent pteropod species in the oceans contiguous to the North American continent.

Most euthecosomatous pteropod species live in the upper 500 m of the ocean, but three species [*Limacina helicoides* Jeffreys, 1877, *Clio balantium* (Rang, 1834), and *Clio chaptalii* (Gray, 1850)] are known to inhabit deeper waters. Several species exhibit diurnal migration, descending below the photic zone during daylight and ascending at night to surface waters where they may feed on phytoplankton, microzooplankton and small organic particles (Boas, 1886; Pelseneer, 1888a, 1888b; Morton, 1954; and Gilmer, 1974).

Pteropods are not commonly preserved: their shells are thin, fragile and composed of aragonite, which is less stable and more susceptible to dissolution than the calcitic shells of planktonic foraminifers and coccolithophorids. The aragonitic shells are rarely found in the relatively organic-rich sediments that border the continents or in oceanic regions below the aragonite compensation depth (ACD). In the ocean, the ACD is that level below which the rate of aragonite solution exceeds the rate of deposition. Thus pteropod shells will not be found below this level. The ACD, according to Berger (1978), varies in depth from ocean to ocean as well as within the same ocean. Its average depth in the Atlantic Ocean is near 1.5 km in low latitudes and between 2 and 3.4 km in middle latitudes. It is between 0.5 and 1.5 km in the Pacific and Indian Oceans. The ACD decreases towards high latitudes and continental slopes.

Fossilization of pteropods clearly requires special paleoenvironmental conditions. Herman (1978, p. 151) noted that pteropods are better preserved in basins having high bottom temperatures, sluggish circulation and rapid rates of sedimentation, such as the Mediterranean and Red seas. She also observed (p. 153) that pteropod distribution is controlled by salinity, food and oxygen availability, and by water depth. Well-preserved pteropods of Pleistocene age have been found in many oceanic regions (see Stubbings, 1938; Herman, 1971, 1973; Jung, 1973; Sarnthein, 1971; Bé *et al.*, 1976; Diester-Haass and Spoel, 1978; Almogi-Labin and Reiss, 1977; and Almogi-Labin, 1982). Preserved pteropod shells are abundant in Recent and Pleistocene sediments, and, in general, pteropod remains become less abundant as geologic age increases.

The shells of certain mature pteropods closely resemble the juvenile stages of other gastropods. For example, the coiled shells of *Limacina* may closely resemble the initial whorls of gastropods with a sinistrally coiled protoconch. Most gastropods have dextrally coiled shells, but many of these have embryonic whorls that are coiled sinistrally (*e.g.*, pyramidellids and many of the opisthobranchs). These protoconchs are often small, smooth, and thin-walled, and superficially resemble spiratellid pteropods. Pteropod shells can also resemble the thin, unornamented, sinistral shells of freshwater gastropods.

Other groups of animals have small, elongated conical shells that superficially resemble some cavoliniid pteropods. Such shells can nevertheless be differentiated. For example, scaphopod shells and worm tubes are open at both ends, whereas pteropod shells are closed at the apex. Caecid gastropods are also closed at the apex but usually have an expanded lip or varix at an intermediate stage of growth and a relatively thick shell, which may be ornate with a distinctively pointed extension of the septum.

Curry (1965, p. 358) noted the following useful characteristics for distinguishing mature pteropod shells from the juvenile shells of other gastropods: (1) pteropods have thinner walls, whose thickness is usually in the range of from 5 to 40 μm; (2) they have a closed apex; (3) they are normally not ornamented except for growth lines or corrugations of the shell wall (we note that the Peraclidae, not recorded as fossils, and *Limacina adornata*, n. sp., have surface ornamentation and are exceptions to this rule); (4) the apertural lip of the shell may be thickened or expanded locally, but such expansion or thickening occurs only when the shell is fully grown; and (5) pteropod shells, if coiled, exhibit a sinistral coiling direction.

Some pteropods (*e.g.*, *Cuvierina* Boas, 1886, *Hyalocylis* Fol, 1875, and *Diacria* Gray, 1847) truncate and discard the juvenile portions of their shells in the same manner as scaphopods (Hodgkinson, 1974, p. 8) and many other mollusks. Before truncation, the pteropod secretes a caudal septum.

PREVIOUS INVESTIGATIONS 0F EOCENE PTEROPODS

North American Eocene pteropods have been described by Meyer (1884, p. 110; 1886, pp. 78, 79; 1887, p. 9), I. Lea (1833, p. 124), Aldrich (1887, p. 83; 1895, p. 5), de Gregorio (1890, pp. 16, 17), Gardner (1927, p. 377; 1951, pp. 10–12), Collins (1934, pp. 137–234), Curry (1965, pp. 357–371), and Squires (1989, pp. 440–442).

Collins (1934) discussed 12 "Eocene" species from six locations in Alabama, Mississippi, and Texas in his monograph of American Tertiary pteropods (see Table 1). Of these, nine are now considered valid, one is not correctly identified, and two are invalid. The two invalid species (*Creseis elba* de Gregorio, 1890 and *C.*

Table 1.—The taxonomic status of the 12 species of American Eocene pteropods discussed by Collins (1934).

Creseis corpulenta (Meyer)	valid
Creseis elba de Gregorio	discarded
Creseis hastata (Meyer)	valid
Creseis nimba de Gregorio	discarded
Creseis simplex (Meyer)	valid
Creseis sp. cf. *C. hastata* (Meyer)	= *C. simplex*
Bovicornu eocenense Meyer	valid
Bovicornu gracile Meyer	valid
Tibiella marshi Meyer	valid
"*Tibiella*" *texana* Collins	valid
Spiratella choctavensis (Aldrich)	valid
Spiratella elongatoidea (Aldrich)	valid

nimba de Gregorio, 1890) were referred to by Collins as "questionable species of *Creseis*." He suggested that these two specific names be discarded from American Tertiary pteropods because the tips of the specimens were not preserved and they had no other well-defined features to prove that they were pteropods. Palmer and Brann (1965) state that the types of these species are lost. They were curated in the de Gregorio Collection, University of Palermo, Palermo, Sicily. We agree that these species should be discarded from the list of valid pteropod species.

To our knowledge, *Spiratella augustana* Gardner, 1951 and *Praehyalocylis cretacea* (Blanckenhorn, 1899), reported by Squires (1989), are the only North American Eocene pteropods found since Collins prepared his monograph on American Tertiary pteropods in 1934.

Two molluscan species in Palmer and Brann's 1965 catalogue are now considered to be pteropods. These are: *Planaria nitens* I. Lea, 1833 [= *Skaptotion nitens*] and *Planorbis andersoni* Gardner, 1927 [= *Skaptotion andersoni*]. Thus, prior to the present study, there were a total of 13 valid Eocene pteropod species recognized in North America. Now there are 48 species.

PRESENT STUDY

Most of the pteropods described in this paper were obtained either by examining sediment from the interior of larger mollusks or by searching through large volumes of washed residue. Fossil shells of *Conus* (*Lithoconus*) *sauridens* Conrad, 1833, a large (5 to 8 cm long) gastropod from the Stone City and Cook Mountain formations of Texas, frequently harbored pteropod shells. Pteropods trapped in larger mollusk shells usually are protected from post-depositional compaction, solution, and destruction by other organisms. A good practice to follow when searching for fossil pteropods is to collect large fossil marine gastropods and closed bivalve shells and examine the sediment in them for pteropod remains. It is possible to recover pteropods in perfect condition by removing sediment from the shell interior. We commonly found pteropod-containing bivalve or gastropod shells buried in sediment otherwise devoid of pteropod remains. These pteropods usually were recovered as internal molds, but in some instances their shells were preserved.

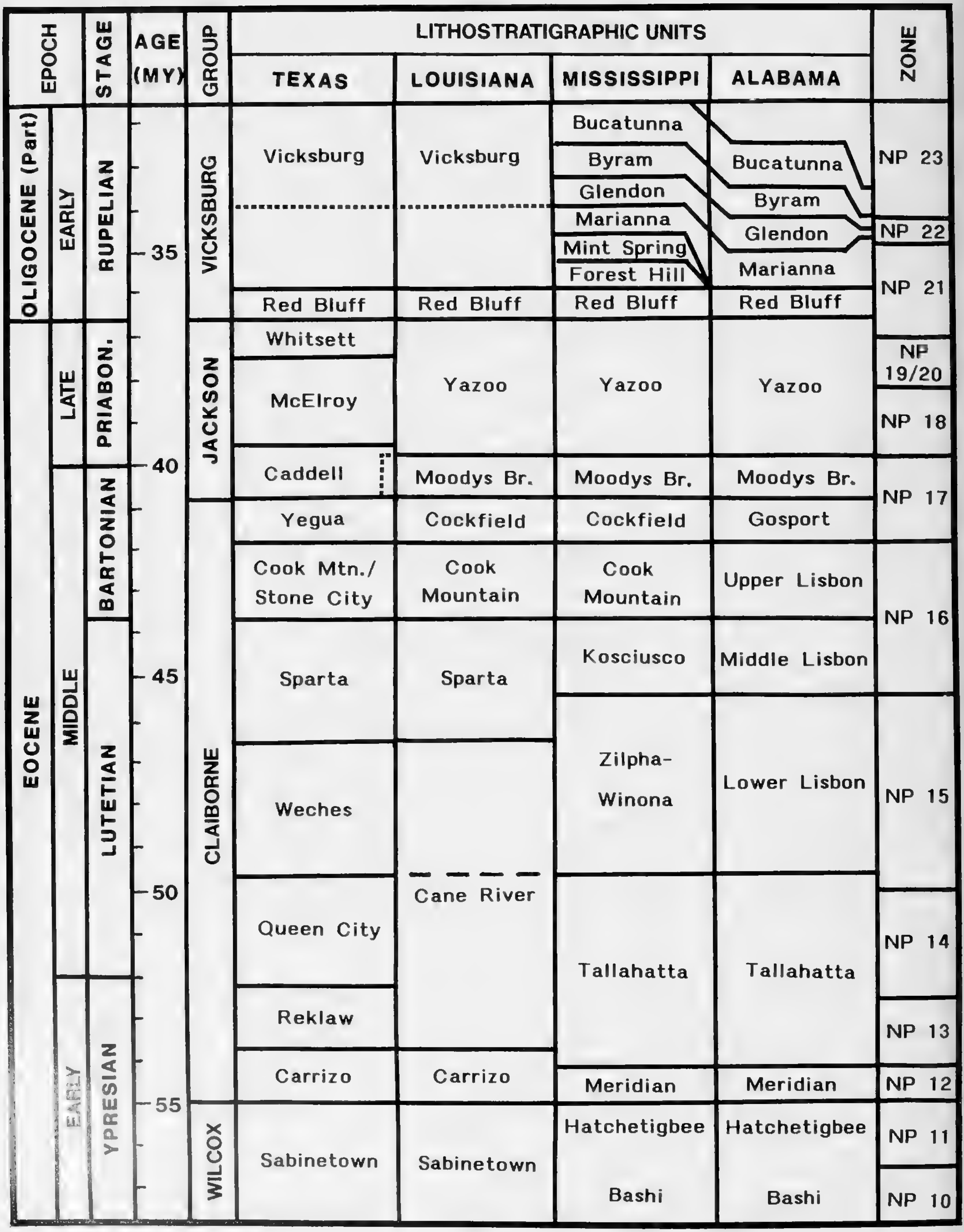
Washed residues were prepared by heating and drying bulk samples of sediment, treating the heated samples with Varsol® (a petroleum-based solvent manufactured by Exxon), soaking the treated material in hot water and washing the disaggregated sediment through a 150-mesh screen. This method is effective if the pteropod shells are relatively strong and resistant, but it is ineffective for the recovery of more delicate forms [Specimens of *Skaptotion nitens* (I. Lea, 1833) from Little Stave Creek, Alabama were recovered intact by washing the sediment, but a very delicate form, *Tibiella marshi* Meyer, 1884 was found only by examining the dry unwashed sediment.]. Although the washing process is relatively gentle, the more delicate forms are frequently destroyed by: (1) the jets of water used during preparation of the sample; (2) the surface tension of water; (3) the abrasive action of various types of particles and the screen on the pteropod shells; and (4) the expansion of water-soaked clays inside the fossil pteropod shells.

Pteropod specimens were frequently found filled, or replaced with pyrite, glauconite, calcite, clay, or other foreign material, which aided in their preservation.

The Eocene and early Oligocene formations in which these pteropods were found are shown in the stratigraphic charts of Text-figures 1 and 2. Text-figure 1 is from Dockery (1986). Another excellent treatment of the stratigraphy of this area is found in the American Association of Petroleum Geologists COSUNA chart series for the Gulf Coast (1988). Text-figure 2 is from Stenzel, Krause, and Twining (1957). We have used the criteria set forth by these authors to identify the formations in this study. There is, however, still some disagreement as to the true stratigraphic positions and validity of several of these formations and members. For example, Nelms (1979) would refer to the Stone City Formation as the Stone City Member of the Crockett Formation. She, like many others, would use the term *Crockett* rather than *Cook Mountain*.

PALEOBIOGEOGRAPHY

Recent pteropods are most commonly found in deeper marine water, usually from water depths of 50 m or more (Janssen, 1990). However, Furnestin (1979) reports that *Creseis acicula* Rang, 1828 develops rapidly during the wet season in the bays of Nosey-Bé off the northwest coast of Madagascar. Andrews (1971) states that the shells of this species can be easily over-



EPOCH		STAGE	AGE (MY)	GROUP	TEXAS	LOUISIANA	MISSISSIPPI	ALABAMA	ZONE
					LITHOSTRATIGRAPHIC UNITS				
OLIGOCENE (Part)	EARLY	RUPELIAN		VICKSBURG	Vicksburg	Vicksburg	Bucatunna	Bucatunna	NP 23
							Byram		
							Glendon	Byram	
							Marianna	Glendon	NP 22
			35				Mint Spring		NP 21
							Forest Hill	Marianna	
					Red Bluff	Red Bluff	Red Bluff	Red Bluff	
EOCENE	LATE	PRIABON.		JACKSON	Whitsett	Yazoo	Yazoo	Yazoo	NP 19/20
					McElroy				NP 18
	MIDDLE	BARTONIAN	40		Caddell	Moodys Br.	Moodys Br.	Moodys Br.	NP 17
				CLAIBORNE	Yegua	Cockfield	Cockfield	Gosport	
					Cook Mtn./ Stone City	Cook Mountain	Cook Mountain	Upper Lisbon	NP 16
		LUTETIAN	45		Sparta	Sparta	Kosciusco	Middle Lisbon	
					Weches	Cane River	Zilpha-Winona	Lower Lisbon	NP 15
			50		Queen City		Tallahatta	Tallahatta	NP 14
	EARLY	YPRESIAN			Reklaw				NP 13
					Carrizo	Carrizo	Meridian	Meridian	NP 12
			55	WILCOX	Sabinetown	Sabinetown	Hatchetigbee	Hatchetigbee	NP 11
							Bashi	Bashi	NP 10

looked if the beach drift is not carefully screened, but that at times they come ashore by the thousands. She has also found the shells of other pteropods in beach sands.

It is important to understand this Recent distribution pattern, because many of the sediments that yield fossil pteropods have been identified as shallow-water deposits. These include strata in the Stone City Formation, Cook Mountain Formation, and Gosport Sand (see Scott, 1963; Nelms, 1979).

Controls on the distribution of Recent pteropods include: (a) salinity; (b) temperature [decrease in number of species from low to high latitudes]; (c) depth; (d) oxygen content of the marine waters; (e) nutrients [because most pteropods feed on phytoplankton and detritus, there is a close association between pteropod abundance, seasonal phytoplankton blooms, and nutrient levels (Bé and Gilmer, 1977)]; (f) light penetration [*i.e.*, clarity of the water]; (g) seasonal abundance; (h) characteristics and movement of oceanic water masses [pteropods tend to be abundant in active current systems in regions of upwelling]; (i) saturation of sea water with respect to aragonite; and (j) species tolerance to other environmental factors. Herman and Rosenberg (1969) reported that the ratio of *Creseis* spp. to *Limacina inflata* d'Orbigny, 1836 was depth-dependent in sediments. This ratio was high in water less than 100 m deep and decreased rapidly with increasing depth.

Factors that control the distribution of Recent pteropods certainly were important during the Eocene. It is necessary to understand these controls when trying to determine the causes for ancient pteropod distributions. It is also important to realize that during the Eocene the climate was warmer (more widespread tropical and subtropical environments), sea level was higher, and oceanic currents may have been significantly different.

BIOSTRATIGRAPHY

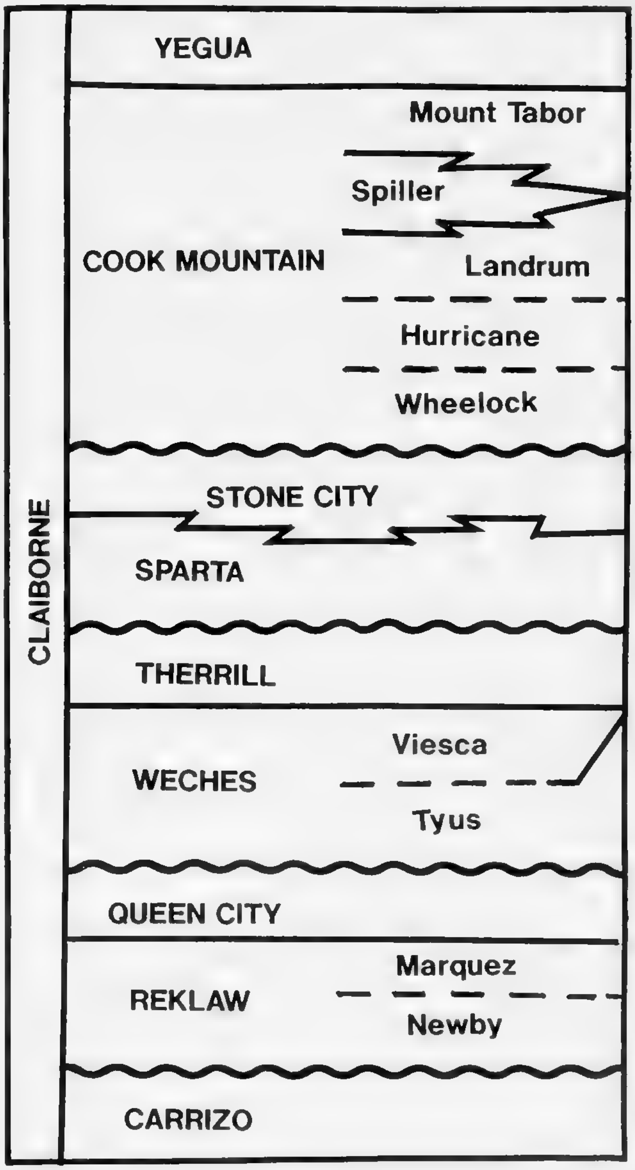
The biostratigraphic distribution of pteropods is not well-known, but Janssen and King (1988) and Janssen (1990) have published significant preliminary range charts with suggested pteropod zones. Pteropod zones suggested by Janssen and King (1988) in the Eocene include part of zone 6, and zones 7 through 12. We have been unable to tie our ranges to Janssen and King's pteropod zones, and their scheme is not used in this paper. We have tried to tie North American pteropod biostratigraphic distributions to the nannoplankton zones used by Dockery (1986) [see NP zones in Text-figs. 1 and 3]. The nannoplankton zones on Dockery's biostratigraphic chart are from Berggren *et al.* (1985).

Text-figure 1.—Correlation chart of Eocene and some Oligocene formations in Texas, Louisiana, Mississippi, and Alabama (adapted from Dockery, 1986, p. 584).

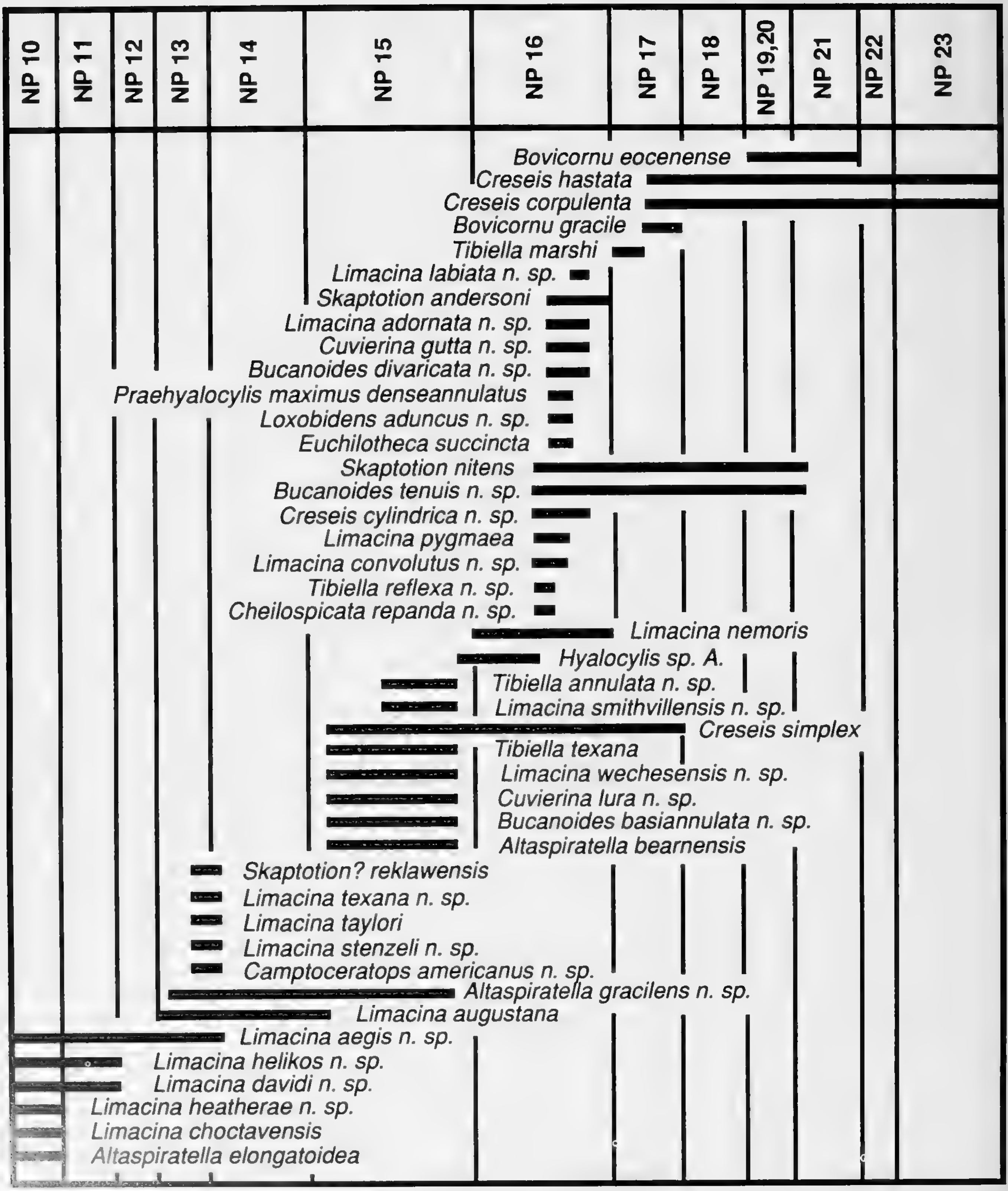
Improved biostratigraphic zonation will result as more data on the geographic and stratigraphic disribution of pteropods become available.

SHELL MICROSTRUCTURE

All euthecosomatous pteropods possess aragonitic shells. The internal shell microstructures of the two extant families are, for the most part, strikingly different. Members of the family Limacinidae build a crossed-lamellar shell microstructure (Pl. 5. fig. 7, Pl. 6, fig. 1), whereas those of the family Cavoliniidae have a helical microstructure (Pl. 10, figs. 9, 10). The latter shell microstructure was first described in pteropods



Text-figure 2.—Eocene stratigraphic units in Texas (from Stenzel, Krause, and Twining, 1957).



Text-figure 3.—Distribution of selected Eocene pteropod species in North America. The ranges of several species are omitted because their biostratigraphic distributions are not well known. European distributions are not shown but are cited in the text.

Table 2.—Shell microstructure of selected American Eocene pteropods.

Crossed-lamellar (all coiled shells)
Limacina nemoris (Curry)
Limacina pygmaea (Lamarck)
Altaspiratella bearnensis (Curry)
Limacina wechesensis, n. sp.
Skaptotion nitens (I. Lea)
Helical microstructure (straight or loosely coiled shells)
Bucanoides basiannulata, n. sp.
Bucanoides tenuis, n. sp.
Creseis simplex (Meyer)
Cuvierina lura, n. sp.
Tibiella reflexa, n. sp.

by Bé, MacClintock, and Chew-Currie (1972, pp. 45–79) for *Cuvierina columnella* (Rang, 1827). It is not known to exist in any other living or fossil molluscan group. Both the crossed-lamellar and helical microstructures consist of first-order elongated rods, which in turn are made up of second-order blocks whose dimensions are approximately 0.2 μm × 0.2 μm × 0.4 μm.

In the living cavoliniid species, such as *Cuvierina columnella*, the helices of aragonite rods always coil clockwise when viewed from the outer side of the shell. Their central axes are perpendicular to the shell surface. Within a shell wall about 40 μm in thickness, the helix spiral makes four turns on the average and the helix radius increases from about 1.6 μm at the outer shell surface to about 14 μm at the inner shell surface. The helical rods are nested in such a manner as to give omnidirectional continuity and flexibility as well as maximum strength to the thin, fragile shell. This is a decided advantage for an organism with a planktonic life-style.

The phylogenetic significance of these two contrasting microstructures has been considered by Bé, MacClintock, and Chew-Currie (1972), Rampal (1973, pp. 133, 134), Richter (1976), Curry and Rampal (1979, pp. 23, 24), and Boltovskoy (1974). According to Bé, MacClintock, and Chew-Currie, the helical microstructure of the Cavoliniidae may indicate that they are evolutionary neomorphs derived from ancestors with reduced or no shells, which have regained the ability to construct an exoskeleton on a new architectural plan. If this supposition is correct, the Limacinidae, with a crossed-lamellar microstructure that is basically similar to other molluscan shell structures, is a more primitive group than the Cavoliniidae.

It is curious that in the course of their long evolutionary history so few marine gastropods have adapted to a holopelagic, shell-bearing existence in the ocean, although they live in great diversity and abundance in shallow-water marine environments where the veliger stages are meroplanktonic. The percentage of gastropod taxa that belong to the holoplankton community in contemporary seas is small indeed in comparison with the eminently successful cephalopods.

The occurrence of a helical microstructure in straight or loosely coiled shells and that of a crossed-lamellar microstructure in coiled Eocene pteropods bears witness that this fundamental difference in shell structure has existed since at least the early Eocene (56.0 m.y.).

Bé examined some of the pteropods discussed in this report, and divided them into two categories of shell microstructure (see Table 2).

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ABBREVIATIONS OF REPOSITORY INSTITUTIONS

Types and figured specimens described in this paper are deposited in the following repositories:

ANSP: Academy of Natural Sciences, Philadephia, Pennsylvania, U. S. A.

BM(NH): British Museum (Natural History), London, England, U. K.

USNM: United States National Museum of Natural History, Smithsonian Institution, Washington, DC, U. S. A.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

In this paper we discuss a total of 14 genera and 47 species of pteropods from the Gulf and Atlantic coastal plains of North America. Many of the species are represented by numerous specimens, the result of field work over many years by both Hodgkinson and Garvie. Other species are represented by only a few specimens, which may indicate that they are very rare, that they are not commonly preserved in sediments, or that they have been missed because of inadequate sampling.

Holotypes from United States institutions and the BM(NH) were examined by Garvie and Hodgkinson. Curry's types were examined with particular care because their stratigraphic range is well-known. As our study involves planktonic forms, stratigraphic correlation has been possible between units in Europe and North America.

Coiled species are illustrated in the traditional North American orientation with the apex up (dorsal) and the aperture below (ventral). Uncoiled or tubular species are described with the aperture up (ventral) and the protoconch down (dorsal).

In our study of fossil pteropods and our examination of numerous Recent pteropods, we have noted that most specimens within a species are remarkably similar. This is probably because their planktonic existence eliminates many of the stresses that benthonic gastropods would experience.

We consider consistent morphological differences in the fossil populations as justification for assigning the specimens in question to separate species. In the case of pteropods, these differences may be minor, due to their relative lack of ornamentation.

CLASSIFICATION

Of the eight Recent euthecosomatous pteropod genera (*Cavolinia* Abildgaard, 1791, *Clio* Linnaeus, 1767, *Creseis* Rang, 1828, *Cuvierina* Boas, 1886, *Diacria* Gray, 1847, *Hyalocylis* Fol, 1875, *Limacina* Bosc, 1817, and *Styliola* Gray, 1850) only *Creseis* and *Limacina* have been reported from the Eocene. We report, for the first time, Eocene species of *Cuvierina*. We also found truncated conical shells with transverse grooves and basal septae, which appear to be Eocene species of *Hyalocylis*. We describe one such specimen as *Hyalocylis* sp. A. *Clio* is found in the Oligocene to lower Miocene of Washington (Squires, 1989). *Cavolinia*, *Diacria*, and *Styliola* have their first occurrences in the Miocene.

SYSTEMATICS

Some of the species descriptions given in this paper are incomplete because specimens are very rare or poorly preserved. In some species (*e.g.*, *Tibiella reflexa* Hodgkinson, n. sp.), only the aperture and adjacent shell material are preserved, whereas in several other species [*e.g.*, *Creseis simplex* (Meyer, 1886)], the shell at the aperture is so thin and delicate that most shells are broken.

We follow the classification used in the *Treatise of Invertebrate Paleontology* (Cox, 1960) and Spoel (1967) for phylum through subfamily designations. All suprageneric names have been verified by reference to original publications. For cases such as *Limacina* Bosc, 1817 *vs.* *Spiratella* Blainville, 1817, where priority cannot be ascertained, Spoel's nomenclature has been accepted.

Phylum **MOLLUSCA** Linnaeus, 1758

Class **GASTROPODA** Cuvier, 1797

Subclass **OPISTHOBRANCHIA** Milne-Edwards, 1848

Description.—Shell small, external, internal, or absent; visceral nerve cords not crossed; one internal gill or with external gills in shell-less forms; usually without operculum; all hermaphroditic and marine. Devonian?, Mississippian–Recent.

Discussion.—During the long geologic history of this subclass, there have been trends toward loss of the shell and toward obtaining symmetry. Bilateral symmetry is well-developed in the shells of several Recent pteropod genera (*Creseis* Rang, 1828, *Cuvierina* Boas, 1886, *Clio* Linnaeus, 1767, *Diacria* Gray, 1847, *Hyalocylis* Fol, 1875, and *Cavolinia* Abildgaard, 1791).

This subclass is one of three into which gastropods are divided (Prosobranchia Milne-Edwards, 1848, Opisthobranchia, and Pulmonata Cuvier, 1817). Some authors combine the Opisthobranchia and Pulmonata into the subclass Euthyneura Spengel, 1881.

Order **THECOSOMATA** Blainville, 1824[4]

Description.—Pelagic, free-swimming. Epipodia greatly expanded, modified into swimming flaps or wings. Mouth with jaws and a small triserial radula. No definite head, no eyes, one pair of tentacles. Shells variously shaped, usually a sinistral spiral, conical, or

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[4] = Pteropoda Cuvier, 1804 of some authors.

bilaterally symmetrical, generally calcareous, delicate and glassy. Late Paleocene–Recent.

Suborder **EUTHECOSOMATA** Meisenheimer, 1905

Description.—External calcareous shell always present; spirally and sinistrally coiled, conical, or bilaterally symmetrical. Epipodia laterally separated, tentacles not paired and symmetrical. Proboscis and rostrum absent. Late Paleocene–Recent.

Family **LIMACINIDAE** Gray, 1847[5]

Description.—Shell small, thin, vitreous, smooth, with or without an umbilicus. Trochoid to nearly discoidal. Hyperstrophically coiled. Late Paleocene–Recent.

Discussion.—Keen (1971) indicated that the coiling in the Spiratellidae is hyperstrophic. Coiled pteropods are anatomically dextral, with genitalia on the right, but they have a falsely sinistral shell. A *bona fide* sinistral shell is formed only by gastropods with genitalia on the left side of the head-foot mass or pallial cavity, and with other soft parts and the shell arranged in mirror-image of dextral gastropods. Thus, when we describe pteropod shells as being sinistral, as we do in this paper, it is only in the loose sense.

Genus **ALTASPIRATELLA** Korobkov, 1966

Altaspiratella Korobkov, 1966, p. 74.
Plotophysops Curry, 1981, p. 39.

Type species.—*Altaspiratella elongatoidea* (Aldrich, 1887). Early Eocene, Alabama.

Description.—Elongated, fusiform species with a large last whorl, an elongate oval aperture, and a narrow umbilicus. Early–middle Eocene.

Discussion.—Korobkov (1966) established the genus *Altaspiratella* for five species that shared the characteristics described above. Curry (1981) proposed the genus *Plotophysops* to cover two species, *Plotophysops bearnensis* Curry, 1981 and *P. multispira* Curry, 1981. He indicated that *Altaspiratella* differed from *Plotophysops* by the presence of an umbilicus, and the complete absence of a twisted columella and modified lip. Janssen (1990) referred the type species of *Plotophysops* (*Plotophysops bearnensis*) to *Altaspiratella*. He correctly noted that *Altaspiratella elongatoidea*, the type species of *Altaspiratella*, is very similar, although not identical, to *Altaspiratella bearnensis* (Curry, 1981). He also observed that a final conclusion as to the identity of *A. elongatoidea* is hampered because it is exclusively known by its holotype, which is a damaged and/or immature specimen. We have found it very difficult to distinguish immature or broken specimens of these two species (see Pl. 1, figs. 2, 3). We follow Janssen's usage and assign these elongated forms to *Altaspiratella*.

Altaspiratella bearnensis (Curry)
Plate 1, figures 1, 2

Plotophysops bearnensis Curry, 1981, p. 40, pl. 1, figs. 9a–c.
Altaspiratella bearnensis (Curry). Janssen, 1990, p. 68.

Description.—

> Montres les caractères du genre. Coquille lisse de 5½ tours arrondis, assez allongés, angle spiral 35–40°. La protoconque, de 2 tours, est terminée par un sillon sinueux qui comprend un fort enfondement bordé de deux proéminences d'une égale grandeur . . . Ouverture ovale, avec dans le stade adulte, un bord évasé, épaissi et aplati qui est sinueux antérieurement et montre une large échancrure près de la columelle. Longueur maximale: 2,7 mm (Curry, 1981).

Free translation.—Shows the characters of the genus. Shell smooth, 5½ whorls, quite elongated, spiral angle 35–40°. The protoconch, of two whorls, ends in a sinuous groove that includes a strong re-entrant edge with two equally large prominences. Aperture oval. In the adult stage, the lip is flared, thickened, and flattened. The anterior edge is sinuous and has a wide indenture near the columella. Maximum length, 2.7 mm.

Measurements.—Hypotype (USNM 180480): height, 2.8 mm; width, 1.4 mm; apical angle, 30°; 6.5 whorls. Average of ten specimens: height, 3.1 mm; width, 1.5 mm; apical angle, 31°; 6.7 whorls.

Discussion.—Broken specimens, with the spiral whorls most commonly preserved, resemble *Limacina tutelina* (Curry, 1965) and *Altaspiratella elongatoidea* (Aldrich, 1887). There is, however, little resemblance between complete specimens of these forms. Neither of the latter species has the well-developed anterior indenture that is so prominent in *A. bearnensis*.

Occurrence.—Early Eocene of France to middle Eocene of the Texas Gulf Coast. Holotype from the early Eocene (NP13) of Gan, France (see Curry, 1981, p. 36). Other specimens from London Clay division E (NP12 or NP13) at Highgate, London; one specimen from division C or D on the Isle of Sheppey, and in the North Sea Basin (Janssen, 1990, p. 68).

All of our specimens are from the middle Eocene Weches Formation at localities 7 and 8.

Material.—Specimens examined in this study were recovered from localities 7 (26 specimens) and 8 (63 specimens, including the hypotype). Most of the specimens from each locality are incomplete, with the spire being preserved more often than the apertural end.

Types.—Holotype, BM(NH) GG 21255; hypotype, USNM 180480, 360382.

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[5] = Spiratellidae Dall, 1921.

Altaspiratella elongatoidea (Aldrich)
Plate 1, figure 3

Physa elongatoidea Aldrich, 1887, p. 83.
Spiralis elongatoidea (Aldrich). Aldrich, 1895, p. 5, pl. 2, fig. 9; G. D. Harris, 1899, p. 103, pl. 12, fig. 25.
Limacina elongatoides [*sic*] (Aldrich). Collins, 1934, p. 177, pl. 7, fig. 1.
Limacina elongatoidea (Aldrich). Palmer and Brann, 1965, p. 358.
Spiratella (*Altaspiratella*) *elongatoides* (Aldrich). Korobkov, 1966, p. 74.

Description.—

> Shell thin, minute, strongly sinistral, whorls five, smooth, suture strongly impressed and very oblique to the axis, aperture almost quadrate, inner lip meeting the parietal wall abruptly and reaching down nearly straight (Aldrich, 1887).

Measurements.—USNM 638862 (holotype): height, 2.5 mm; width, 1.2 mm; apertural height, 1.3 mm; apertural width, 0.7 mm; spiral angle, 36°; 5½ whorls.

Discussion.—Although Collins included this species in the Pteropoda with some hesitation, it now appears that *A. elongatoidea* (Aldrich) definitely is a pteropod. It is similar to several high-spired forms [*e.g.*, *Limacina tutelina* (Curry, 1965) and *Altaspiratella bearnensis* (Curry, 1981)].

Future work may show that *A. elongatoidea* and *A. bearnensis* are very closely related or even the same species. At the present, however, it appears that *A. bearnensis* differs in the absence of an umbilicus and the presence of a twisted columella, an anterior sulcus, and a broad outer lip.

Occurrence.—Early Eocene, Wilcox Group, Hatchetigbee Formation, Bashi Member at locality 1.

Material.—The holotype, from locality 1, is the only known specimen.

Types.—Holotype, USNM 638862.

Altaspiratella gracilens Hodgkinson, new species
Plate 1, figures 4, 5

Etymology of name.—The species name refers to the slender shape of this form (L. *gracilis* = slender, thin).

Description.—Shell small, smooth, sinistrally coiled, extremely high-spired, whorls increasing slowly in width and height. Umbilicus very small or absent. Aperture inclined to shell axis, ventral edge of lip has a prominent sulcus and outer lip is flanged. Whorls rounded, in a fairly loose spiral, sides nearly parallel, sutures deep.

Measurements.—USNM 180481 (holotype): two whorls (only the last two whorls are preserved on the holotype), height, 2.6 mm; width of last whorl, 1.1 mm; greatest dimension of aperture, 1.1 mm; smallest dimension of aperture, 0.6 mm.

Discussion.—This species resembles *Altaspiratella bearnensis* (Curry, 1981) but differs in being more loosely coiled, having deeper sutures, nearly parallel sides, and a much smaller spiral angle (about 11° rather than 36°).

Occurrence.—Middle Eocene. Weches Formation, at localities 7 and 8, and Cane River Formation at well locality 41 (cuttings at 9,950 ft).

Material.—Specimens examined in this study were recovered from localities 7 (3 specimens, including the paratype), 8 (3 specimens, including the holotype), and 41 (1 specimen).

Types.—Holotype, USNM 180481; paratype, USNM 180482.

Genus **LIMACINA** Bosc, 1817

Limacina Bosc, 1817, p. 42.
Spiratella Blainville, 1817, p. 407.

Type species.—*Limacina helicina* Phipps, 1774, a Recent species.

Description.—Shell small, thin, glassy, little or no exterior ornamentation. Trochoid to nearly planispiral, hyperstrophic coiling with rounded, closely wound whorls. Last whorl ½ to ⅘ of the entire shell. Aperture wide, rounded, prolonged at base; columella projecting; umbilicus broad and deep or almost absent. Latest Paleocene–Recent (see Janssen and King, 1988).

Discussion.—Spoel (1967, 1972), Keen (1971), and Janssen and King (1988) have given reasons for using the generic name *Limacina* in preference to *Spiratella*.

Limacina adornata Hodgkinson, new species
Plate 1, figures 6–9

Etymology of name.—The trivial name refers to the unusual ornamentation on the surface of this pteropod (L. *adornare* = to decorate, embellish).

Description.—Shell thin, small, broad, subtriangular in axial section, sinistral, about 4½ whorls. External surface of whorls smooth or faintly ornamented with about 25 very fine, discontinuous spiral threads that are more continuous near the base. The segments of these discontinuous threads are aligned vertically to give an appearance of rough axial sculpture. Just below the suture are very short axial ribs that are more or less aligned with the raised portion of the axial threads. Thus the impression of axial sculpture is reinforced. Aperture subquadrate with a strong vertical columella, inner lip reflected, umbilicate, sutures distinct, slightly impressed. First several whorls smooth and polished without ornamentation.

Measurements.—USNM 180483 (holotype): height, 1.6 mm; width, 1.4 mm; height of aperture, 0.7 mm; apical angle (of last formed whorls), 50°. Average of 20 measured specimens: height, 1.1 mm; width, 1.1 mm; height of aperture, 0.5 mm; apical angle (of last-formed whorls), 65°.

Discussion.—There is a possibility that *L. adornata*,

n. sp. is not a pteropod, but instead is the sinistrally coiled juvenile portion of a larger dextral gastropod, or may belong to one of the rare sinistrally coiled gastropod species not related to pteropods. The uncertainty exists because the shell surface of *L. adornata*, n. sp. usually is ornamented. No other known fossil pteropod has an ornamented shell, although Recent pteropods in the family Peraclidae are ornamented with a delicate noncalcareous hexagonal meshwork.

Limacina adornata, n. sp. does have other basic characteristics that help separate pteropods from other gastropods. These include its small size, sinistral coiling, and thin shell wall. It also has more whorls than most of the Eocene sinistrally coiled protoconchs of dextrally coiled gastropods. We believe the larger shells are mature because: (1) the later-formed whorls have a much more acute apical angle than the first-formed whorls; (2) they have a distinct smooth protoconch, which consists of approximately the first two whorls; and (3) there appears to be a maximum size limit. Of the specimens found, none appear to grow beyond 2 mm in height. We have examined most of the gastropod species that occur with *L. adornata*. None of these species has a juvenile shell similar to this new pteropod. *Limacina adornata*, n. sp. occurs in beds that contain other species of pteropods, and it is also very similar in shape to smooth pteropods from certain Louisiana oil wells. One such form, *Limacina helikos*, n. sp., is described in this paper.

It is our opinion that *L. adornata*, n. sp. is a pteropod with a smooth or ornamented shell.

Occurrence.—Middle Eocene. Holotype and paratypes from the Wheelock Member of the Cook Mountain Formation at locality 18. Other specimens from this member were found at locality 16. Specimens were also found in the Hurricane Lentil of the Cook Mountain Formation at localities 22, 23, and 25.

Material.—Specimens examined in this study were recovered from localities 16 (2 specimens), 18 (69 specimens), 22 (3 specimens), 23 (1 specimen), and 25 (5 specimens).

Types.—Holotype, USNM 180483; paratype, USNM 180484.

Limacina aegis Hodgkinson, new species
Plate 1, figures 10–15

Etymology of name.—The specific name refers to the flat nature and the resemblance of the dorsal surface to the round shields of the Norwegian Vikings (L. *aegis* = a shield).

Description.—Shell small, smooth, sinistral, almost twice as wide as high, lenticular in cross-section. Umbilicus narrow and deep (about ⅙ to ¼ width of shell). First 1½ whorls flat on dorsal side, subsequent whorls inclined at about 133°.

Measurements.—USNM 180485 (holotype): height, 0.8 mm; width, 1.5 mm; height of aperture, 0.4 mm; width of aperture, 0.5 mm; spiral angle (of last-formed whorls), 133°. Average of eight measured specimens: height, 0.8 mm; width, 1.5 mm; height of aperture, 0.7 mm; width of aperture, 0.5 mm; spiral angle, 133°; 3.75 whorls.

Discussion.—This form differs from other species of *Limacina* in being much wider in relation to height. The whorls of *L. aegis*, n. sp. are sharper at the periphery than those of other species, most of which have gently rounded whorls.

Occurrence.—Early Eocene? Rare in cuttings from several wells of offshore eastern Canada. The holotype, from cuttings at well locality 53 (2,940 ft), and a specimen from well locality 47 (3,300 ft) are early Eocene in age. A paratype from well locality 45 (7,780 ft) and several specimens from well locality 50 (3,600 ft) are from the Cretaceous interval. The occurrences in Cretaceous age sediments are believed to have resulted from downhole caving of Eocene sediments into older strata.

Material.—Specimens examined in this study were recovered from well localities 45 (1 specimen, the paratype), 47 (1 specimen), 50 (4 specimens), and 53 (1 specimen, the holotype).

Types.—Holotype, USNM 180485; paratype, USNM 180486.

Limacina augustana (Gardner)
Plate 2, figures 1–3

Spiratella augustana Gardner, 1951, p. 10, fig. 2; Palmer and Brann, 1965, p. 359.

Description.—

> Shell very small. Whorls 4–4½, sinistrally coiled in a nearly horizontal plane, the body embracing the whorls of the spire as in *Planorbis*. The aperture higher than it is wide, the body expanding at the aperture both vertically and horizontally; the outer surface of the preceding whorl forming the inner wall of the aperture; posterior margin of the body folded into the suture. The visible surface of the apical whorls rounded, scarcely elevated above the plane of the body. Umbilical area narrowly funicular. No sculpture other than obscure incrementals and the cording of the adult margin of the outer lip.
>
> Dimensions of holotype USNM 560589: Maximum diameter, 3 mm; diameter at right angles to the maximum diameter, 2.6 mm; minimum diameter, 2.3 mm; height, 1.5 mm (Gardner, 1951).

Discussion.—The holotype of *L. augustana* (Gardner) is an internal mold and exact characteristics are difficult to determine. Additional material was collected from the Tallahatta Formation at locality 5 (holotype locality) and many poorly preserved and highly variable specimens were recovered. Some specimens have depressed apical and umbilical sides (like *Skaptotion* Curry, 1965), some have a flat dorsal side and a depressed umbilical side, and others are moderately high-spired [like *Limacina pygmaea* (Lamarck, 1804)]. Probably more than one species is represented by these internal molds. Until better preserved specimens are collected, the exact characteristics of *L. augustana* cannot be determined accurately.

Gardner's illustration of the holotype shows an apparent aperture significantly below the horizontal plane of an otherwise nearly planispiral test. This illustration, although accurately drawn, is misleading. The upper part of the aperture is eroded away and the configuration and location of the entire aperture cannot be determined. If the complete aperture were present, the shell would appear more planispiral than it does in Gardner's drawings and in our photographs of the holotype.

Occurrence.—Early–middle Eocene. Holotype from the Tallahatta Formation, locality 5. We have collected many specimens, almost planispirally coiled and with a nearly flat dorsal surface, from Eocene and Oligocene deposits in Alabama, Mississippi, and Louisiana. Most are internal molds composed of glauconite, pyrite, calcite, or clay. Because of their poor preservation, identification is difficult, but they may well belong to this species.

Material.—Specimens examined in this study were recovered from locality 5 (51 specimens).

Types.—Holotype, USNM 560589.

Limacina canadaensis Hodgkinson, new species
Plate 2, figures 4–6

Etymology of name.—The species name refers to the location (Canada) where this species was first found.

Description.—Shell small, sinistral, smooth, medium- to low-spired; juvenile whorls more nearly in a plane than latter whorls, all involute and a little wider than high, sutures strongly impressed. Aperture about half as high as entire shell.

Measurements.—USNM 180487 (holotype): height, 1.0 mm; width, 1.2 mm; 3¾ whorls; spiral angle, 153°. Average of 16 specimens: height, 0.9 mm; width, 1.1 mm; 3⅔ whorls; apical angle, 139°.

Discussion.—The spiral angle varies from low to medium (118° to 160°). This species resembles *Limacina taylori* (Curry, 1965) [p. 363, figs. 21a, b] from the early Eocene of England, but is much smaller, has a greater spiral angle, and a shorter inner lip.

Occurrence.—Early–late Eocene. Holotype from early Eocene sediments at well locality 49 (5,380 ft). Because these specimens of *L. canadaensis* were recovered from well cuttings, age determinations are apt to be inaccurate. Late Eocene; well localities 45 (4,530 ft) and 54 (6,940 ft); middle Eocene, well localities 48 (2,100 ft), 49 (4,840 ft), 50 (2,640 ft), and 55 (4,770 ft); and early Eocene, well localities 45 (7,420 ft), 48 (2,220 ft), 49 (5,380 and 5,500 ft), and 53 (2,670 ft).

Material.—Specimens examined in this study were recovered from well localities 45 (2 specimens), 48 (2 specimens), 49 (7 specimens), 50 (3 specimens), 53 (1 specimen), 54 (1 specimen), and 55 (1 specimen).

Types.—Holotype, USNM 180487.

Limacina choctavensis (Aldrich)
Plate 2, figure 7

Physa choctavensis Aldrich, 1887, p. 83.
Spiralis choctavensis (Aldrich). Aldrich, 1895, p. 5, pl. 2, fig. 10; G. D. Harris, 1899, p. 103, pl. 12, fig. 24; Brann and Kent, 1960, p. 807.
Limacina choctavensis (Aldrich). Collins, 1934, p. 176, pl. 7, fig. 2; Palmer and Brann, 1965, p. 358.

Description.—

> Shell thin, minute, rather obtuse and broad, whorls probably five, somewhat shouldered, outer lip slightly patulous, inner lip reflected and reaching well upon the body wall, surface showing lines of growth only (Aldrich, 1887).
>
> The type is 2.9 mm. long and 2.1 mm. in diameter. . . . The lower half of the outer lip of the fossil specimen is slightly produced and a small umbilicus is present. The nucleus, preserved on two of the additional specimens, consists of about one and a quarter whorls, smooth and polished, with a slight ridge developed at the apertural end beyond which enlarging whorls bear irregularly-spaced wrinkles near the suture (Collins, 1934).

Measurements.—Apical angle of the figured syntype (USNM 638860) is 70°. Average apical angle of three syntypes (USNM 638861) is also 70°.

Discussion.—The apical whorls are missing from Aldrich's figured syntype, but are present on several other syntypes. The first whorl is nearly planispiral and is followed by trochoid whorls. For additional notes, see Collins (1934).

Occurrence.—Early Eocene. Upper Wilcox Group, Hatchetigbee Formation, Bashi Member at locality 1.

Material.—Specimens examined in this study were recovered from locality 1 (5 specimens, the syntypes of Aldrich, 1895). To our knowledge, these are the only known specimens.

Types.—Syntype, USNM 638860 (Aldrich, 1895, pl. 2, fig. 10); syntypes, USNM 638861 (three smaller unfigured specimens); and syntype, USNM 638863 (one unfigured specimen, presumably one of Aldrich's five syntypes).

Limacina convolutus Hodgkinson, new species
Plate 2, figures 8–10

Etymology of name.—The trivial name refers to the coiling habit of this species, with portions of all whorls visible (L. *convolutus*, *-a*, *-um* = rolled together, one part upon another).

Description.—Shell small, very thin, smooth, discoidal (almost planispiral), sinistral, all whorls visible on the apical side. Spire depressed and umbilicus prominent. Aperture reniform with a simple, unflanged lip. Very faint fold on inner lip just below base of previous whorl.

Measurements.—USNM 180488 (holotype): height, 0.9 mm; width, 1.2 mm; height of aperture, 0.9 mm; width of aperture, 0.4 mm; 4⅛ whorls. Average of ten specimens: height, 0.7 mm; width, 1.0 mm; length of aperture, 0.7 mm; width of aperture, 0.5 mm; 3⅓ whorls.

Discussion.—*Limacina convolutus*, n. sp. resembles several of the species of *Skaptotion* Curry, 1965, but this new species does not have a flanged lip, a turbiniform protoconch (which is often inclined to the axis of the mature shell in *Skaptotion*), or part of one of the earlier whorls completely covered by the next whorl. This new species also resembles *L. planidorsalis*, n. sp. but they differ significantly in the shape of the dorsal side. In *Limacina convolutus* it is distinctly depressed; in *L. planidorsalis* it is flat or nearly so.

Occurrence.—Middle Eocene. Holotype from the Stone City Formation at locality 12. Also found in the Wheelock Marl Member of the Cook Mountain Formation at localities 17, 18, and 19.

Material.—Specimens examined in this study were recovered from localities 12 (5 specimens), 17 (36 specimens), 18 (11 specimens), and 19 (23 specimens).

Types.—Holotype, USNM 180488.

Limacina davidi Hodgkinson, new species

Plate 2, figures 11–14

Etymology of name.—The species is named for the senior author's son, who helped collect samples for this study.

Description.—Shell small, smooth, sinistrally coiled, nearly round in axial section. Umbilicus narrow and deep (about ⅛ width of shell). First two whorls flat or slightly depressed on dorsal side, remaining whorls added in a broad spiral.

Measurements.—USNM 180489 (holotype): height, 1.3 mm; width, 1.4 mm; height of aperture, 0.3 mm; apical angle, 90°.

Discussion.—This species differs from other Eocene pteropods in its almost round shape when viewed both from the side and top or bottom.

Occurrence.—Early Eocene, very rare in cuttings at well locality 42 (10,040 ft: Wilcox Formation).

Material.—Specimens examined in this study were recovered from well locality 42 (10,040 ft, 2 specimens). Rare in several Louisiana oil and gas wells. We are unable to release confidential well data on wells other than those of Exxon Company, U. S. A. and Esso Resources, Canada.

Types.—Holotype, USNM 180489.

Limacina heatherae Hodgkinson, new species

Plate 2, figures 15–18

Etymology of name.—The species is named for the senior author's daughter, who helped collect specimens for this study.

Description.—Shell small, smooth, sinistrally coiled, subquadrate in axial section. Spire depressed to slightly elevated. Aperture narrow in width, oblique to the shell axis. Gradual increase in whorl width. Last whorl significantly below plane of earlier whorls. Umbilicus narrow and deep (⅛ to ⅑ of maximum width).

Measurements.—USNM 180490 (holotype): height, 0.9 mm; width, 1.1 mm; 4 whorls.

Discussion.—This species differs from other pteropods by its gradual increase of whorl width and its subquadrate shape.

Occurrence.—Late Paleocene?–early Eocene?. Holotype from well locality 42 (12,370 ft) in sediments near the base of the Wilcox Formation. However, the possibility of downhole caving of younger sediments exists and the holotype could be of Eocene or younger age.

Material.—Specimens examined in this study were recovered from well locality 42 (12,370 ft, 2 specimens).

Types.—Holotype, USNM 180490.

Limacina helikos Hodgkinson, new species

Plate 3, figures 1–5

Etymology of name.—The trivial name refers to the shape of this species (Gr. *helikos* = a spiral, anything of a spiral shape).

Description.—Shell small, smooth, sinistrally coiled, umbilicate; about as wide as high, first two whorls almost planispiral, later whorls with a spiral angle of about 62°. Whorl profile and aperture quadrate. Sutures only slightly impressed. Aperture about ⅓ as high as shell and a little wider than high. Umbilicus small (poorly preserved in our specimens). Sides nearly straight but never parallel.

Measurements.—USNM 180491 (holotype): height, 1.3 mm; width, 1.3 mm; spiral angle, 63°; 5¾ whorls.

Discussion.—*Limacina helikos*, n. sp. differs from other described high-spired species of *Limacina* by its nearly straight sides. It resembles *L. adornata*, n. sp., but the latter has curved sides and slight ornamentation.

Occurrence.—Early Eocene. The holotype is from the Upper Wilcox Formation, and the paratype is from the Lower Wilcox Formation at well locality 42.

Material.—Specimens examined in this study were recovered from well locality 42 (2 specimens). Four specimens from three other industry wells. We are unable to release confidential well data on wells other than those of Exxon Company, U. S. A. and Esso Resources, Canada.

Types.—Holotype, USNM 180491, well locality 42 (12,290 ft: Lower Wilcox Formation); paratype, USNM 180492, well locality 42 (10,070 ft: Upper Wilcox Formation).

Limacina labiata Hodgkinson, new species
Plate 3, figures 6–8

Etymology of name.—The trivial name refers to the prominent flange around the aperture (L. *labiata* = bearing a lip).

Description.—Shell thin, small, smooth, sinistral, of about five whorls. Suture strongly impressed. Aperture roughly hemispherical, higher than wide. Inner lip flanged, straight and slightly oblique to the shell axis. Outer lip also flanged and circular in outline. A shallow sulcus is at the ventral edge of the aperture. Initial 1½ whorls almost planispiral, remaining whorls form a relatively high spiral.

Measurements.—USNM 180493 (holotype): height, 1.5 mm; width, 0.9 mm; spiral angle, 51°.

Discussion.—*Limacina labiata* n. sp., *Altaspiratella gracilens*, n. sp., and *Altaspiratella bearnensis* (Curry, 1981) are the only described high-spired Eocene pteropods with distinctly flanged apertures. These apertural flanges resemble those of the nearly planispiral pteropod *Skaptotion* Curry, 1965.

Occurrence.—Middle Eocene. Very rare in the Cook Mountain Formation, Hurricane Lentil, at locality 23.

Material.—Specimens examined in this study were recovered from locality 23 (1 complete and 2 broken specimens). One broken specimen has the juvenile whorls missing; the other lacks the outer lip.

Types.—Holotype, USNM 180493.

Limacina nemoris (Curry)
Plate 3, figures 9, 10

Spiratella nemoris Curry, 1965, p. 362, figs. 16a–b; Curry, 1981, p. 37, pl. 1, figs. 5a–b.

Description.—

> Shell very small, sinistral, smooth, umbilicate, naticiform, with a spire of four whorls, which forms about one-third of the total height. First 1½ whorls almost planispiral, later whorls with a spiral angle of about 80°. Aperture roughly semicircular, suture impressed. Outer lip slightly oblique to axis, sloping forward abapically. Inner (columellar) lip straight. The whole unattached margin of the lip slightly expanded in the adult shell. Dimensions of holotype, height, 1.0 mm, width, 0.8 mm (Curry, 1965).

Measurements.—Average of 20 specimens: height, 0.9 mm; width, 0.7 mm; height of aperture, 0.6 mm; height of spire, 0.3 mm (spire about ⅓ of total height); spiral angle, 81°.

Discussion.—The above measurements show that the North American specimens conform very closely to those from England.

Several minor differences exist between the English specimens described by Curry and those illustrated here. Only the first 1¼ whorls of the Gulf Coast specimens are planispiral and the inner lip is folded toward the umbilicus. These differences are minor and may be as much the result of description and preservation as true morphological differences between two widely separated populations. Squires (written commun., 1990) noted that the populations are widely separated now, but that the Atlantic Ocean was narrower during the Eocene. In shape and size, *L. nemoris* resembles the Recent pteropod *Limacina trochiformis* (d'Orbigny, 1836).

Occurrence.—Middle–late Eocene. From the middle Eocene upper Bracklesham Beds of England and the late Eocene "marnes bleues" of France. In North America the species is found in the following middle Eocene formations: Stone City Formation, localities 11 and 12; from the Wheelock Member of the Cook Mountain Formation, localities 16 and 18; and from the upper Lisbon Formation, locality 6. The species is also found in undifferentiated Eocene sediments at well locality 53 (2,940 ft).

Material.—Specimens examined in this study were recovered from localities 6 (29 specimens), 11 (4 specimens), 12 (4 specimens), 16 (2 specimens), 18 (61 specimens, including the hypotype), and 53 (1 specimen).

Types.—Holotype, BM(NH) GG 7100; hypotype, USNM 180494.

Limacina planidorsalis Hodgkinson, new species
Plate 3, figures 11–13

Etymology of name.—The species name refers to the nearly flat dorsal surface of this species.

Description.—Shell small, smooth, without ornamentation, 4–4½ whorls, sinistrally coiled in a nearly horizontal plane. Dorsal side may be slightly depressed or with a slight spire, but usually is flat. All whorls are visible on the dorsal surface and are coiled in the same plane. Maximum width is near the dorsal surface; ventral side has a deep and moderately wide umbilicus (about ¼ as wide as shell). Aperture simple, higher than wide.

Measurements.—USNM 180495 (holotype): height, 0.7 mm; maximum diameter, 1.0 mm; 4 whorls. Average of five specimens: height, 0.7 mm; maximum diameter, 1.1 mm; 3.9 whorls.

Discussion.—*Limacina planidorsalis*, n. sp. is similar to *Limacina augustana* (Gardner, 1951), but is smaller, even though it has as many whorls and is also not as high in relation to its width. It also is similar to *Limacina convolutus*, n. sp., but the latter species has a distinctly depressed dorsal side.

Occurrence.—Early to middle Eocene. Middle Eocene, holotype and a second specimen from cuttings at well locality 51 (1,250 ft). Early Eocene, from well localities 48 (2,220 ft), 51 (1,470 ft), and 53 (2,700 ft).

Material.—Specimens examined in this study were recovered from well localities 48 (1 specimen), 51 (3 specimens), 53 (1 specimen).

Types.—Holotype, USNM 180495.

Limacina pygmaea (Lamarck)
Plate 3, figures 14, 15

Ampullaria pygmaea Lamarck, 1804, p. 30.
Spirialis pygmaea (Lamarck). Deshayes, 1862, p. 520.
Spirialis bernayi Laubrière, 1881, p. 377, pl. 8, fig. 5.
Spirialis parisiensis Watelet and Lefevre, 1885, p. 101, pl. 5, figs. 3a–c.
Spirialis pygmaea (Lamarck) var. *pezanti* Cossmann, 1913, p. 238.
Spiratella pygmaea (Lamarck). Curry, 1965, p. 362, figs. 18a–b, 19.

Description.—

Shell small, smooth, sinistrally coiled, almost globular. Spire of about four whorls. The relative height of the spire is variable, from flush to nearly half of the height of the shell, suture impressed. Umbilicus narrow. Outer lip thin, not expanded, in approximately the same plane as the axis. Adaxial wall of the shell gently folded spirally but not thickened. Inner (columellar) lip expanded towards the axis.

Dimensions. Height about 1.7 mm; width, about 1.5 mm (Curry, 1965).

Measurements.—Average of five specimens: height, 1.0 mm; width, 1.0 mm; height of aperture, 0.8 mm; spiral angle, 103°.

Discussion.—Curry's illustrations of *Spiratella pygmaea* show a species with an apical angle of about 115°. The specimens from Texas are different from those illustrated by Curry in being as wide as high, in being smaller, and in having a lateral periphery which is sharper (less rounded) than the English specimens. The differences do not appear to be sufficient to warrant placing these forms in different species or subspecies.

Occurrence.—Middle Eocene. Very rare in the Stone City Formation at localities 11 and 12; more common in the Cook Mountain Formation, Wheelock Marl Member, at localities 16 and 18, and in Lutetian strata, Paris Basin, France, and England.

Material.—Specimens examined in this study were recovered from the Stone City Formation at localities 11 (3 specimens) and 12 (2 specimens), and from the Cook Mountain Formation, Wheelock Marl Member, at locality 16 (2 specimens) and 18 (11 specimens).

Types.—Hypotype, USNM 180496.

Limacina smithvillensis Hodgkinson, new species
Plate 3, figure 16

Etymology of name.—The species name refers to the location (Smithville, Texas) where this species was first found.

Description.—Shell small, with about five whorls, sinistrally coiled, smooth, naticiform, sutures depressed. Aperture a little more than half as wide as high, also a little more than half as high as the entire shell. Both inner and outer lip oblique to the shell axis. Umbilicus a small elongated slit mostly covered by the inner lip.

Measurements.—USNM 180497 (holotype): height, 1.5 mm; width, 1.1 mm; apical angle, 89°. Average of four other specimens: height, 1.4 mm; width, 1.0 mm; apical angle, 90°.

Discussion.—Similar to *Limacina nemoris* (Curry, 1965) but less umbilicate, also different in the character of initial whorls (the first 1½ whorls of *L. nemoris* are nearly planispiral). In *L. smithvillensis*, n. sp., the juvenile whorls are trochoid. In *L. nemoris*, the inner lip of the aperture is straight, whereas in *L. smithvillensis*, n. sp., it is curved and oblique to the shell axis. In overall shape, *L. smithvillensis* is also similar to *L. stenzeli*, n. sp., but the latter species has a large umbilicus, a columellar fold, and an outer lip that is produced submedially.

Occurrence.—Middle Eocene. Very rare in the Viesca Member of the Weches Formation at locality 8.

Material.—Specimens examined in this study were recovered from locality 8 (5 specimens).

Types.—Holotype, USNM 180497.

Limacina stenzeli Garvie, new species
Plate 4, figure 1

Etymology of name.—The species is named in honor of H. B. Stenzel, the geologist who did much to elucidate the geology and paleontology of Texas.

Description.—Shell minute, holostomatous, sinistral, thin and shining. Whorls 5¼, nucleus inflated and depressed, just visible above the plane of the next whorl. Postnuclear whorls showing lines of growth only, suture deeply impressed, bordered by a high rounded collar. Aperture elliptical, slightly flaring posteriorly and next to the umbilicus. Outer lip very slightly produced submedially and thickened behind the sharp outer edge. Umbilicus teardrop-shaped and bounded on the left by the inner lip; weak columellar fold present.

Measurements.—USNM 180498 (holotype): height, 2.8 mm; width, 2.0 mm; height of aperture, 1.4 mm; width of aperture, 0.8 mm; apical angle, 77°; 6 whorls. Average of 20 other specimens: height, 1.7 mm; width, 1.5 mm; height of aperture, 1.2 mm; width of aperture, 0.6 mm; apical angle, 81°; 4.6 whorls.

Discussion.—This species is similar to *Limacina choctavensis* (Aldrich, 1887), but the umbilicus of the latter species is larger, and there is no columellar fold. *Limacina stenzeli* would seem to be the species figured but not described in Stenzel (1953, p. 82, fig. 42).

Occurrence.—Early Eocene. Reklaw Formation, Marquez Shale Member, locality 2. The form figured by Stenzel is from locality 4.

Material.—One-hundred-twenty-two specimens have been collected from locality 2.

Types.—Holotype, USNM 180498.

Limacina taylori (Curry)
Plate 4, figure 2

Spiratella taylori Curry, 1965, p. 363, figs. 21a, b; Curry, 1981, p. 37, pl. 1, figs. 3a–b.
Spiratella sp. Venables, 1963, p. 262.

Description.—

Internal mould in pyrite of a small, sinistral, naticiform, umbilicate shell, with a spire of 4½ turns forming one-quarter of the total height of the shell. First turn almost planispiral, later turns with a spire angle of about 100°. Whorl profile rounded, apical and abapical portions of the profile somewhat flattened, giving the whole shell a somewhat angulate appearance. Shell smooth, though in some moulds faint spiral ridges are present in the neighbourhood of the periphery. Apertural features difficult to distinguish because only faint traces of growth-lines have been seen in some specimens. However these suggest that the aperture lies in the plane of the axis and that the outer lip is sharp and slightly sinuous. Inner (columellar) lip has a slight fold as described in *L. pygmaea*.

Dimensions of holotype. Height, 2.5 mm; width, 2.3 mm. Topotypes may range up to 3 mm or more. (Curry, 1965).

Measurements.—Average of five specimens: height, 1.8 mm; width, 1.8 mm; aperture height, 1.2 mm; aperture width, 0.7 mm; spiral angle, 100°; 4.5 whorls.

Discussion.—The characters of our specimens are similar to those described for *Limacina taylori* by Curry, even though the species was described from pyritic molds. Curry's specimens (from England) and our specimens are the same size, possess the same apical angle, and have a weak columellar fold. This species can be distinguished from *L. stenzeli*, n. sp. by its smaller size, more globose form, and by the round umbilicus which is not covered by the reflected inner lip.

It is interesting that we found *Limacina taylori* in the Taylor Branch of Two Mile Creek. The species was named, however, after Mr. J. E. Taylor, who collected the type specimens from the seashore at Bognor Regis, Sussex, England.

Occurrence.—Early Eocene. The holotype is from the seashore at Bognor Regis, Sussex, and is believed to have come from the Beetle Bed of the London Clay (Venables, 1963, p. 252). Our specimens are from the Reklaw Formation at locality 3.

Material.—Specimens examined in this study were recovered from the Marquez Shale Member of the Reklaw Formation at locality 3 (8 specimens).

Types.—Holotype, BM(NH) GG 7101; Hypotype, USNM 180499.

Limacina texana Garvie and Hodgkinson,
new species
Plate 4, figures 3–6

Etymology of name.—The species name refers to the location (Texas) where this species was first found.

Description.—Shell small, smooth. Whorls 4⅛, sinistrally coiled. Aperture reniform, about one-half as wide as high, with a pronounced reflected outer lip and a slight columellar fold. Dorsal side flat to slightly depressed.

Measurements.—USNM 180500 (holotype): height, 2.0 mm; width, 2.4 mm; height of aperture, 2.0 mm; width of aperture, 0.9 mm.

Discussion.—*Limacina texana* resembles *Limacina wechesensis*, n. sp., but the shoulders of that species are much more rounded, and it lacks the columellar fold and the reflected outer lip. It also resembles *Limacina augustana* (Gardner, 1951), but because the holotype of Gardner's species is an internal mold, exact comparisons are difficult to make. In general, it appears that the aperture of *L. texana* comprises a larger portion of the test and that it is higher in relation to its width than *L. augustana*.

Occurrence.—Early Eocene. Marquez Shale Member of the Reklaw Formation, locality 3.

Material.—Specimens examined in this study were recovered from the Marquez Shale Member of the Reklaw Formation at locality 3 (33 specimens).

Types.—Holotype, USNM 180500; paratype, USNM 180501.

Limacina tutelina (Curry)
Plate 4, figures 7, 8

Spiratella tutelina Curry, 1965, p. 363, figs. 20a–b.

Description.—

Shell small, smooth, sinistral, oval-conic, with a spire forming one-half or more of the height of the shell. Spire is markedly cyrtoconoid and has an apical angle of about 40°. Whorl profile rounded, umbilicus narrow. Aperture lies in the plane of the axis of the shell; outer lip is slightly sinuous, apparently not expanded.

Dimensions of holotype: height, 3.5 mm; width, 1.9 mm (Curry, 1965).

Measurements.—BM(NH) GG 7102 (holotype): apical angle, 40°. Average of five North American specimens: apical angle, 42°.

Discussion.—In nearly all respects the specimens from eastern Canada offshore locations resemble the illustration of the holotype. The shape and proportions of *Limacina tutelina* are very close to *Altaspiratella bearnensis* (Curry, 1981), but there are significant differences in the characteristics of the aperture. *Limacina tutelina* lacks the well-developed flange and sulcus that are found in *A. bearnensis*.

Occurrence.—Early Eocene–late Eocene. Early Eocene specimens are described by Curry (1965) from the middle or upper London Clay (Ypresian) of England. This species is rare in several wells on the Nova Scotian Shelf off eastern Canada. These include middle–late Eocene specimens from well localities 48 (1,680 ft) and 50 (2,640 ft).

Material.—Specimens examined in this study were recovered from well localities 48 (1,680 ft: 1 specimen) and 50 (2,640 ft: 1 specimen).

Types.—Holotype, BM(NH) GG 7101; hypotypes, USNM 180502, 180503.

Limacina voluta Hodgkinson, new species
Plate 4, figure 9

Etymology of name.—The species name refers to the spiraled nature of the test (L. *voluta* = spiral).

Description.—Shell small, about 4½ whorls, smooth, sinistrally coiled. Aperture oval, a little less wide than high and a little more than half as high as the entire shell. Whorls rounded, sutures strongly depressed. Umbilicus small.

Measurements.—USNM 180504 (holotype): height, 1.8 mm; width, 1.7 mm; spiral angle, 86°. Average of ten specimens: height, 1.2 mm; width, 1.2 mm; spiral angle, 94°.

Discussion.—Most high-spired species of *Limacina* have sutures that are not nearly as depressed as those of *L. voluta*, n. sp.

Occurrence.—Eocene. Holotype from cuttings at well locality 50 (3,720 ft). This specimen was recovered from a horizon which is Cretaceous in age, but probably represents caved material from the overlying Eocene section. Other specimens were obtained from Eocene sediments. Late Eocene, well localities 45 (6,880 and 7,000 ft), 49 (4,880 ft), 53 (2,250 ft), and 56 (2,130 ft). Middle Eocene: localities 50 (2,580 and 2,640 ft) and 56 (2,340 ft). Early Eocene: locality 53 (2,820 ft).

Material.—Specimens examined in this study were recovered from well localities 45 (2 specimens), 49 (2 specimens), 50 (3 specimens), 53 (2 specimens), and 56 (2 specimens).

Types.—Holotype, USNM 180504.

Limacina wechesensis Hodgkinson, new species
Plate 5, figures 1–7; Plate 6, figure 1

Etymology of name.—The species name refers to the formation (Weches) from which this species was first collected.

Description.—Shell small, smooth, sinistrally coiled, slightly depressed to slightly raised apical whorls. All whorls visible and about equally involute. Upper part of all whorls in about the same plane. Aperture simple, outer lip semicircular, inner lip almost straight and essentially parallel to the shell axis. Umbilicus small (⅐ to ⅙ of shell diameter) and circular, but on some specimens appears to be teardrop-shaped because of the way the inner lip meets the outer wall of the preceding whorl.

Measurements.—USNM 360337 (holotype): height, 0.8 mm; width, 1.1 mm; width of umbilicus, 0.2 mm; 3.6 whorls. Average of 20 specimens: height, 0.8 mm; width, 1.0 mm; width of umbilicus, 0.1 mm; 3.5 whorls.

Discussion.—This form bears a close resemblance to the Recent pteropod *Limacina helicina* (Phipps, 1774) but *L. wechesensis*, n. sp. has a lower spire, a differently shaped aperture, and is only about one-half the size of *L. helicina*. It is also similar to *L. elevata* Collins, 1934 from the middle Miocene of Veracruz, Mexico, but that form has a depressed apex and a distinctly elevated protoconch. *Limacina wechesensis* is also similar to *L. texana*, n. sp. from the Reklaw Formation, but this latter form is more quadrate, has a columellar fold, and a strongly developed lip.

Occurrence.—Middle Eocene. Common in the Weches Formation at localities 7 and 8.

Material.—Specimens examined in this study were recovered from localities 7 (12 specimens), and 8 (38 specimens, including the holotype).

Types.—Holotype, USNM 360337.

Genus **SKAPTOTION** Curry, 1965

Skaptotion Curry, 1965, p. 368.

Description.—

> Shell small, smooth, discoidal, sinistral, involute except for the first whorl or so, which are [*sic*] turbiniform. Shell wall very thin, apertural lip of adult shell thickened and expanded into a platform (Curry, 1965).

Middle–late Eocene.

Discussion.—We have collected many specimens of *Skaptotion* and have found considerable variation in these forms. Only four of these have been recognized as existing or new species; namely *S. andersoni* (Gardner, 1927), *S. nitens* (I. Lea, 1833), *S.? reklawensis*, n. sp., and *S. spirale*, n. sp.

There is much variation, especially in the depth of apical depression and umbilicus, and the degree to which the whorls are involute. Probably *Skaptotion* could be studied best in thin-section. Statistical data could then be obtained on whorl shape, number of whorls per unit diameter, angle of the apical depression and umbilicus, and height/width ratios of the shell and its aperture.

Type species.—*Skaptotion bartonense* Curry, 1965, from the Barton Beds (Bartonian), Hampshire, England.

Skaptotion andersoni (Gardner)
Plate 6, figures 2–4

Planorbis andersoni Gardner, 1927, p. 377, figs. 36, 37; Gardner, 1951, p. 11; Henderson, 1935, pp. 19, 38, 244; Palmer, 1937, p. 504, pl. 76, figs. 1, 2 (copies Gardner); Palmer and Brann, 1966, p. 826.

Description.—

Shell small, exceedingly thin, discoidal, depressed on the umbilical, and to a lesser degree, on the apical surface. Whorls five in number, the two earliest included in the protoconch; first whorl of conch constricted at its opening and depressed below the plane of the protoconch; later whorls increasing rather rapidly in diameter and altitude; body relatively high, broadly rounded along the periphery; obtusely rostrate on both the apical and umbilical surfaces. Surface sculpture not developed. Aperture reniform, adnate to the body wall upon the inner surface; less produced and more sharply rounded anteriorly than posteriorly. Umbilical surface funnel-shaped and somewhat scalariform, revealing all of the obtusely carinated posterior extremities of the component whorls.

Dimensions: Altitude, 1.0 millimeter; maximum latitude, 2.2 millimeters; latitude, at right angles to maximum latitude, 2.0 millimeters (Gardner, 1927).

Discussion.—Gardner (1951) and Curry (1965) have suggested that *Skaptotion andersoni* is a pteropod, rather than a fresh-water planorbid gastropod as earlier reported. This conclusion appears valid since this species is found in the Cook Mountain Formation, which is a marine unit containing numerous other marine invertebrates and very few, if any, freshwater gastropods. *Skaptotion andersoni* is also similar to *Skaptotion nitens* (I. Lea, 1833), but these two forms appear to be separate and distinct species. The apex of *S. andersoni* is much more depressed than it is in specimens of *S. nitens*. The apertural lip is not preserved on the holotype and has not been described from other specimens. If *S. andersoni* has a distinct lip, it should be placed in the genus *Skaptotion*. We are tentatively placing it in this genus because of its similarity to *S. nitens* both in shape and size.

Occurrence.—Middle Eocene. Holotype from Claiborne Group, Cook Mountain Formation at locality 15. Specimens are fairly common at this locality (Gardner, 1927).

Material.—We are not aware of any specimens in collections other than the holotype in the USNM.

Types.—Holotype, USNM 369235.

Skaptotion nitens (I. Lea)
Plate 6, figures 5–10

Planaria nitens I. Lea, 1833, p. 124, pl. 4, fig. 113; H. C. Lea, 1849, p. 104; Conrad, 1865, p. 33; Conrad, 1866, p. 11; Dall, 1892, p. 332; G. D. Harris, 1895, p. 30.

Cyclostrema (*Daronia*) *nitens* (I. Lea). de Gregorio, 1890, p. 138, pl. 12, fig. 64; Cossmann, 1893, p. 21.

Homalaxis sp. Burton, 1933, p. 157.

"*Planaria*" *nitens* (I. Lea). Palmer, 1937, p. 474, pl. 90, fig. 17; Palmer and Brann, 1966, p. 826.

Skaptotion bartonense Curry, 1965, p. 368, figs. 11a–c, 13a–b, 14.

Description.—

Shell discoidal, impressed above and below, smooth and shining, diaphanous; substance of the shell very thin and fragile; whorls three, convex; mouth lunate; outer lip reflected. Length less than $\frac{1}{20}$th; breadth less than $\frac{1}{20}$th of an inch (I. Lea, 1833).

Curry (1965) makes the following additional oberservations:

> Exhibits the characters of the genus . . . . The first two whorls are turbiniform; two later whorls are discoidal and involute, with an umbilicus on each side. The adapical umbilicus has a spiral angle of about 240°, the abapical umbilical angle is variable between about 30° and 90°. Shell wall gently rounded, aperture kidney-shaped, apertural lip approximately in one plane which is inclined forward abapically at about 10° to the axis of the shell. In the juvenile shell, the lip is very thin and not expanded. When the shell has attained full size, the lip becomes expanded and thickened to form a heavy flange, which is much stronger than the rest of the shell and is frequently found fossil in a detached state.

Measurements.—Average of 20 specimens from the Stone City Formation at locality 11: height, 1.0 mm; width, 1.4 mm; average of 20 specimens from the Gosport Sand at locality 26: height, 0.9 mm; width, 1.4 mm. Curry's type of *Skaptotion bartonense* [BM(NH) GG 7103] has a height of 1.8 mm and a width of 2.5 mm.

Discussion.—Because *Skaptotion nitens* was described long before *S. bartonense*, it has priority. Shells from the Gosport Sand differ slightly from those found in other (older) beds. They are a little smaller and have fewer whorls; the aperture is more rounded and the flanged lip is simpler and less well-developed. The lip of those specimens found in the Cook Mountain Formation of Texas and the Barton Beds of England is wider and more pointed at the base (Pl. 6, figs, 8–10). These differences are consistent, but so slight that they do not warrant division of these forms into two species or subspecies.

The axis of the nuclear (juvenile) whorls of *S. nitens* is invariably tilted at an angle of about 35° to the axis of the mature shell and part of the second whorl is completely involute and hidden by the third whorl.

Occurrence.—Middle–late Eocene. Middle Eocene specimens are found in the Lisbon Formation at locality 6; in the Stone City Formation at localities 11 and 12; in the Wheelock Member of the Cook Mountain Formation at localities 17 and 18; in the Hurricane Lentil of the Cook Mountain Formation at locality 23; in the Gosport Sand at localities 26, 27 (holotype), and 28; at well localities 50 (2,580 and 2,640 ft); 51 (1,400 ft); 53 (2,240 ft); and 54 (4,700 ft); in England in the Upper Bracklesham Beds; and in the North Sea Basin. Late Eocene shells are found in the Barton Beds at

Hampshire, England; in the North Sea Basin; and at well localities 48 (between 1,740 and 2,220 ft); and 51 (between 1,070 and 1,250 ft). For additional locality data, see Curry (1965, p. 368); and Janssen and King, (1988, p. 360, figs. 188, 190, 191).

Material.—Specimens examined in this study were recovered from the upper Lisbon Formation at locality 6 (1 specimen); from the Stone City Formation at localities 11 (19 specimens) and 12 (23 specimens); from the Cook Mountain Formation, Wheelock Marl Member at localities 17 (3 specimens) and 18 (12 specimens); from the Cook Mountain Formation, Hurricane Lentil at locality 23 (30 specimens); from the Gosport Sand at localities 26 (800 specimens), 27 (2 specimens), and 28 (3 specimens); from well localities 48 (1,740 ft, 1 specimen; 1,860 ft, 1 specimen; 2,220 ft, 3 specimens); 50 (2,580 ft, 6 specimens; 2,640 ft, 7 specimens); 51 (1,070 ft, 2 specimens; 1,100 ft, 1 specimen; 1,130 ft, 1 specimen; 1,160 ft, 1 specimen; 1,190 ft, 1 specimen; 1,220 ft, 3 specimens; 1,250 ft, 3 specimens; 1,400 ft, 1 specimen); 53 (2,240 ft, 1 specimen); and 54 (4,700 ft, 1 specimen). We also have six specimens from the Barton Beds of England in our collection.

Types.—Holotype, ANSP 5635. The holotype specimen is broken and lacks the flanged lip, but the nuclear and mature whorls are exactly like those of the specimens we have collected from the Gosport Sand. There is no doubt that they are the same species and that they are pteropods. Hypotypes, USNM 360338, 360339. Curry's type of *S. bartonense* is BM(NH) GG 7103.

Skaptotion? **reklawensis** Garvie, new species
Plate 7, figures 1–4

Etymology of name.—The species is named after the formation in which it occurs.

Description.—Shell small, thin–shelled, globose. Whorls three or four, rapidly expanding, surface smooth with microscopic collabral growth lines that swing back feebly over the midpoint of the whorls. Biumbilicate, above small and circular, below moderately wide, showing the previous whorls. Aperture arcuate, produced above and below, below wider and flaring. Labium with very thin callus deposit, hardly distinguishable from the rest of the shell.

Measurements.—USNM 360340 (holotype): height, 2.3 mm; width, 2.4 mm. Largest specimen (paratype, USNM 360380): height, 3.0 mm; width, 3.2 mm.

Discussion.—This is a very strange species, which superficially resembles a small nautiloid, but broken specimens show no chambers or siphuncle. The internal whorls seem to be partially resorbed, and one broken specimen shows a very thin internal whorl that is apparently entirely composed of nacre. The shell is composed of two layers, an inner one with no observable structure, and a thicker outer one that shows fine collabral striae over the entire surface. A very closely allied species is *Skaptotion cossmanni* Curry, 1981, from the middle Eocene (Lutetian) of southern France. The microstructure of the shell of both species is the same. The aperture of the French specimens flares a little more.

Due to their extreme fragility, attempts at cleaning have usually broken the specimens.

This form and *S. cossmanni* Curry, 1981 appear to have dextral, rather than sinistral, coiling. The specimens collected from the Reklaw Formation of Texas have very deep umbilici, and we could not observe the juvenile whorls. Broken specimens show that if the species indeed has sinistral coiling, the dorsal (posterior) umbilicus must be much deeper than the ventral (anterior) umbilicus. This would be very unusual.

Occurrence.—Early–middle? Eocene. From the Reklaw Formation at locality 2; several specimens, with a slightly more planispiral shape (Pl. 7, figs. 3, 4), were collected by Hodgkinson from the Weches Formation at locality 8.

Material.—Specimens examined in this study were recovered from localities 2 (18 specimens, including the holotype and paratype) and 8 (2 specimens).

Types.—Holotype, USNM 360340; paratype, USNM 360380.

Skaptotion spirale Hodgkinson, new species
Plate 7, figures 5–8

Etymology of name.—This species was named for its spiral shape (L. *spiralis* = spiral).

Description.—Shell small, smooth, almost planispiral, juvenile whorls turbiniform, axis of nuclear whorls just barely inclined to axis of mature shell, part of second or third whorl completely covered by the succeeding whorl. Whorls involute, spire strongly depressed and nearly as deep as the umbilicus. Aperture reniform. Aperture of adult shell may have a lip or flange, but no complete specimens were found.

Measurements.—USNM 360341 (holotype): height, 0.5 mm; width, 0.8 mm. Average of ten specimens: height, 1.1 mm; width, 1.9 mm.

Discussion.—In contrast to *Skaptotion nitens* (I. Lea, 1833), *S. spirale* is more nearly planispiral, its apical depression and the umbilicus are much narrower, and its whorls are much more involute. *Skaptotion andersoni* (Gardner, 1927) is as nearly planispiral as *S. spirale*, n. sp., but, like *S. nitens*, differs in being less involute, and consequently has a more open apical depression and umbilicus.

Occurrence.—Eocene. This form was found at the following localities: Undifferentiated Eocene, well locality 49 (5,380 ft); middle Eocene, well localities 41

(9,590 ft: Sparta Formation), 43 (11,190 ft: Cockfield Formation), and 51 (1,260 ft, the holotype).

Material.—Specimens examined in this study were recovered from well localities 41 (1 specimen), 43 (1 specimen), 49 (1 specimen), and 51 (1 specimen).

Type.—Holotype, USNM 360341.

Family **CAVOLINIIDAE** Gray, 1850

Description.—Shell thin, vitreous, variable in shape, often bilaterally symmetrical with a median axis, sometimes with radial symmetry, never strongly coiled, non-operculate. Shell relatively large (up to 15 mm long). May be conical, pyramidal, or cylindrical (bulbous). Eocene–Recent.

Subfamily **CLIONAE** Jeffreys, 1869

Description.—Shell a long cone, needle-like; oval, round, or triangular in cross-section. Embryonic shell usually retained during the entire life of the animal, except for that of the Recent genus *Hyalocylis* Fol, 1875 and in some cases that of the fossil form *Euchilotheca* Fischer, 1882. Dorsal and ventral differentiation not well-developed. Eocene–Recent.

Discussion.—Recent pteropods in this subfamily include *Clio* Linnaeus, 1767, *Creseis* Rang, 1828, *Hyalocylis*, and *Styliola* Gray, 1850. Fossil forms are *Bovicornu* Meyer, 1886, *Camptoceratops* Wenz, 1923, *Cheilospicata* Hodgkinson, n. gen., *Clio*, *Creseis*, *Euchilotheca*, *Hyalocylis*, and *Praehyalocylis* Korobkov *in* Korobkov and Makarova, 1962. *Euchilotheca* has an internal septum and some individual specimens of this species have a truncated apex. In these respects, it is similar to genera in the subfamily Cuvierininae, but because the apex is usually retained, we include this form in the subfamily Clionae.

Genus **BOVICORNU** Meyer, 1886

Description.—

> Shell minute, subulate, pointed, spirally contorted (Meyer, 1886).

Collins (1934) expanded the description based on Meyer's type specimen as follows:

> Shell very small, slender, evenly tapering conical and spirally twisted, circular in section. The apex of the shell is quite sharp, a more or less well defined bulb-like inflation is developed just above the tip and separated from the more mature part of the shell by a well defined constriction.

Eocene–Oligocene.

Discussion.—Meyer erected a new genus because the type species is spirally twisted and thus differs from the straight or slightly curved, needle-like species of *Creseis* Rang, 1828. Subsequent authors have suggested that these unusual forms are: (1) perhaps synonymous with *Euchilotheca* Fischer, 1882, from the Paris Basin Eocene (Collins, 1934, p. 165; G. D. Harris and Palmer, 1946–1947, p. 464); (2) synonymous with *Camptoceratops* Wenz, 1923 (Curry, 1965, p. 360); or (3) the second stage of *Meioceras* Carpenter, 1858, a caecid gastropod (Dall, 1892, p. 302 [in part]; Cossmann, 1912, p. 155). There is little doubt, however, that *Bovicornu* is a pteropod and is not closely related to any of these. *Euchilotheca* has a septum that is either internal or at the truncated apex. *Camptoceratops* has a lipped aperture and the shells are more inflated than those of *Bovicornu*. *Meioceras* has a much thicker shell wall, a lipped aperture, and a septum at the truncated apex. We found none of these features in the holotypes of the two species in this genus, none in the numerous specimens of *Bovicornu eocenense* Meyer, 1886 that we collected from the Red Bluff Formation at locality 33, and none in specimens from oil and gas wells in Louisiana.

Type species.—*Bovicornu eocenense* Meyer, 1886.

Bovicornu eocenense Meyer
Plate 7, figures 9, 10

Bovicornu eocenense Meyer, 1886, p. 79, pl. 3, fig. 12; Cossmann, 1893, p. 51; Collins, 1934, pp. 212, 213, pl. 9, fig. 3; pl. 13, fig. 5; MacNeil and Dockery, 1984, pp. 243, 244, pl. 66, figs. 22–25, pl. 67, figs. 1–6; Dockery and Zumwalt, 1986, pp. 9, 10, pl. 1, figs. 1–6.

Meioceras eocenense (Meyer). Dall, 1892, p. 302 (in part).

Description.—

> Smooth, somewhat inflated at the closed end; section circular. Locality — Red Bluff, Miss. (Meyer, 1886).

We expand the *Description* as follows: Exterior smooth and polished, apex bears a prominent apical bulb separated from the rest of the shell by a definite constriction. Shell conical, spirally twisted and circular in cross-section, aperture round, not thickened.

Measurements.—USNM 644596 (holotype): length, 2.8 mm; maximum diameter, 0.7 mm.

Discussion.—We have collected numerous specimens from the Red Bluff Formation at the type locality, the source of Meyer's type specimen. Most of them have tighter coiling than the holotype.

Except for the spiral coiling, *B. eocenense* is almost identical to *Creseis hastata* (Meyer, 1886). At equivalent lengths, the diameters of these two forms are almost equal, as are the shapes and sizes of the apical bulbs.

Occurrence.—*Bovicornu eocenense* was so named because it came from the Red Bluff Formation which, in 1886, was regarded as being Eocene in age. The unit is now regarded as of early Oligocene age (MacNeil, 1944; Mancini, 1979; Dockery, 1986). Eocene specimens have been described from the Upper Yazoo Formation at locality 33 (Dockery and Zumwalt, 1986, p. 9).

Material.—Specimens examined in this study were recovered from locality 34 (30 specimens).

Type.—Holotype, USNM 644596.

Bovicornu gracile Meyer
Plate 7, figures 11, 12

Bovicornu gracile Meyer, 1887, p. 9, pl. 2, fig. 17; Collins, 1934, p. 213, pl. 9, fig. 8; pl. 13, fig. 4; G. D. Harris and Palmer, 1947, p. 464, pl. 62, figs. 21, 22 (copies Collins); Palmer and Brann, 1965, p. 356.
Caecum (*Meioceras*) *gracile* (Meyer). Cossmann, 1912, p. 155.

Description.—

> Schlanker und stärker spiralig gewunden als *Bovicornu eocenense* M'r. von Red Bluff; auch fehlt die auftreibung an der Spitze.
>
> Diese Art dürfte typischer für das Genus *Bovicornu* sein, als die zuerst von mir beschriebene (Meyer, 1887).

Free translation.—Slenderer and more strongly twisted than *Bovicornu eocenense* Meyer from Red Bluff; also lacks the swelling at the apex.

This species is typical of the genus *Bovicornu*, which was first described by me [Meyer, 1887].

We revise the *Description* as follows: exterior smooth and polished, apex bearing a slight bulb-like inflation separated from the remainder of the shell by a weak, but definite constriction. Shell conical, spirally twisted and circular in cross-section, aperture round and simple.

Measurements.—USNM 638880 (holotype): length, 2.7 mm; maximum diameter, 0.5 mm.

Discussion.—Meyer noted that this species is slenderer and more strongly twisted than is *Bovicornu eocenense* Meyer, 1886 from locality 33. Most specimens of *B. eocenense* that we collected from this same locality are more strongly twisted than the holotype and the two species cannot be distinguished on the degree of twisting. They can, however, easily be identified when the apical bulb is preserved. The bulb of *B. gracile* is small and oval, while that of *B. eocenense* is larger and has a distinctive shape. The illustration of the apex of *B. gracile* by Collins (1934) is misleading. The tip of the holotype is smaller and more nearly oval than shown in his figure. Differences between the apices of these two species can best be observed by examining the holotypes or by referring to our photographs of these specimens.

The only noticeable difference between *Creseis simplex* (Meyer, 1886) and *B. gracile* is the loose spiral coiling of the latter species. Most specimens of *C. simplex* are straight or slightly curved, but a few specimens do have a very slight spiral (Pl. 9, fig. 7). In all other respects they are nearly identical. The bulbs are very similar and the maximum width of the shell at equivalent lengths (untwisted length of *B. gracile*) is almost the same. There is a close relationship between these two species.

Even though we recognize that *Bovicornu* may be little more than a coiled species or variety of *Creseis* Rang, 1828, we follow the previous division of these forms into two genera because nearly all specimens of *Creseis* are straight or slightly curved and a only few are slightly coiled. All specimens of *Bovicornu* are strongly coiled. This difference is easily recognized.

Occurrence.—Late Eocene. Moodys Branch Formation at locality 31, *fide* Collins (1934, p. 214), *not* locality 34 as stated in Meyer (1887, p. 9).

Material.—The specimen examined in this study was recovered from locality 31.

Type.—Holotype, USNM 638880.

Genus **CAMPTOCERATOPS** Wenz, 1923

Description.—Shell conical, smooth, apical end straight with the remainder of shell prominently coiled in an open spiral. Aperture of mature shell may be thickened and expanded and may be extended into a broad test or rostrum [*e.g.*, *Camptoceratops prisca* (Godwin-Austen, 1882)] or may have a strongly reflected lip (*e.g.*, *Camptoceratops americanus* Garvie, n. sp.). Apex conical, slightly swollen at the tip. No evident septae. Eocene.

Type species.—*Camptoceratops prisca* (Godwin-Austen, 1882).

Camptoceratops americanus Garvie, new species
Plate 7, figures 13–15

Etymology of name.—The specific name notes the first reported occurrence of this genus in North America.

Description.—Shell small, smooth, initially straight, followed adorally by about 1½ sinistral whorls that are prominently coiled in an open spiral. Aperture oval, bordered by a prominent flange. The aperture is incomplete but enough is preserved to show a well-developed, anteriorly produced, outer lip. A thickened columella is present at the apertural end.

Measurements.—USNM 360342 (holotype): length, 2.8 mm; maximum width, 0.9 mm. Average of holotype and three other specimens: length, 2.8 mm; maximum width, 0.8 mm.

Discussion.—This is the second species assigned to the genus. The type species, *C. prisca* (Godwin-Austen, 1882), is from the London Clay on the Isle of Sheppey in England. Curry (1981) also reported *C. prisca* from the lower Eocene of Gan in southwestern France. *Camptoceratops americanus*, n. sp. can be distinguished from *C. prisca* by the far greater development of the reflected outer lip and lack of a broad tooth or rostrum. *Bovicornu gracile* Meyer, 1887 and *Bovicornu eocenense* Meyer, 1886 are also spirally twisted, but show no reflection and thickening of the outer lip.

Occurrence.—Early Eocene. Rare in the Reklaw Formation at localities 2 and 3.

Material.—Specimens examined in this study were recovered from localities 2 (10 specimens, including the holotype and paratype) and 3 (1 specimen).

Types.—Holotype, USNM 360342; paratype, USNM 360343.

Genus **CHEILOSPICATA** Hodgkinson, new genus

Etymology of name.—The generic name is derived from Gr. *cheilos* = lip, rim + L. *spica* = ear of grain, point, spear.

Description.—Shell small, conical, smooth and without ornamentation. Aperture circular, bordered by a distinctive rounded flange. Widest at the aperture. Middle Eocene.

Discussion.—*Cheilospicata*, n. gen. is similar to *Creseis* Rang, 1828, but that genus has a simple aperture without a lip or flange. The genus is also similar to *Tibiella* Meyer, 1884 and *Euchilotheca* Fischer, 1882, but these genera have basal septa. *Euchilotheca* also has an axis that describes a gentle sinistral spiral and an aperture that may have a slight lip, but does not bear a distinct flange. We have not observed these shell characters in *Cheilospicata*.

Type species.—*Cheilospicata repanda* Hodgkinson and Garvie, n. sp., from the Stone City Formation at locality 12.

Cheilospicata repanda Hodgkinson and Garvie, new species
Plate 8, figures 1–6

Etymology of name.—The species name refers to the characteristics of the lip (L. *repandus* = bent backward).

Description.—Shell small, tubular, straight or slightly curved. Shell walls essentially parallel in the mature portion of the shell, smooth. Apertural end thickened; a recurved lip borders the shell just below the apertural end.

Measurements.—USNM 360344 (holotype): length (apical bulb missing), 6.9 mm; maximum diameter (including lip), 1.3 mm; maximum diameter (excluding lip), 1.1 mm. Average of ten specimens: maximum diameter (including lip), 1.4 mm; maximum diameter (excluding lip), 1.2 mm.

Discussion.—The thick lip surrounding the apertural end makes that portion of the shell much stronger than the thin apical end. We have, however, found several shells with only the apical bulbs missing.

Occurrence.—Middle Eocene. Holotype, paratypes (USNM 360345, 360346, 360348), and other specimens from the Stone City Formation at locality 12. Paratype (USNM 360347) and several other specimens from the same formation at locality 11.

Material.—Specimens examined in this study were recovered from localities 12 (13 specimens: most are apertural fragments, but two are nearly complete) and 11 (3 specimens, which are apertural fragments).

Types.—Holotype, USNM 360344; paratypes, USNM 360345–360348.

Genus **CRESEIS** Rang, 1828

Description.—Shell long and conical; straight, slightly curved, or with a very slight sinistral spiral; circular in cross-section, smooth exterior. Aperture at widest part of shell, sharp-edged, not constricted. Apex retained. One or two slight constrictions near the apical end of the shell. Middle Eocene–Recent.

Type species.—*Creseis virgula* Rang, 1828, a Recent pteropod.

Creseis corpulenta (Meyer)
Plate 8, figures 7–9

Styliola corpulenta Meyer, 1887, p. 9, pl. 2, fig 16; Cossmann, 1893, p. 51.

Meioceras eocenense (Meyer). Dall, 1892, p. 302 (in part).

Creseis corpulenta (Meyer). Dall, 1892, p. 430; MacNeil and Dockery, 1984, p. 243, pl. 66, figs. 19–21.

Caecum (*Meioceras*) *corpulenta* (Meyer). Cossmann, 1912, p. 155.

Cleodora (*Creseis*) *corpulenta* (Meyer). Collins, 1934, p. 206, pl. 9, fig. 4; pl. 13, fig. 3.

Clio (*Creseis*) *corpulenta* (Meyer). G. D. Harris and Palmer, 1947, p. 462, pl. 62, figs. 25, 26; Palmer and Brann, 1965, p. 357.

Description.—

Verlangert kegelformig; gerade oder schwach gebogen, Querschnitt kreisformig. Spitzes Ende mit Auftreibung. Diese Art ist seltener als *Styliola simplex* Mr. von derselben Lokalität (Meyer, 1887).

Free translation.—Elongated, cone-shaped, straight or slightly curved. Circular in cross-section. Apex swollen. This species is rarer than *Styliola simplex* Meyer from the same locality.

Measurements.—USNM 638879 (holotype): length, 3.3 mm; maximum diameter, 1.0 mm.

Discussion.—The holotype is very small. The shell is smooth, slightly curved, and expands rapidly with increased length. The apex of the shell has a bulb very similar to that of *Creseis hastata* (Meyer, 1886), and *Bovicornu eocenense* Meyer, 1886. Although the apical ends of *C. corpulenta*, *C. hastata* and *B. eocenense* are very similar, there is no difficulty in distinguishing one species from the other. *C. corpulenta*, as the name suggests, has a much more expanded shell than the slenderer *C. hastata* and the slender, but twisted *B. eocenense*.

Occurrence.—Late Eocene–late Oligocene. From the middle to late Eocene Moodys Branch Formation at locality 31 (holotype); from the early Oligocene Byram Formation at locality 39; and from well locality 44 (late Oligocene: cuttings). This last occurrence is younger than other reported occurrences of *C. corpulenta*.

Material.—The pyritized, but well-preserved specimen examined in this study was recovered from well locality 44 (13,050–13,086 ft: cuttings).

Types.—Holotype, USNM 638879; hypotype, USNM 360349.

Creseis cylindrica Hodgkinson, new species
Plate 8, figures 10–14

Etymology of name.—The species name refers to the cylindrical nature of the apertural end.

Description.—Shell small, conical, tubular near the apertural end, straight or slightly curved, oval in cross-section, smooth, without ornamentation. Shell wall at aperture thickened on inner side, hence apertural end is stronger and more apt to be preserved. The sides of the mature portion of the shell are straight and almost parallel.

Measurements.—USNM 360350 (holotype): diameter at aperture, 1.2 mm. Longest specimen (USNM 360353): length, 9.8 mm; flattened apertural width, 1.7 mm. Average of 70 specimens: diameter at aperture, 1.3 mm.

Discussion.—The apertural ends of *C. cylindrica* are very similar in size and shape to those of *Tibiella reflexa*, n. sp., but the added apertural shell material in the latter species is on the outside of the shell and has a narrow open space between the two layers of shell material (Pl. 13, figs. 2, 3). A few specimens have a narrow outward-projecting lip. This lip is better developed in smaller tests and in specimens from the Stone City Formation. Specimens from this unit are geologically the oldest specimens of *C. cylindrica* collected.

Creseis cylindrica, n. sp. is assigned to the genus *Creseis* Rang, 1828 because the overall shape is very similar to other species of the genus. The thickened apertural end is not typical in this genus, and in this respect *C. cylindrica* has features noted in the genus *Tibiella* Meyer, 1884.

The shells of this species must have been abundant on the sea floor during certain times during the middle Eocene. Many specimens are found which contain a number of successively smaller nested shells (Pl. 8, fig. 12).

Occurrence.—Middle Eocene. The holotype, two paratypes, and additional specimens are from the Wheelock Member of the Cook Mountain Formation at locality 18. One paratype is from the Cook Mountain Formation, Wheelock Marl Member at locality 17. Other specimens from the Wheelock Marl were found at localities 16 and 19. The species is also found in the Stone City Formation at localities 11 and 12, and in the Hurricane Lentil of the Cook Mountain Formation at localities 22, 23, and 25.

Material.—Specimens examined in this study were recovered from localities 11 (5 specimens), 12 (18 specimens), 16 (3 specimens), 17 (1 specimen), 18 (66 specimens), 19 (5 specimens), 22 (8 specimens), 23 (6 specimens), and 25 (6 specimens).

Types.—Holotype, USNM 360350; paratypes, USNM 360351–360353.

Creseis hastata (Meyer)
Plate 9, figures 1–3

Styliola hastata Meyer, 1886, p. 78, pl. 3, fig. 11; de Gregorio, 1890, p. 15, pl. 17, figs. 56, 57.
Creseis hastata (Meyer). Dall, 1892, pp. 430, 432; MacNeil and Dockery, 1984, p. 243, pl. 66, figs. 6–13, 15–18.
Cleodora (*Creseis*) *hastata* (Meyer). Collins, 1934, p. 204, pl. 9, fig. 1; pl. 13, figs. 1, 2.
Clio (*Creseis*) *hastata* (Meyer). Shimer and Shrock, 1944, p. 517, pl. 213, figs. 32–34; G. D. Harris and Palmer, 1947, p. 463; Palmer and Brann, 1965, p. 357.

Description.—

> Shell subulate, nearly straight; section circular; closed end inflated (Meyer, 1886).
>
> The shell is very small, slender, conical, slightly arched, and the exterior smooth and polished. The tip of the shell is relatively sharp, with a prominent bulb-like swelling just above it. Length 2.25 mm; maximum diameter 0.4 mm (Collins, 1934).

Discussion.—The most characteristic feature of this species is the sharp point and prominent bulb at the apex. Although *C. hastata*, *C. corpulenta* (Meyer, 1887), and *Bovicornu eocenense* Meyer, 1886 have similar tips and bulbs, they are easily distinguished. *Creseis corpulenta* is much more inflated than the other species, and *B. eocenense* has a definite and prominent open coil.

Occurrence.—Middle Eocene to early Oligocene. Collins (1934) referred to Eocene specimens from the Moodys Branch Formation at localities 29 and 31. We have examined specimens from this same formation at localities 29 and 30. Both de Gregorio (1890) and Dall (1892) noted the occurrence of *C. hastata* in the Claiborne Eocene, but no specimens were found in our examination of Claiborne sediments (including the Gosport Sand, which previously was referred to as the Claiborne Sands).

The holotype and other specimens were collected from the Oligocene Vicksburg Group at locality 35. We have examined 11 Oligocene specimens (collected by C. Wythe Cooke and currently on deposit in the USNM) from the Mint Spring Formation at locality 36. We have also collected specimens from the basal part of the Bucatunna Formation (Oligocene), locality 37, and from the type section of the Byram Formation, locality 38. MacNeil and Dockery (1984) have figured Oligocene specimens from the Red Bluff Formation at locality 34; from the Mint Spring Formation at locality 36; from the Byram Formation at localities 39 and 40;

and from the Stampian (Oligocene), Gaas, Aquitaine Basin, France.

Material.—Specimens examined in this study were recovered from localities 29 (7 specimens) 30 (2 specimens), 37 (8 specimens), and 38 (24 specimens).

Types.—Holotype, USNM 644595.

Creseis simplex (Meyer)
Plate 9, figures 4–9

Styliola simplex Meyer, 1886, p. 78, pl. 3, fig. 10; Cossmann, 1893, p. 51.
Creseis simplex (Meyer). Dall, 1892, p. 430; MacNeil and Dockery, 1984, p. 243, pl. 66, fig. 14.
Creseis sp. Aldrich, 1895, p. 5, pl. 1, fig. 5.
Cleodora (*Creseis*) *simplex* (Meyer). Collins, 1934, p. 207, pl. 9, fig. 5; pl. 13, fig. 6.
Cleodora (*Creseis*) sp. cf. *C.* (*C.*) *hastata* (Meyer). Collins, 1934, p. 205, pl. 9, fig. 2.
Clio (*Creseis*) *simplex* (Meyer). G. D. Harris and Palmer, 1947, p. 463, pl. 62, figs. 23, 24; Palmer and Brann, 1965, p. 358; Dockery, 1977, p. 106, pl. 18, figs. 6, 7.
Clio (*Creseis*) sp. Palmer and Brann, 1965, p. 358.

Description.—

> Shell subulate, nearly straight, smooth; section circular. The closed end of this species is not inflated.
>
> Locality.—Jackson, Miss. (Meyer, 1886).

Collins (1934) supplemented the original description with the following:

> . . . the tip of this species is quite sharp, slightly constricted above the closed end, above this constriction the shell enlarges gradually, but somewhat irregularly and is slightly and somewhat unevenly curved. Length 4.5 mm., maximum diameter 0.6 mm. This species has an apex that is intermediate in outline between that of the Recent *C. virgula* Rang and *C. acicula* Rang . . . .

Discussion.—Although the holotype is from the Jackson Eocene, this species probably is more abundant in the Claiborne. Aldrich (1895) described and illustrated as *Creseis* sp. a form from the Cook Mountain Formation, at Wheelock, Robertson Co., Texas. He stated, "It is more slender than typical *Styliola simplex* M'r, but is probably that species." Collins (1934) assigned Aldrich's figured specimen to *Creseis* sp. cf. *C. hastata* (Meyer, 1886) and Palmer and Brann (1965) later classified it as *Clio* (*Creseis*) sp.

We have collected numerous specimens of *Creseis simplex* from the Weches, Stone City, and Cook Mountain formations of Texas and the Lisbon Formation and Gosport Sand of Alabama. They are the same form illustrated and described by Aldrich. Those that we have collected have a very small oval bulb at the apex, followed adorally by two slight constrictions (Pl. 9, fig. 9).

The apex of the middle Eocene *C. simplex* is smaller, less well-defined, and more oval than that of the late Eocene and early Oligocene *C. hastata*. Meyer (1886) stated that the closed end of this species was not inflated, but because the bulb at the tip of this species is very small, it might easily have been overlooked by him. Cossmann (1893) and Collins (1934) noted that there is a small swelling at the apex.

Specimens collected for this study show considerable variation in their width/length ratios (width about $\frac{1}{10}$ to $\frac{1}{4}$ of length). Aldrich stated that the form sent to him was more slender than typical "*Styliola*" *simplex*, but calculations of width/length ratios for 100 specimens from the Stone City and Cook Mountain formations (Table 3) show that about half of the specimens are more inflated and about half are more slender than the holotype of *C. simplex*.

Despite considerable variation in maximum diameter as a function of length, all of the examined specimens are identified as *Creseis simplex* because of the similarity of their apices, and because there is a continuous gradation from the slender to the inflated specimens.

Most specimens of *C. simplex* are straight or slightly curved but a few show loose, yet distinct sinistral spiral coiling (Pl. 9, fig. 7). This coiling is similar to, but much weaker than that of *Bovicornu eocenense* Meyer, 1886 and *B. gracile* Meyer, 1887.

Occurrence.—Middle Eocene. This species is very common in many Eocene outcrops. We have found other specimens in the following formations and localities: Weches Formation, localities 7, 8, and 9; Stone City Formation, localities 11 and 12; Wheelock Marl Member of the Cook Mountain Formation, localities 11, 16, 17, 18, 19, and 20; Hurricane Lentil of the Cook Mountain Formation, localities 22 and 23; Cook Mountain Formation, locality 13; Lisbon Formation, locality 6; Gosport Sand, locality 26; and the Moodys Branch Formation, localities 31 (holotype) and 32..

Material.—Specimens examined in this study were recovered from localities 6 (5 specimens), 7 (29 specimens), 8 (47 specimens, including paratype, USNM 360354), 9 (5 specimens), 11 (8 specimens), 12 (19 specimens), 13 (5 specimens), 16 (6 specimens), 17 (10 specimens), 18 (114 specimens), 19 (19 specimens), 20 (5 specimens), 22 (6 specimens), 23 (24 specimens), 26 (15 specimens), 31 (1 specimen, the holotype), and 32 (10 specimens).

Type.—Holotype, USNM 638841; hypotype, USNM 360354.

Creseis species A
Plate 9, figures 10, 11

Description.—Shell small, conical, slightly curved, smooth, and circular in cross-section. Apex sharp, heart-shaped, slightly constricted near the tip, and with a second constriction about 0.5 mm from the apical end. Shell diameter expands rapidly as length increases.

Measurements.—USNM 360355 (figured speci-

Table 3.—Measurements (in mm) and diameter/length ratios of specimens of *Creseis simplex* used in this study.

unit	*locality*	*number of specimens*	*maximum diameter (d)*	*length (l)*	*d/l*
Weches Fm.	7	21	0.4	2.2	0.1818
Weches Fm.	8	47	0.5	3.7	0.1351
Stone City Fm.	12	20	0.7	3.9	0.1795
Cook Mountain Fm.	18	20	0.6	4.9	0.1224
Gosport Sand	26	10	0.6	2.9	0.2069
Moodys Branch Fm.	32	5	0.4	2.7	0.1481

men): length, 2.0 mm; maximum diameter, 0.5 mm.

Discussion.—*Creseis* sp. A differs from other Eocene species of *Creseis* Rang, 1828 in having a distinct heart-shaped apical bulb followed adorally by two distinct constrictions. The curved shell, which increases rapidly in width as a function of length, is also distinctive.

Occurrence.—?Eocene. Figured specimen from well locality 52 (2,080 ft: cuttings). Foraminifera recovered at this depth are Cretaceous in age, but in all probability the figured specimen came from Eocene sediments that caved into the hole. Other, less well-preserved specimens were found at the following well localities: early Eocene, locality 45 (7,240 and 7,420 ft); middle Eocene, locality 56 (2,340 ft); and late Eocene, locality 51 (1,100 ft).

Material.—Specimens examined in this study were recovered from localities 45 (2 specimens), 51 (1 specimen), 52 (1 specimen), and 56 (1 specimen).

Type.—Figured specimen, USNM 360355.

Genus **EUCHILOTHECA** Fischer, 1882

Description.—Shell approximately conical with the axis of the cone describing a very gentle sinistral spiral that gives the shell a slightly undulating appearance. The apex of the shell is ovoid and slightly inflated. An internal septum is commonly present at about one-tenth of the distance from the apex to the aperture of the adult shell (see Curry, 1965, p. 359).

Type species.—*Euchilotheca succincta* (Defrance, 1828).

Euchilotheca succincta (Defrance)
Plate 9, figures 12–17

?*Vaginella succinta* [*sic*] Defrance, 1828, p. 427, pl. 97, figs. 5, 5a, 5b.
Cleodora (*Creseis*) *chastelii* Potiez and Michaud, 1838, p. 44, pl. 10, figs. 11–14.
Cleodora parisiensis Deshayes, 1861, p. 187, pl. 3, figs. 15–17.
Euchilotheca succincta (Defrance). Wrigley, 1934, p. 10, pl. 1, fig. 2; Curry, 1965, p. 359, figs. 3–5.

Description.—Our description is based primarily on apertural fragments. These fragments show a shell that is small, tubular, circular, smooth, and without ornamentation. The aperture is circular, has a flanged lip, and is slightly oblique to the shell axis. Shell walls adjacent to the aperture are essentially parallel.

Discussion.—A single apical fragment in our collection shows a gentle sinistral spiral. We cannot determine if the apical fragment belongs to the same species as the apertural fragments, but if the two are regarded as a single species, the combined fragments bear a remarkable similarity to *E. succincta.* We could not observe an internal septum.

Measurements.—Average of ten specimens: maximum diameter (including lip), 0.8 mm; maximum diameter (excluding lip), 0.6 mm.

The small size of these specimens is similar to specimens described and illustrated by Curry (1965). He gives the following measurements: length, about 3.5 mm; diameter, 0.7 mm.

Occurrence.—Middle Eocene. *E. succincta* occurs in the Lutetian of France and England. In North America, we have found this species only in the Wheelock Member, Cook Mountain Formation at locality 19.

Material.—Specimens examined in this study were recovered from locality 19 (18 apertural fragments and a single apical fragment).

Types.—Hypotypes, USNM 360356, 360357.

Genus **HYALOCYLIS** Fol, 1875

Description.—Shell small, fragile, conical, slightly curved dorsally. Apex truncated in adults, tip closed by a very thin septum. Transverse annulations on shell surface. Middle Eocene?, middle Miocene–Recent.

Type species.—*Hyalocylis striata* (Rang, 1828), the only Recent species.

Hyalocylis species A
Plate 9, figures 18, 19

Description.—Shell small, conical with raised annulations and a basal septum. The only specimen is a pyritic internal mold.

Measurements[6].—USNM 360358 (figured specimen): length, 1.5 mm; maximum diameter, 2.2 mm; minimum diameter, 1.1 mm.

Discussion.—This specimen differs from the Recent

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[6] The specimen is apparently crushed so a measurement of the width is difficult. Perhaps a reconstructed width of 1.7 mm is a close approximation.

Hyalocylis striata (Rang, 1828) in being much larger at the apical end. If this form is a true *Hyalocylis*, it would mark the earliest worldwide occurrence of the genus.

Occurrence.—Middle Eocene. Sparta Formation, at well locality 41.

Material.—The single specimen examined in this study was recovered from well locality 41 (9,740–9,770 ft)

Types.—Figured specimen, USNM 360358.

Genus **PRAEHYALOCYLIS** Korobkov *in* Korobkov and Makarova, 1962

Description.—

> The shells are comparatively large (up to 23 mm long), in the shape of a high, straight-sided cone with a straight apex, and are circular in cross-section both in the initial and the apertural parts of the shell. The initial part has the form of a very narrow, elongated, smooth-surfaced or annular-striated tube. The embryonic chamber (prodissoconch) is papillate and separated by a neck from the initial part of the shell. Both the initial and basal parts of the shell lack septation. The external surface bears numerous annular ribs whose number varies sharply within a single species. The shell wall is very thin, homogeneous, and lacks canals (Korobkov and Makarova, 1962; translated from Russian).

Middle Eocene to lower Miocene.

Type species.—*Praehyalocylis chivensis* Korobkov and Makarova, 1962, from the Upper Eocene in the southern part of the U. S. S. R.

Praehyalocylis maximus denseannulatus (Ludwig)
Plate 10, figures 1–5

Tentaculites maximus var. *dense-annulatus* Ludwig, 1864, p. 42, pl. 50, figs. 21a, b.; Blankenhorn, 1889, p. 602, pl. 22, figs. 10, 11.

Praehyalocylis maximus var. densecostatus (Ludwig). Blanckenhorn, 1889 (copied in Korobkov and Makarova, 1962, pl. 3, fig. 11).

Praehyalocylis maximus (Ludwig) var. *dense-annulatus* (Ludwig). Korobkov and Makarova, 1962, pl. 3, figs. 12, 13.

Description.—

> Gehäuse gross, conisch, oben grade abgeschnitten, mit dickwandiger, geschlossener, in ein kleines Knötchen endender Spitze. Die Schale wird nach oben sehr dünn; sie ist von dicht stehenden, nach oben runden, nach unten scharfkantig umgebogenen Ringeln umgeben, im Querschnitte kreisrund, ohne Längsspalte. Länge 23,0 Mm., obere Weite 6,0 Mm, Anzahl der Ringel 200.
>
> Die Gehäuse sind fast sämmtlich platt gedrückt und waren wohl schon ehe sie auf den feinen Kalkschlamm, worin sie liegen, niedersanken, zusammengefaltet. Sie sind so dünn, dass sie im Gestein obenher nur als ein leiser Anflug erscheinen, dessen beide Wände durch einen schwachen Steinkern getrennt über einander liegen. Gegen die Spitze hin verdicken sie sich allmählich; das äusserste Ende, aus weissem Kalk bestehend, ist mit einer kleinen Kugel ausgestattet und dickwandig. Die Schälchen sind häufig durch Längsbrüche in viele Stücke zertrümmert, wobei die Ringelchen gegenseitig verschoben wurden. Die Gehäuse haben alle Merkmale, welche die Tentaculiten auszeichnen, und können vorläufig nur mit diesen vereinigt werden; obgleich sie in der Tertiär-Formation gefunden werden. Es ist nicht unwahrscheinlich, dass sie der das Mittelmeer und den Ocean bewohnenden Styliola striata Rang, welche zwar von ovalen Querschnitt, an ihrem Unterende nach hinten gekrümmt, auch nur 6 Mm. lang ist, nahe stehen, denn auch die Gehäuse dieses lebenden Pteropoden sind fein geringelt, und dann würden vielleicht alle Tentaculiten mit den Styliolen zu vereinigen seyn (Ludwig, 1864).

Free translation.—Shell large, conical, aperture normal to shell axis, terminating in a small thick-walled expanded globular apex. The shell wall thins considerably toward the aperture and is ornamented by crowded annulations whose profile is rounded abapically, sharp adapically, and with a smoothly rounded cross-section; longitudinal slit absent. Length 2.0 mm, apertural diameter 6.0 mm, number of annulations 200.

The shells are all essentially squashed flat and were probably deposited in a fine carbonate mud in which they fractured. The shell walls are so thin that only the slightest impressions remain, separated by the thinnest deposit of sediment; toward the apex the remains are more substantial and the small thicker-walled globular apex is composed of white limestone. The shells are frequently longitudinally fractured into many pieces such that the annulations are shifted relative to one another. In all characters, the shells can be referred to the tentaculitids although they are found in the Tertiary formations. Possibly this species can be placed near *Styliola striata* Rang, a species from the Oceans and Mediterranean Sea, due to its size (6 mm) and its similarly fine annulations, although that species is oval in cross-section and curved at the apex; if that were the case all tentaculitids might be referred to the styliolids.

Discussion.–Squires (1989, p. 444) described the first species of *Praehyalocylis* Korobkov *in* Korobkov and Makarova, 1962 from the Western Hemisphere. His late Eocene specimens of *Praehyalocylis cretacea* (Blanckenhorn, 1889) were found in the northwestern states of Oregon and Washington. The genus is now recognized in the Gulf Coast of the United States but our specimens are narrower, have more closely spaced annulations and belong to *Praehyalocylis maximus denseannulatus*.

We have included a composite drawing (Pl. 10, fig. 5) to show some of the features found in the specimens from the Gulf Coast of the United States. The apical bulb is very small, unornamented and teardrop-shaped. There is no ornamentation for a short distance beyond the constriction adoral of the bulb, but the remainder of the shell has regular annulations. There is a distinct flaring lip at the aperture.

Measurements.—Most complete specimen (USNM 360360): length, 9.5 mm; maximum flattened width, 1.5 mm; apical angle, 9°; annulations per mm, 7.4; widest flattened specimen (USNM 360361): apertural width, 3.8 mm.

Occurrence.—Middle Eocene–middle Oligocene. In

North America, this species has been found in the middle Eocene Wheelock Marl Member of the Cook Mountain Formation, at locality 17. The species has been reported previously from the Upper Eocene near the southern coast of the Aral Sea, Soviet Union and from the middle Oligocene of Germany.

Material.—Specimens examined in this study were recovered from locality 17 (1 nearly complete specimen, 2 specimens that may be as much as 50% preserved, and numerous partial specimens).

Types.—Hypotypes, USNM 360359–360361.

Subfamily **CUVIERININAE** Gray, 1840

Description.—Shell smooth, bottle- or vase-shaped with a round, oval, trigonal, or reniform aperture. The juvenile shell is discarded at maturity leaving the apical end of the mature shell closed by a distinctive septum.

Discussion.—Characteristics of the subfamily are based on the only Recent species, *Cuvierina columnella* (Rang, 1827), and on fossil species discussed in this paper.

Fossil pteropods with characteristics similar to *C. columnella* include the genera *Bucanoides* Hodgkinson, n. gen., *Loxobidens* Hodgkinson n. gen., and *Tibiella* Meyer, 1884. We place these in the subfamily Cuvierininae. Eocene–Recent.

Genus **BUCANOIDES** Hodgkinson, new genus

Etymology of name.—The generic name is derived from Gr. *bykane* = trumpet + Gr. *-oides* = like, resembling.

Description.—Shell small, like a truncated cone, smooth. Aperture round and simple without flanges or thickened lip. Widest at the aperture, septum at apex of adult shell.

Discussion.—Differs from *Cuvierina* Boas, 1886 in being widest at the aperture, and from *Tibiella* Meyer, 1884 in having a simple aperture without flanges or thickened lip. Species in the genus include *B. basiannulata* Hodgkinson, n. sp., *B. divaricata* Hodgkinson, n. sp., and *B. tenuis* Hodgkinson, n. sp. Middle Eocene.

Type species.—*Bucanoides tenuis* Hodgkinson, n. sp.

Bucanoides basiannulata Hodgkinson, new species
Plate 10, figures 6–10

Etymology of name.—The species name refers to the annulations near the apical end of the shell.

Description.—Shell a truncated cone, small, curved, smooth, thin-walled. Maximum diameter at the rounded aperture. Apex truncated and closed by a slightly oblique septum, which makes a sharp and distinctive junction with the shell wall. Faint annulations occur near the truncated apical end. Moderate to strong increase in maximum diameter as a function of length.

Measurements.—USNM 360362 (holotype): length, 2.2 mm; maximum diameter, 0.9 mm. Average of ten specimens; length, 2.0 mm; maximum diameter, 0.9 mm.

Discussion.—Differs from *Bucanoides tenuis* Hodgkinson, n. sp. in being more curved, possessing a greater maximum diameter in relation to length, and in having faint annulations at the apical end of most specimens. *Bucanoides divaricata* Hodgkinson, n. sp. is similar to *B. basiannulata*, but it flares to a greater degree as a function of length.

Occurrence.—Middle Eocene. Weches Formation at localities 7, 8, and 9.

Material.—Specimens examined in this study were recovered from localities 7 (5 specimens), 8 (10 specimens, including the holotype and paratype), and 9 (4 specimens).

Types.—Holotype, USNM 360362; paratype, USNM 360363.

Bucanoides divaricata Hodgkinson, new species
Plate 11, figures 1–3

Etymology of name.—The species name (L. *divaricatus* = spread apart) refers to the rapid increase in maximum diameter as a function of increased length.

Description.—Shell subconical, small, short, slightly curved and rapidly expanding, aperture round. Truncated apical end closed by a prominent septum, which is flat to slightly rounded and makes a distinctive, sharp contact with the shell wall. Shell thin, especially at aperture.

Measurements.—USNM 360364 (holotype): length, 2.0 mm; maximum diameter, 1.1 mm; largest specimen (USNM 360381)[7]: length, 7.4 mm; width, 4.3 mm. Average of 110 specimens: length, 1.3 mm; maximum diameter, 0.8 mm.

Discussion.—This species is short and flares rapidly at the apertural end. In these respects, it bears no close resemblance to any other described pteropod. It bears a superficial resemblance to *Bucanoides basiannulata* Hodgkinson, n. sp., but *B. divaricata* flares more rapidly and does not have basal annulations.

Occurrence.—Middle Eocene. Wheelock Member, Cook Mountain Formation at localities 16, 17, and 18, and in the Hurricane Lentil of the Cook Mountain Formation at locality 23.

Material.—Specimens examined in this study were recovered from localities 16 (5 specimens), 17 (4 specimens, including paratype, USNM 360381), 18 (165 specimens, including the holotype and paratype, USNM 360365), and 23 (2 specimens).

Types.—Holotype, USNM 360364; paratypes, USNM 360365 and 360381. Our largest specimen (Pl. 11, fig. 3: USNM 360381) is on the same rock frag-

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[7] A flattened specimen still in the matrix [Pl. 11, fig. 3].

ment, but on the opposite side, as a paratype (USNM 360353) of *Creseis cylindrica* Hodgkinson, n. sp.

Bucanoides tenuis Hodgkinson, new species
Plate 11, figures 4–6

Etymology of name.—The species name (L. *tenuis* = thin) refers to the slender, narrow shape of the shell.

Description.—Shell a truncated cone, small, smooth, straight to slightly curved. Shell wall thin throughout, but especially so at the apertural end. Apex truncated, blunt, closed by a slightly oblique septum, junction with shell wall sharp and distinct.

Measurements.—USNM 360366 (holotype): length, 3.0 mm; maximum diameter, 0.8 mm. Average of 40 specimens: length, 1.9 mm; maximum diameter, 0.6 mm.

Discussion.—This species has an unornamented, thin and unflanged apertural lip. Although most specimens have the aperture completely broken away, a few individuals have just enough shell remaining at the aperture to show its characteristics. There is a significant variation in the length/maximum diameter ratio, with some shells being more inflated than others.

Bucanoides tenuis Hodgkinson, n. sp. is much like *Euchilotheca elegans* G. F. Harris, 1894 from England and France, which also truncates its posterior end. However, the axis of *E. elegans* describes a very gentle sinistral spiral, which gives the shell a slightly undulating appearance; it may have a slight lip. *Bucanoides tenuis,* n. sp. has neither of these characteristics.

Occurrence.—Middle to late? Eocene. *Bucanoides tenuis*, n. sp. is widespread. It is found in the Stone City Formation at localities 11 and 12 (paratype, USNM 360366); and in the Wheelock Member of the Cook Mountain Formation at localities 11, 16, 17, 18, and 20. It occurs in the Hurricane Lentil at localities 23 (includes the holotype, and paratype, USNM 360367), 24, and 25; and in the upper Lisbon Formation at locality 6. It is also found at well locality 53 (2,250 ft: late Eocene).

Material.—Specimens examined in this study were recovered from localities 6 (1 specimen), 11 (15 specimens), 12 (4 specimens), 16 (52 specimens), 17 (16 specimens), 18 (81 specimens), 20 (4 specimens), 23 (26 specimens), 24 (25 specimens), 25 (3 specimens), and well locality 53 (1 specimen).

Types.—Holotype, USNM 360366; paratypes, USNM 360367, 360368.

Genus **CUVIERINA** Boas, 1886

Description.—Adult shell cylindrical, shaped like a flask or fat cigar, may be slightly constricted behind aperture, surface smooth. Widest near middle of shell length. Oval in cross-section, but apertural end may be compressed. Aperture reniform, oval, or round. Apex blunt in adult, closed by a thin curved caudal septum. Juvenile shell straight, with an apex which is slightly constricted above the tip. Shell caducous (*i.e.*, the conical section, the juvenile stage, breaks off at or near the caudal septum after the adult portion of the shell develops).

The generic description of *Cuvierina* has been expanded here to include forms with a round or oval aperture and species which are not necessarily constricted near the apertural end. To date Eocene species of *Cuvierina* have been found only in Texas. Eocene–Recent.

Type species.—*Cuvierina columnella* (Rang, 1827), a Recent species.

Cuvierina gutta Hodgkinson, new species
Plate 11, figures 7–10

Etymology of name.—The trivial name (L. *guttus* = a narrow-necked flask) refers to the flask-shaped shell.

Description.—Shell small, flask-shaped, smooth, laterally compressed, slightly constricted about one-fifth of distance from aperture, maximum diameter just slightly adoral of midlength. Apical end truncated and closed by a convex septum, aperture laterally compressed, ventral edge of aperture strongly recessed and resembles the sinus of some other gastropods. Dorsal edge slightly recessed. Shell laterally symmetrical.

Measurements.—USNM 360369 (holotype): length, 2.2 mm; dorso-ventral maximum inflation, 0.7 mm; lateral maximum inflation, 0.6 mm; dorso-ventral diameter of aperture, 0.7 mm; lateral diameter, 0.3 mm.

Discussion.—In some respects, this form is similar to the Recent pteropod, *Cuvierina columnella* (Rang, 1827), but it is laterally rather than dorso-ventrally compressed, and is much smaller (*C. columnella* is up to 10 mm long).

Occurrence.—Middle Eocene. Very rare in the bentonite bed (see Scott, 1963, fig. 4), Wheelock Member, Cook Mountain Formation at locality 18. Also very rare in the Hurricane Lentil of the Cook Mountain Formation at locality 23.

Material.—Specimens examined in this study were recovered from localities 18 (2 specimens, the holotype and an apertural fragment) and 23 (1 apertural fragment, paratype USNM 360370).

Types.—Holotype, USNM 360369; paratype, USNM 360370.

Cuvierina lura Hodgkinson, new species
Plate 11, figures 11–15

Etymology of name.—The species name (L. *lura* = sack, bag) refers to the sac-like shape of this form.

Description.—Shell small, barrel-shaped, highly inflated and globose, maximum diameter near midlength. Aperture circular and slightly oblique to shell axis. Apex truncated, blunt, closed by a septum that is adorally concave and slightly oblique to the shell axis; junction of septum and shell wall sharp and distinct. Shell wall thin and polished, varying in thickness from about 11 to 22 μm.

Measurements.—USNM 360371 (holotype): length, 1.0 mm; maximum diameter, 0.8 mm; diameter of aperture, 0.4 mm. Average of ten specimens of the highly inflated form similar to the holotype: length, 1.0 mm; maximum diameter, 0.8 mm. Average of ten specimens of the less inflated form: length, 1.1 mm; maximum diameter, 0.6 mm.

Discussion.—Shells of this species can be divided into two distinct forms. One form has shells similar to the holotype described above (Pl. 11, fig. 11). Shells of the second form are less inflated with sides that are almost parallel in some specimens. Their maximum diameter is about one-third of the distance from the truncated apex to the aperture (Pl. 11, fig. 12). In cross-section, the shell is slightly compressed laterally.

Squires (written commun., 1990) suggested that the differences in shell shape could be attributed to ecologic or reproductive features, especially since the two forms are from the same beds. We agree that both should be placed within a single species. However, it is important to recognize that all modern pteropods are hermaphroditic. Hence, they are less likely to have differences in morphology based on male or female characteristics than do animals that have separate and distinct sexes. Further, one could argue equally as well that since these forms occur in the same beds at the same locality, ecologic conditions might not be a factor in determining shell shape. Perhaps future studies will help in determining whether these two forms represent a single or two separate species.

Cuvierina inflata (Bonelli, 1872) from the early Pliocene of Italy, *Cuvierina globosa* Collins, 1934 from the middle Miocene of Veracruz, Mexico, and *C. senonica inflata* Avnimelech, 1945 from the Miocene of Syria are all much larger than *C. lura*, n. sp.

The shell wall of most specimens terminates abruptly at the septum, but in a few instances the juvenile portion of the shell truncates a short distance from the septum (Pl. 11, figs. 14, 15).

Occurrence.—Middle Eocene. Rare in the Weches Formation. Both the inflated and less-inflated forms are found at locality 8; only the less-inflated form has been found at locality 7.

Material.—Specimens of the highly-inflated form examined in this study were recovered from locality 8 (26 specimens), and specimens of the less-inflated form were recovered from localities 7 (3 specimens, including the paratype) and 8 (12 specimens).

Type.—Holotype, USNM 360371; paratype, USNM 360372.

Genus **LOXOBIDENS** Hodgkinson, new genus

Etymology of name.—The generic name (Gr. *loxos* = slanting, + L. *bidens* = two-toothed) is based on the nature of the lip and its ornamentation.

Description.—Shell small, tubular, smooth, straight, or slightly curved. Sides parallel. Well-developed flanged lip with two distinct but continuous crenulations associated with two slight projections that extend into the apertural opening.

Discussion.—Only apertural fragments have been found, so the nature of the apex is unknown. To date found only in Texas. Middle Eocene.

Type species.—*Loxobidens aduncus* Hodgkinson, n. sp.

Loxobidens aduncus Hodgkinson, new species
Plate 12, figures 1–5, 6[?]

Etymology of name.—The species name (L. *aduncus* = bent, hooked) refers to the characteristics of the aperture.

Description.—Shell small, tubular, straight or slightly curved, smooth, unornamented. Sides of shell essentially parallel, may constrict slightly just before the aperture. Cross-section mainly circular, but becomes compressed laterally at the apertural end. Well-developed flanged lip that is oblique to the shell axis. The lip has two distinct crenulations of the shell wall connected with two slight projections that extend into the apertural opening. One crenulated projection on each lateral side, with one being significantly larger than the other.

Measurements.—USNM 360373 (holotype): maximum dorso-ventral diameter (including flanged lip), 0.7 mm; maximum dorso-ventral diameter (excluding lip), 0.6 mm; maximum lateral diameter (including lip), 0.5 mm; maximum lateral diameter (excluding lip), 0.4 mm.

Discussion.—Several small apical fragments of a pteropod were collected with essentially the same maximum diameter as *L. aduncus*. These broken specimens expand slowly from a basal septum (Pl. 12, fig. 6). There is no evidence, however, that these apical fragments are the apical ends of this species. They might be the apical end of some other pteropod species. These apical fragments closely resemble the apex of *Bucanoides tenuis*, n. sp., but are smaller and the septum is much more rounded.

Occurrence.—Middle Eocene. Holotype and all specimens from the Wheelock Member, Cook Mountain Formation, locality 19.

Material.—Specimens examined in this study were recovered from locality 19 (12 apertural fragments, and a larger number of apical fragments).

Types.—Holotype, USNM 360373; paratype, USNM 360374.

Genus **TIBIELLA** Meyer, 1884

Etymology of name.—*Tibiella* was so named because the specimen described by Meyer (1884) resembled the tibia of mammals.

Description.—Shell small, tubular, straight or slightly curved, smooth, round in cross-section at apex and throughout most of the shell. Aperture round or rounded triangular with a flanged or significantly thickened lip, apex closed by a curved oblique septum.

Discussion.—The type species, *Tibiella marshi* Meyer, 1884, has a subtriangular aperture and a flared lip. "*Tibiella*" *texana* Collins, 1934 has a round aperture and a distinct lip. Prior to the publication of this paper, these two species were the only ones included in the genus. New species are *T. annulata* and *T. reflexa*. Both have been found only in the Gulf Coast of North America. Middle Eocene.

Type species.—*Tibiella marshi* Meyer, 1884.

Tibiella annulata Garvie, new species
Plate 12, figures 7, 8

Etymology of name.—The species name (L. *annulatus* = beringed, ornamented with rings) refers to the annulations that are so prominent on the shell of this species.

Description.—Shell a small, slightly curved, cigar-shaped tube, closed at the posterior end by a septum resembling a low rounded cone, the apex of which diverges at an angle of about 130°. The aperture is ovate-elliptical, constricted parallel to the axis of curvature of the tube. On the flattened sides, it is somewhat anteriorly extended, and terminates in a thickened reflected lip. The posterior two-thirds of the shell is radially costate with about 10.7 annulations per mm. The remainder of the shell is smooth or has very faint to obsolete costae.

Measurements.—USNM 360375 (holotype): length, 3.5 mm; maximum diameter (including lip), 1.4 mm; maximum diameter (excluding lip), 1.1 mm; minimum diameter (including lip), 1.0 mm; minimum diameter (excluding lip), 0.8 mm. (USNM 464544; almost complete paratype): length, 3.1 mm; maximum diameter (including lip), 1.2 mm; maximum diameter (excluding lip), 1.0 mm; minimum diameter (including lip), 0.9 mm; minimum diameter (excluding lip) 0.7 mm.

Discussion.—The species most closely allied to *T. annulata*, n. sp. is "*T.*" *texana* Collins, 1934, but it can be easily differentiated from the latter species by its compressed aperture and well-developed annulations.

Occurrence.—Middle Eocene. Viesca Member, Weches Formation at locality 10.

Material.—Specimens examined in this study were recovered from locality 10 (2 well-preserved specimens and 3 broken specimens).

Types.—Holotype, USNM 360375; paratype, USNM 464544.

Tibiella marshi Meyer
Plate 12, figures 9, 10

Tibiella marshi Meyer, 1884, p. 110, unnumbered text-fig.; Dall, 1892, p. 432; Collins, 1934, p. 226, pl. 14, fig. 1, Palmer and Brann, 1965, p. 360.

?*Tibiella marshalli* [*sic*] Meyer. Zilch, 1959, p. 49, fig. 165.

Etymology of name.—The species was named after a Professor Marsh that Meyer does not further identify.

Description.—

> Shell thin, tubular. The closed end little convex. The lower part, about one-third of the whole length, of a circular section, then by tapering a little forming a kind of neck, above which the shell is of a rounded trigonal section. Aperture dilated. Length 3½ mm (Meyer, 1884).

Emended description.—Shell thin, tubular, slightly curved, smooth. Apical end truncated and closed by a rounded, slightly oblique septum. Junction of septum and shell wall sharp and distinct. Lower part of shell circular in section, upper part subtriangular. Growth from truncated apex to aperture even and regular. Shell flared at aperture to form a distinct lip.

Measurements.—USNM 360376 (neotype, herein designated): length, 5.2 mm; dorso-ventral diameter (including lip), 1.3 mm; dorso-ventral diameter (excluding lip), 1.2 mm; lateral diameter (including lip), 1.2 mm; lateral diameter (excluding lip), 1.0 mm.

Discussion.—Meyer's figure shows a specimen that is considerably different from ours. We have collected several deformed or injured specimens, which have some characteristics similar to Meyer's specimen. Even these, however, do not duplicate the shell shape shown by Meyer. Because the aperture is rounded trigonal on Meyer's specimens and on those collected by us, and because all were found in the Gosport Sand, we are confident that they are the same species. Meyer's specimen probably is not typical of the species; it is perhaps not mature and may have been injured or damaged during life. His specimen probably had a basal septum as suggested by his statement:

> If the figured specimen is adult, in the young ones the apex may be perhaps acute and afterwards partitioned off, as in the genus *Triptera* Quoy et Gaimard . . . (Meyer, 1884, p. 110).

Meyer also wrote:

> Pteropoda are described from the Miocene and Oligocene, but as

far as I am acquainted with the literature this is the first Pteropod from the Eocene.

Occurrence.—Middle Eocene. The type described by Meyer (1884) was from the "Eocene sand, Claiborne, Ala." Palmer and Brann (1965, p. 360) correctly listed the formation and locality as Gosport Sand, Claiborne Bluff, Alabama River, Monroe Co., Alabama (loc. 27). All of the specimens described in this paper are from the Gosport Sand (loc. 26).

Material.—All specimens examined in this study were recovered from the Gosport Sand at locality 26 (2 well-preserved and 11 broken specimens). These include an almost complete specimen donated by the late Mr. and Mrs. Gus Lindveit (neotype) and a well-preserved shell contributed by Mr. and Mrs. Jim Knight, all of Houston, Texas.

Types.—The type was originally in the Aldrich Collection at Johns Hopkins University. It could not be located by Collins (1934, p. 226) or Palmer and Brann (1965, p. 360), nor during a search initiated by museum personnel on our behalf. All of these searches were made after the Aldrich Collection had been transferred to the USNM. Because the type specimen apparently is lost, we designate USNM 360376 as the neotype.

Tibiella reflexa Hodgkinson, new species
Plate 12, figures 11, 12; Plate 13, figures 1–3

Etymology of name.—The species name (L. *reflexus* = bent or turned back) refers to the reflexed lip.

Description.—Only apertural ends have been recovered by us. The apertural end is small, tubular, round in cross-section, smooth, unornamented. Shell walls essentially parallel. A distinctive, strongly recurved lip is added externally at the aperture. A narrow gap, seen only on broken specimens, separates the outer recurved lip from the normal shell wall.

Measurments.—USNM 360377 (holotype): maximum diameter (including lip), 1.5 mm; maximum diameter (excluding lip), 1.3 mm. Average of five specimens: maximum diameter (including lip), 1.6 mm; maximum diameter (excluding lip), 1.5 mm.

Discussion.—In size and shape, *T. reflexa*, n. sp. resembles *Creseis cylindrica* Hodgkinson, n. sp., but the lip at the aperture of the latter form is produced by an internal, rather than external, thickening of the shell wall. We are also assuming that when a complete specimen is found, *T. reflexa* will be shown to have a basal septum, whereas *C. cylindrica* does not.

Occurrence.—Middle Eocene. Stone City Formation, locality 12.

Material.—Specimens examined in this study were recovered from locality 12 (8 apertural fragments).

Types.—Holotype, USNM 360377; paratype, USNM 360378.

Tibiella texana Collins
Plate 13, figures 4–8

"*Tibiella*" *texana* Collins, 1934, p. 227, pl. 14, figs. 2–5; Palmer and Brann, 1965, p. 360.

Description.—

Shell small, subcylindrical, smooth and polished, growth lines faint. Posterior end tapering slightly; irregularly truncated and closed by a smooth oblique septum. Median part of shell slightly inflated. Aperture subcircular, slightly expanded, and oblique to axis of shell. A strongly developed flange lies directly below the margin of the aperture (Collins, 1934).

Measurements.—USNM 644568 (holotype): length, 4.5 mm; diameter (including lip), 1.7 mm; diameter (excluding lip), 1.5 mm. USNM 360379 (topotype): length, 3.9 mm; diameter (including lip), 1.7 mm; diameter (excluding lip), 1.5 mm.

Discussion.—The holotype of "*Tibiella*" *texana* and an additional broken specimen were the only ones available to Collins for study. We have found several well-preserved specimens and many apertural fragments that further illustrate the nature of the apertural flange. The illustrations prepared by Collins show a double flange. We have examined the holotype and note that the second flange is that of another specimen of *T. texana* nested within the holotype.

The flange on the holotype is sharp and strongly developed and is similar to the flanges on most of our specimens; the flange on our best specimen (topotype, USNM 36034) is rounded. There is complete gradation from sharp to rounded flanges (Pl. 13, figs. 5, 6).

Collins (1934, p. 227) placed this species in the genus *Tibiella* Meyer, 1884 with hesitation because he had no access to the type of *Tibiella marshi* Meyer, 1884 and because Meyer's illustration of that specimen showed neither a basal septum nor a prominent flange. We feel that Collins was correct in his assignment of the species to *Tibiella*, because we have had access to well-preserved specimens of *T. marshi* that do have a basal septum and a well-developed apertural flange.

Occurrence.—Middle Eocene. Fragments of *Tibiella texana* are common in the Weches Formation at localities 7, 8, and 9.

Material.—Specimens examined in this study were recovered from localities 7 (23 specimens), 8 (22 specimens, including the holotype and topotype, and 20 broken specimens), and 9 (5 specimens).

Types.—Holotype, USNM 644568, topotypes, USNM 360379, 360383, and 360384.

APPENDIX

COLLECTING LOCALITIES

The pteropods included in this study were obtained from locations in Texas, Louisiana, Alabama, Mississippi, and offshore eastern Canada (Text-figs. 4, 5). All of the specimens from the Reklaw Formation in Texas were found by Garvie, who is preparing a manuscript on the molluscan fauna of this unit. Garvie also found *Tibiella annulata* Garvie, n. sp. (Weches Formation) and the first North American specimens of *Praehyalocylis maximus denseannulatus* (Ludwig) from the Cook Mountain Formation. Other species were first found by Hodgkinson.

Texas Bureau of Economic Geology (TBEG) numbers are included in our locality descriptions for most Texas localities. For localities outside of Texas, we have used numbers listed by Toulmin (1977) or MacNeil and Dockery (1984). The localities cited in the latter publication bear United States Geological Survey (USGS), Mississippi Geological Survey (MGS), and Paleontological Research Institution [Ithaca, New York] (PRI) numbers.

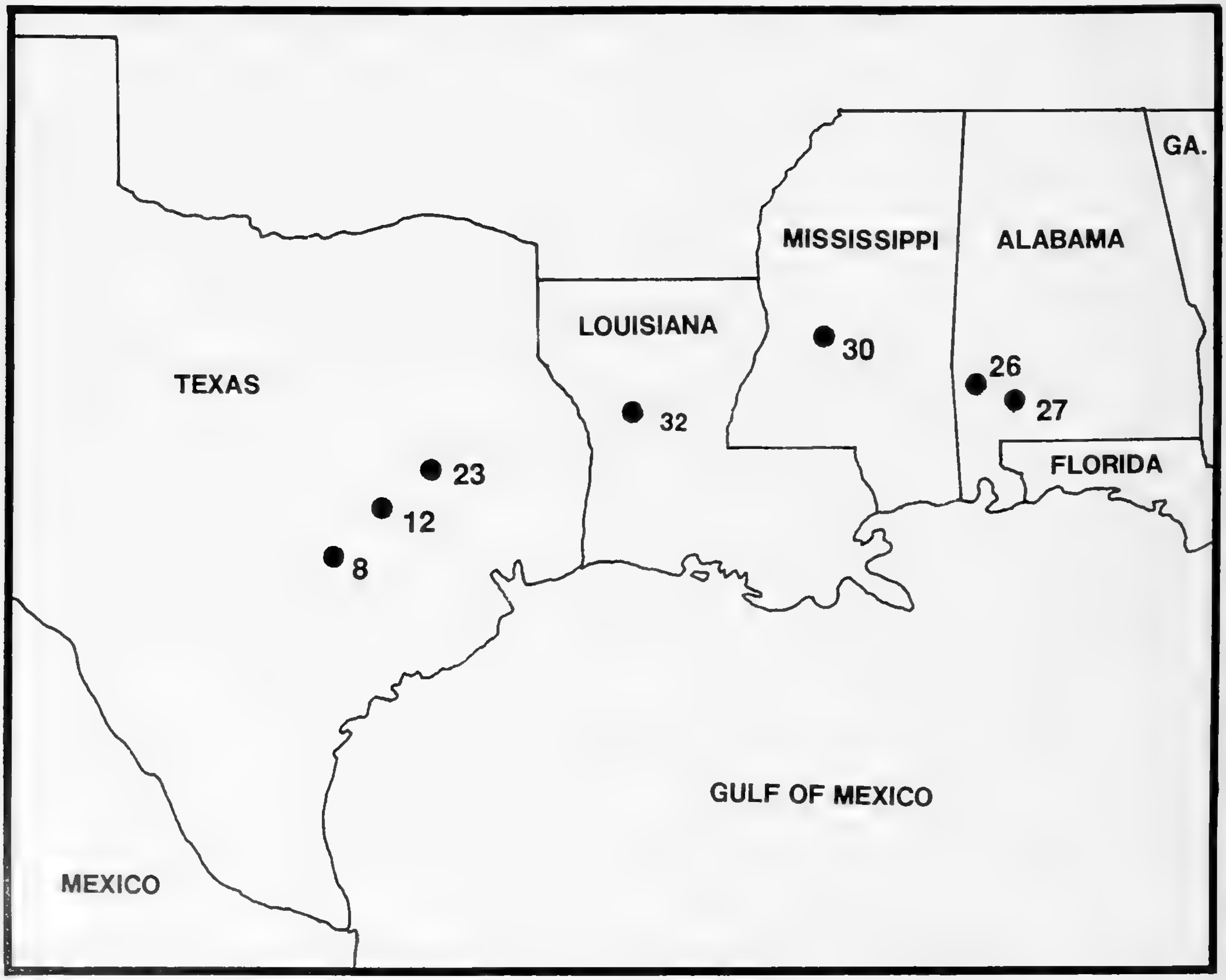
Locality 1.—Wilcox Group, Hatchetigbee Formation, Bashi Member, Choctaw Corner, Clarke Co., Alabama.

Unfortunately we are unable to give more precise data for Aldrich's locality [source of the holotype of *Altaspiratella elongatoidea* (Aldrich, 1887)].

Locality 2.—TBEG locality 11-T-7, Reklaw Formation, Marquez Shale Member, Ridge Creek, bluff approximately 30 m (100 ft) long exposed on the north side of creek; about 250 m (825 ft) south of the Missouri, Kansas, and Texas Railroad trestle and the county road bridge across the creek. Approximately 8 km (5 mi) W of Smithville or 1 km (0.6 mi) E of Upton, Bastrop Co., Texas.

Locality 3.—Reklaw Formation, Marquez Shale Member, 0.2 km (0.1 mi) from TBEG loc. 165-T-13. Taylor Branch, exposures in Two Mile Creek (also called Joe Taylor Branch) downstream from a county road. The point at which the road crosses the creek is given on the USGS map of the Gause Quadrangle (1989: 1:24,000) as 96°39′06″ N., 30°48′48″ E., Milam Co., Texas.

Locality 4.—Reklaw Formation, Marquez Shale Member, NE Cherokee Co., Texas (Stenzel, 1953).[8]



Text-figure 4.—States bordering the northern Gulf of Mexico. The locations of several collecting sites are shown. These site locations show the general Eocene outcrop trend around the northern Gulf Coast.

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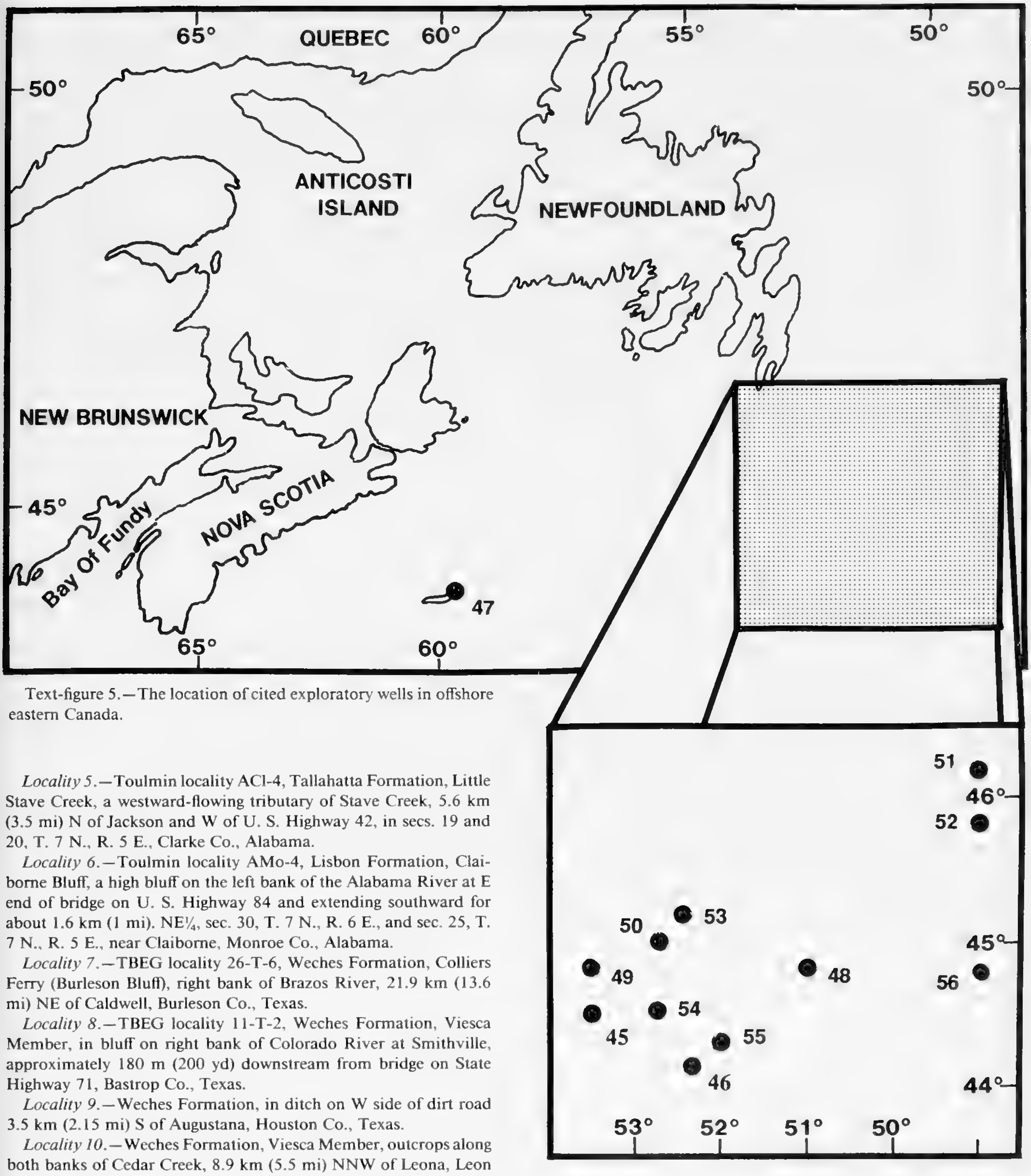
[8] Stenzel (1953) gave only this very general location for the pteropod specimens that he found and illustrated but did not formally describe.



Text-figure 5.—The location of cited exploratory wells in offshore eastern Canada.

Locality 5.—Toulmin locality ACl-4, Tallahatta Formation, Little Stave Creek, a westward-flowing tributary of Stave Creek, 5.6 km (3.5 mi) N of Jackson and W of U. S. Highway 42, in secs. 19 and 20, T. 7 N., R. 5 E., Clarke Co., Alabama.

Locality 6.—Toulmin locality AMo-4, Lisbon Formation, Claiborne Bluff, a high bluff on the left bank of the Alabama River at E end of bridge on U. S. Highway 84 and extending southward for about 1.6 km (1 mi). NE¼, sec. 30, T. 7 N., R. 6 E., and sec. 25, T. 7 N., R. 5 E., near Claiborne, Monroe Co., Alabama.

Locality 7.—TBEG locality 26-T-6, Weches Formation, Colliers Ferry (Burleson Bluff), right bank of Brazos River, 21.9 km (13.6 mi) NE of Caldwell, Burleson Co., Texas.

Locality 8.—TBEG locality 11-T-2, Weches Formation, Viesca Member, in bluff on right bank of Colorado River at Smithville, approximately 180 m (200 yd) downstream from bridge on State Highway 71, Bastrop Co., Texas.

Locality 9.—Weches Formation, in ditch on W side of dirt road 3.5 km (2.15 mi) S of Augustana, Houston Co., Texas.

Locality 10.—Weches Formation, Viesca Member, outcrops along both banks of Cedar Creek, 8.9 km (5.5 mi) NNW of Leona, Leon Co., Texas.

Locality 11.—Stone City Formation, Rocky Creek, 0.8 km (0.5 mi) W of Stone City Bluff, Burleson Co., Texas.

Locality 12.—TBEG locality 26-T-1, Stone City Formation, Stone City Bluff, S or right bank of the Brazos River 19.3 km (17.4 mi) W of Bryan, Burleson Co., Texas.

Locality 13.—TBEG locality 11-T-29, Cook Mountain Formation, right bank of Colorado River, 1.3 km (0.8 mi) downstream from Bastrop–Fayette Co. line, 2.6 km (1.6 mi) NE of Kirtley, Fayette Co., Texas.

Locality 14.—TBEG locality 11-T-26, Cook Mountain Formation, Pin Oak Creek, at crossing of Smithville–Winchester road, Bastrop Co., Texas.

Locality 15.—Cook Mountain Formation, 1.2 km (0.75 mi) S of Elkhart, Anderson Co., Texas.

Locality 16.—TBEG locality 26-T-1, Cook Mountain Formation, Wheelock Marl Member, Stone City Bluff, S or right bank of the Brazos River 18.3 km (11.4 mi) W of Bryan, Burleson Co., Texas.

Locality 17.—Cook Mountain Formation, Wheelock Marl Member, stream bed of Little Brazos River about 90 m (100 yd) upstream from Little Brazos Bluff, Brazos Co., Texas.[9]

Locality 18.—TBEG locality 21-T-1, Cook Mountain Formation, Wheelock Marl Member, Little Brazos Bluff, on E side of Little Brazos River just upstream from Texas Highway 21 bridge over the Little Brazos River, 15.5 km (9.6 mi) W of Bryan, Brazos Co., Texas.

Locality 19.—Cook Mountain Formation, Wheelock Marl Member, Little Brazos River, exposures 1.0 km (0.6 mi) downstream from Texas Highway 21 bridge, at the base of a small waterfall caused by a resistant ironstone ledge, Brazos Co., Texas.

Locality 20.—TBEG locality 21-T-6, Cook Mountain Formation, Wheelock Marl Member, outcrop near junction of Little Brazos and Brazos rivers, Brazos Co., Texas.

Locality 21.—Cook Mountain Formation, Wheelock Marl Member, Wheelock, Robertson Co., Texas.[10]

Locality 22.—TBEG locality 113-T-2, Cook Mountain Formation, Hurricane Lentil, type section of Hurricane Lentil in Hurricane Bayou, 0.3–0.8 km (0.2–0.5 mi) upstream from bridge on Crockett–Rusk Co. road, 5.6 km (3.5 mi) NE of Crockett, Houston Co., Texas.

Locality 23.—TBEG locality 113-T-9, Cook Mountain Formation, Hurricane Lentil, Alabama Ferry, E bank of Trinity River, 12.1 km (7.5 mi) WSW of Porter Springs, Houston Co., Texas.

Locality 24.—TBEG locality 145-T-58, Cook Mountain Formation, Hurricane Lentil, Flat Branch, 0.6 km (0.4 mi) from entrance gate on Middleton–Guys Store Co. road, Leon Co., Texas.

Locality 25.—TBEG locality 145-T-52, Cook Mountain Formation, Hurricane Lentil, Two Mile Creek, 8.5 km (5.3 mi) SW of Leona, Leon Co., Texas.

Locality 26.—Toulmin locality ACl-4, Gosport Sand, Little Stave Creek, 5.6 km (3.5 mi) N of Jackson and W of U. S. Highway 43, a westward-flowing tributary of Stave Creek, in secs. 19 and 20, T. 7 N., R. 2 E., Clarke Co., Alabama.

Locality 27.—Toulmin locality AMo-4, Gosport Sand, Claiborne Bluff on the left bank of the Alabama River at E end of bridge on U. S. Highway 84 and extending S for about 1.6 km (1.0 mi), NE¼, sec. 30, T. 7 N., R. 6 E. and sec. 25, T. 7 N., R. 5 E., Monroe Co., Alabama.

Locality 28.—Toulmin locality AMo-6, Gosport Sand, Rattlesnake Bluff on the left bank of the Alabama River 3.2 km (2.0 mi) below Gosport Landing in SE¼, sec. 31, T. 7 N., R. 5 E. at mi. 69.8, Monroe Co., Alabama.

Locality 29.—Toulmin locality MCl-1, Moodys Branch Formation, Garland Creek, in S bluff of Garland Creek, 7.7 km (4.8 mi) NE of Shubuta, NW¼, sec 28, T. 1 N., R. 16 E., Clarke Co., Mississippi.

Locality 30.—Toulmin locality MHi-1, Moodys Branch Formation, gully or steephead east of swimming pool in Riverside Park, in S½, sec. 25 or N½, sec. 36, T. 6 N., R. 1 E., Jackson, Hinds Co., Mississippi.

Locality 31.—Moodys Branch Formation, Jackson, Hinds Co., Mississippi.[11]

Locality 32.—Moodys Branch Formation, Montgomery (Creola) Landing near the town of Montgomery on the east side of the Red River, SE¼, sec. 25, T. 8 N., R. 5 W., Grant Parish, Louisiana.

Locality 33.—Yazoo Formation, Miss Lite Aggregate clay pit, SE¼SW¼, sec. 25, T. 7 N., R. 1. W., Cynthia, Hinds Co., Mississippi.

Locality 34.—USGS locality 5264, Red Bluff Clay (Oligocene), type locality, Red Bluff, 1.6 km (1.0 mi) SW of Hiwannee on E side of the Chickasawhay River, sec. 28, T. 10 N., R. 7 W., Wayne Co., Mississippi.

Locality 35.—Vicksburg Group (early Oligocene), Vicksburg, Warren Co., Mississippi.

Locality 36.—USGS locality 7671, Vicksburg Group, Mint Spring Formation, Brown's Cave, E bank of Leaf River, 0.8 km (0.5 mi) above the bridge on Bay Springs–Raleigh road in sec. 13, T. 2 N., R. 8 E., Smith Co., Mississippi.

Locality 37.—Toulmin locality AWa-3. Yazoo Formation and Vicksburg Group, Bucatunna Formation, St. Stevens Quarry on the right bank of the Tombigbee River E of St. Stephens, sec. 33, T. 7 N., R. 1 W., Washington Co., Alabama.

Locality 38.—USGS locality 6454 and MGS locality 102, Vicksburg Group, Byram Formation, type locality. From beneath indurated ledge at low water level, Pearl River, just upstream from bridge at Byram, NW¼SW¼NW¼, sec. 19, T. 4 N., R. 1 E., Hinds Co., Mississippi.

Locality 39.—Vicksburg Group, Byram Formation, Big Black River, near Edwards, Hinds Co., Mississippi.

Locality 40.—MGS locality 112c, Vicksburg Group, Byram Formation, Mississippi Valley Portland Cement quarry, north of Redwood on Highway 3, NW¼, sec. 26, T. 18 N., R. 4 E., Warren Co., Mississippi.

Locality 41.—Exxon Corporation #1 R. H. Strain well, East Baton Rouge Parish, Louisiana.

Locality 42.—Exxon Corporation #1 Baker well, East Baton Rouge Parish, Louisiana.

Locality 43.—Exxon Corporation #1 Labokay well (Houston River Prospect), Calcasieu Parish, Louisiana.

Locality 44.—Exxon Corporation #1 State Lease 12770 well, Cameron Parish, Louisiana.

Locality 45.—Amoco-Imperial #A-1 Puffin B-90 well, 44°30′N, 53°30′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 46.—Amoco Imperial #A-1 Heron H-73 well, 44°10′N, 52°15′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 47.—Mobil Sable Island #1 F-67 well, 44°00′N, 59°45′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 48.—Amoco-Imperial #A-1 Bittern M-62 well, 44°50′N, 51°00′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 49.—Amoco-Imperial #A-1 Kittiwake P-11 well, 44°50′N, 53°30′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 50.—Amoco-Imperial #A-1 Petrel A-62 well, 45°00′N, 52°45′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 51.—Amoco-Imperial #A-1 Murre G-67 well, 46°10′N, 49°00′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 52.—Amoco-Imperial-Skelly #A-1 Spoonbill D-30 well, 45°50′N, 49°00′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 53.—Amoco-Imperial #A-1 Gannet O-54 well, 45°10′N, 52°30′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 54.—Amoco-Imperial #A-1 Shearwater J-20 well, 44°30′N, 52°45′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 55.—Amoco-Imperial-Skelly #A-1 Mallard M-45 well, 44°20′N, 52°00′W, Nova Scotian shelf, offshore Eastern Canada.

Locality 56.—Amoco-Imperial-Skelly #A-1 Osprey G-84 well, 44°50′ N, 49°00′ W, Nova Scotian shelf, offshore eastern Canada.

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[9] Locality 17, normally under the water of the Little Brazos River, can be collected only during periods of extremely low water level.

[10] Numerous individuals have searched for this locality, including Hodgkinson and Garvie. To our knowledge no one has been able to find Cook Mountain sediments at this locality.

[11] This may be same locality as that listed immediately above.

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PLATES

Note: Specimens described as "lost" in the following plates were lost or destroyed during the preparation of scanning electron micrographs [SEM]. Some images were obtained using a light microscope [LM].

EXPLANATION OF PLATE 1

Figure Page

1, 2. ***Altaspiratella bearnensis*** (Curry, 1981) 13

Weches Formation.

1. Locality 8, hypotype (USNM 180480), apertural view, showing showing sinus at base of the aperture, ×33 [SEM].
2. Locality 7, hypotype (USNM 360382) showing sinuous columella, ×71 [SEM].

3. ***Altaspiratella elongatoidea*** (Aldrich) 14

Locality 1, Wilcox Group, Bashi Member. Holotype (USNM 638862), apertural view, ×17 [LM].

4, 5. ***Altaspiratella gracilens*** Hodgkinson, new species 14

Weches Formation.

4. Locality 8, holotype (USNM 180481), apertural view, ×27 [SEM].
5. Locality 7, paratype (USNM 180482), apertural view, ×29 [SEM].

6–9. ***Limacina adornata*** Hodgkinson, new species 14

Locality 18, Cook Mountain Formation, Wheelock Member.

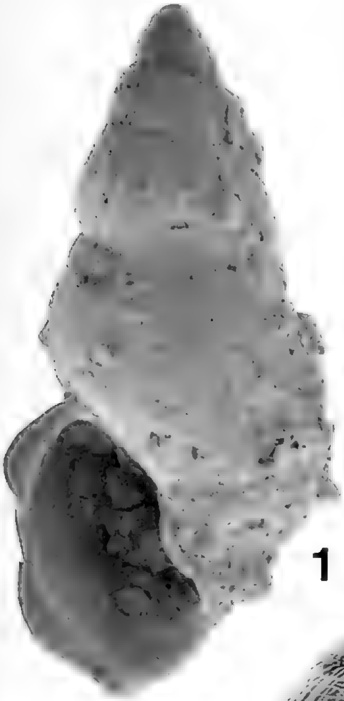
6–8. Holotype (USNM 180483). 6, apertural view, ×28 [SEM]; 7, dorsal view, ×33 [SEM]; 8, ventral view, ×33 [SEM].

9. Paratype (USNM 180484), apertural view, ×41 [SEM].

10–15. ***Limacina aegis*** Hodgkinson, new species 15

10–12. Well locality 53 (2,940 ft), Eocene (cuttings). Holotype (USNM 180485). 10, apertural view, ×27 [SEM]; 11, dorsal view, ×27 [SEM]; 12, ventral view, ×27 [SEM].

13–15. Well locality 45 (7,780 ft: recovered from cuttings in a Cretaceous interval, but probably from "caved-in" Eocene sediments). Paratype (USNM 180486). 13, apertural view, ×16 [SEM]; 14, dorsal view, ×15 [SEM]; 15, ventral view, ×16 [SEM].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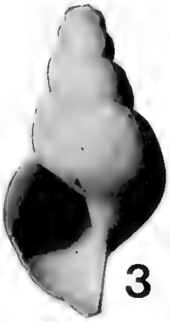
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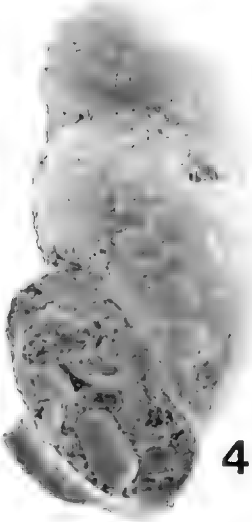
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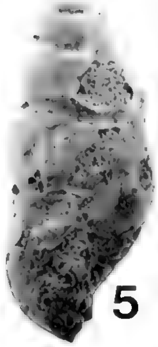
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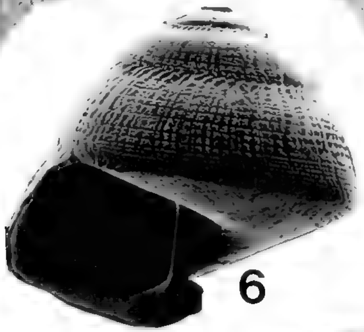
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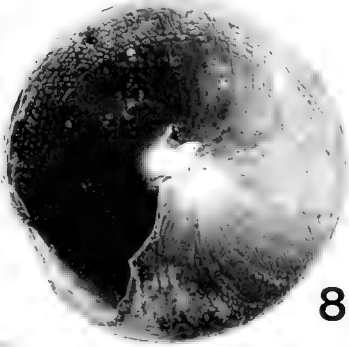
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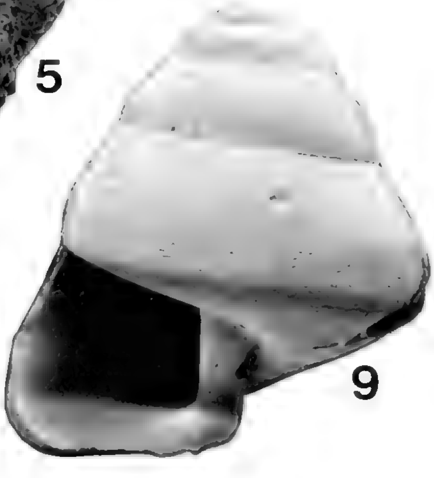
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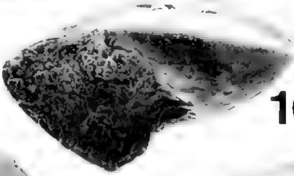
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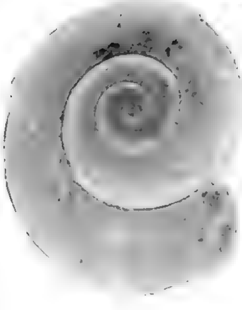
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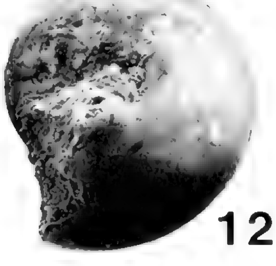
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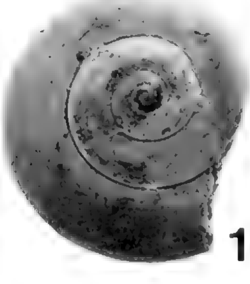
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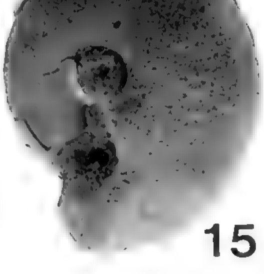
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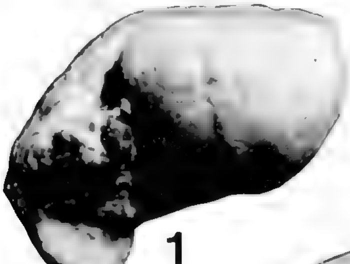
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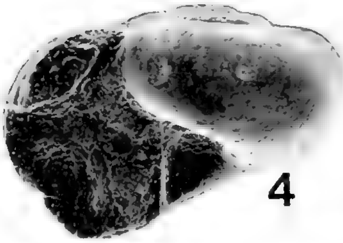
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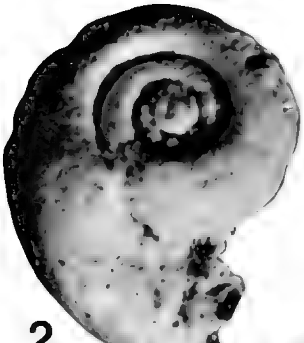
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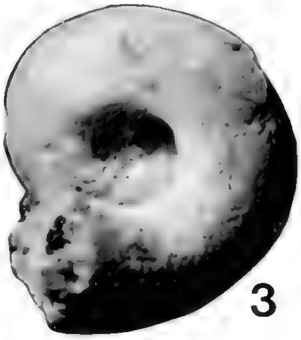
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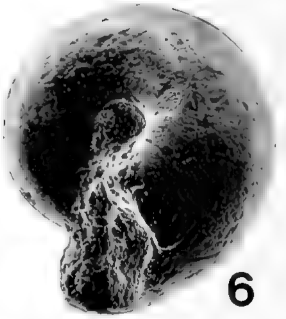
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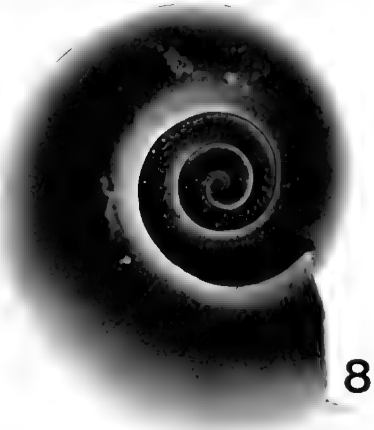
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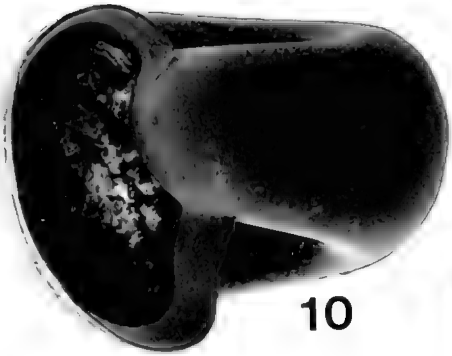
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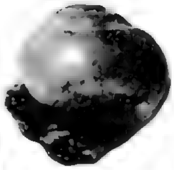
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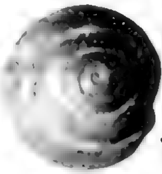
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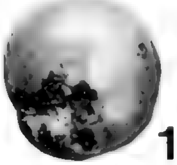
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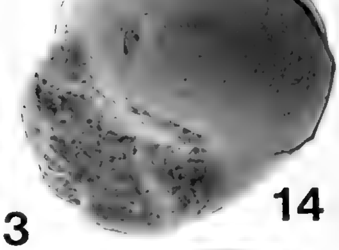
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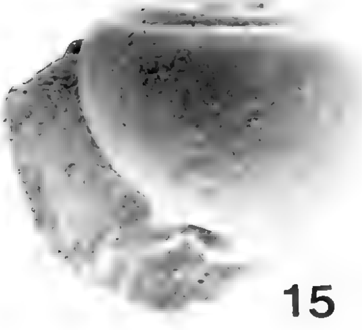
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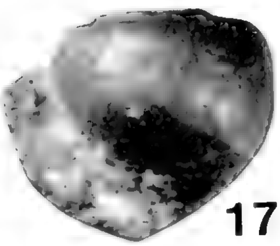
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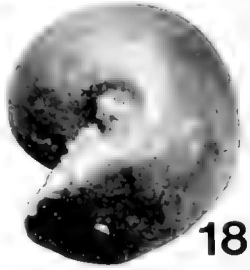
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EXPLANATION OF PLATE 2

Figure Page

1–3. ***Limacina augustana*** Gardner 15
Locality 5, Tallahatta Formation. Holotype (USNM 560589).
1. Apertural view, ×16 [LM].
2. Dorsal view, ×16 [LM].
3. Ventral view, ×15 [LM].

4–6. ***Limacina canadaensis*** Hodgkinson, new species 16
Well locality 49. Holotype (USNM 180487).
4. Apertural view, ×38 [SEM].
5. Dorsal view, ×35 [SEM].
6. Ventral view, ×35 [SEM].

7. ***Limacina choctavensis*** (Aldrich) 16
Locality 1, Wilcox Group, Hatchetigbee Formation, Bashi Member. Syntype (USNM 638860), apertural view, juvenile whorls missing, ×18.

8–10. ***Limacina convolutus*** Hodgkinson, new species 16
Locality 12, Cook Mountain Formation, Wheelock Member. Holotype (USNM 180488).
8. Dorsal view, ×51 [SEM].
9. Ventral view, ×54 [SEM].
10. Apertural view, ×51 [SEM].

11–14. ***Limacina davidi*** Hodgkinson, new species 17
Well locality 42, Wilcox Formation. Holotype (USNM 180489).
11. Dorsal view, ×16 [LM].
12. Apertural view, ×17 [LM].
13. Ventral view, ×17 [LM].
14. Apertural view, ×32 [SEM].

15–18. ***Limacina heatherae*** Hodgkinson, new species 17
Well locality 42, Lower Wilcox Formation (cuttings). Holotype (USNM 180490).
15. Apertural view, ×51 [SEM].
16. Dorsal view, ×36 [LM].
17. Apertural view, ×36 [LM].
18. Ventral view, ×36 [LM].

EXPLANATION OF PLATE 3

Figure — Page

1–5. ***Limacina helikos*** Hodgkinson, new species 17

1–4. Well locality 42, Lower Wilcox Formation. Holotype (USNM 180491). 1, dorsal view, ×39 [LM]; 2, apertural view ×39 [LM]; 3, ventral view, ×39 [LM]; 4, apertural view, ×35 [SEM].

5. Well locality 42, Upper Wilcox Formation. Paratype (USNM 180492), apertural view, ×18 [LM].

6–8. ***Limacina labiata*** Hodgkinson, new species 18

Locality 23, Cook Mountain Formation, Hurricane Lentil. Holotype (USNM 180493).

6. Oblique lateral view showing inner lip and flanged outer lip, ×38 [SEM].
7. Apertural view, ×39 [SEM].
8. Oblique lateral view, showing flanged outer lip, ×37 [SEM].

9, 10. ***Limacina nemoris*** (Curry) 18

Locality 18, Cook Mountain Formation, Wheelock Member.

9. Hypotype (USNM 180494), apertural view, ×38 [SEM].
10. Lost specimen, apertural view, ×95 [SEM].

11–13. ***Limacina planidorsalis*** Hodgkinson, new species 18

Well locality 51, middle Eocene (cuttings). Holotype (USNM 180495).

11. Dorsal view, ×45 [SEM].
12. Apertural view, ×45 [SEM].
13. Ventral view, ×45 [SEM].

14, 15. ***Limacina pygmaea*** (Lamarck) 19

Locality 18, Cook Mountain Formation, Wheelock Member.

14. Hypotype (USNM 180496), apertural view, ×39 [SEM].
15. Lost specimen, apertural view, ×85 [SEM].

16. ***Limacina smithvillensis*** Hodgkinson, new species 19

Locality 8, Weches Formation. Holotype (USNM 180497), apertural view, ×41 [SEM].


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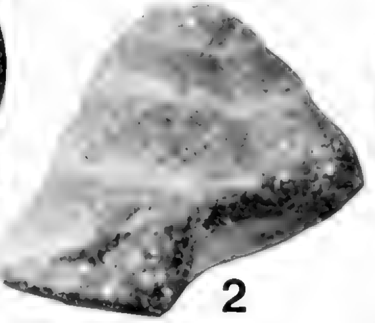
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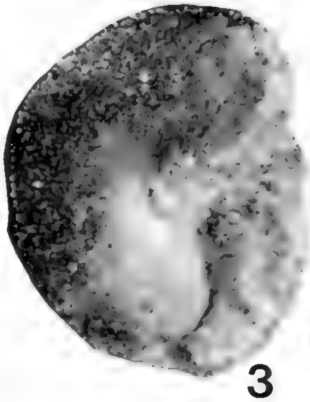
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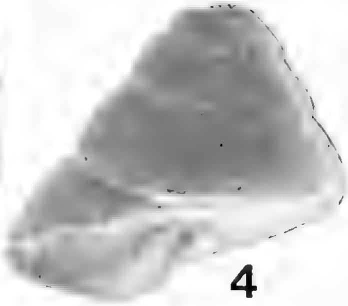
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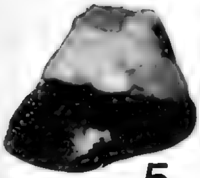
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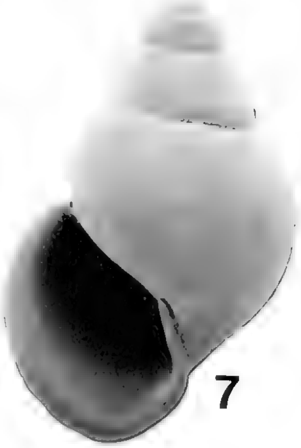
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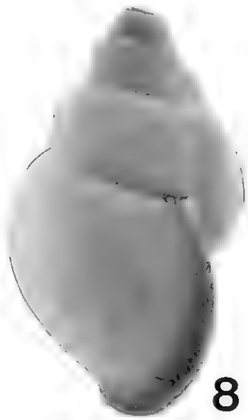
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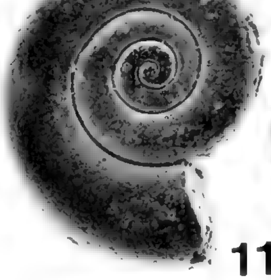
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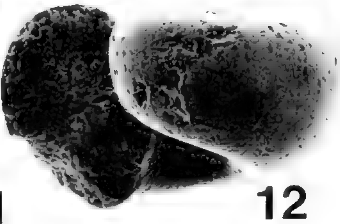
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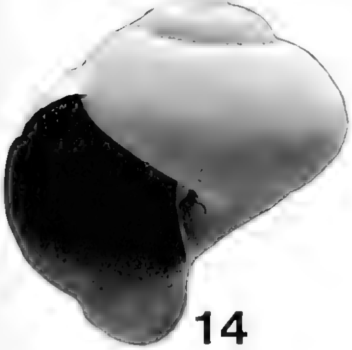
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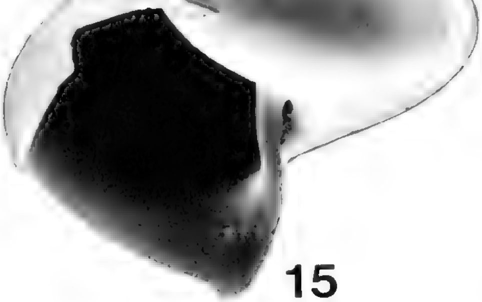
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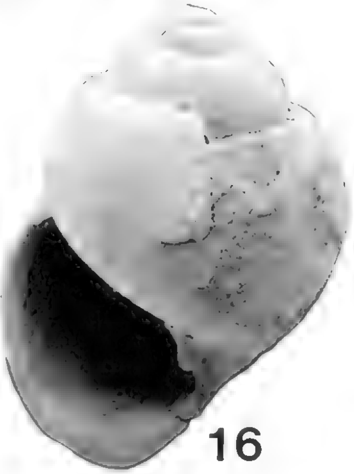
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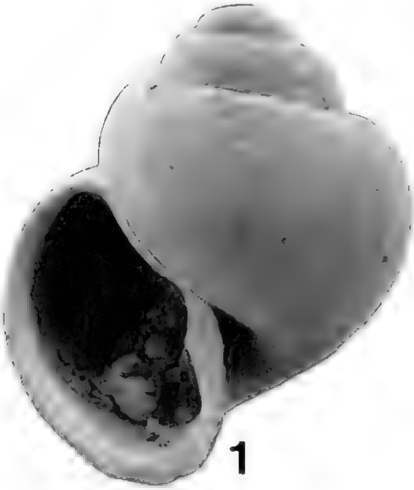

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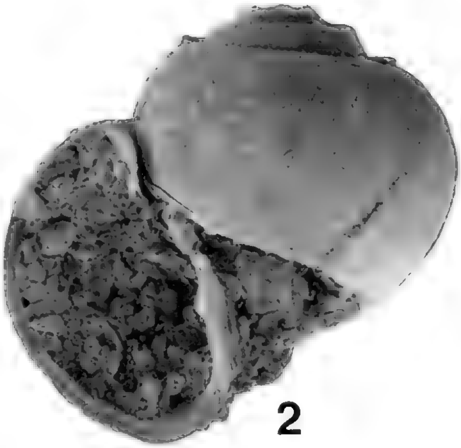

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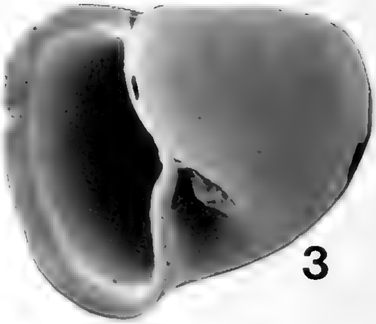

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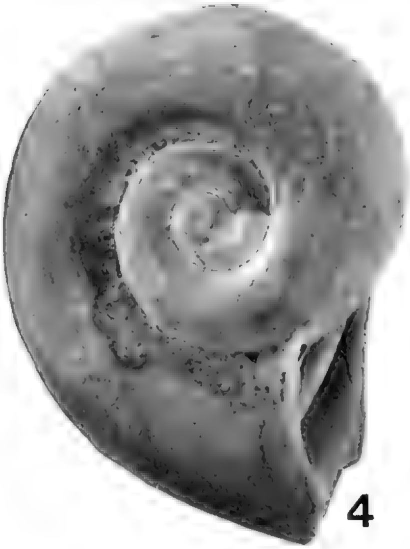

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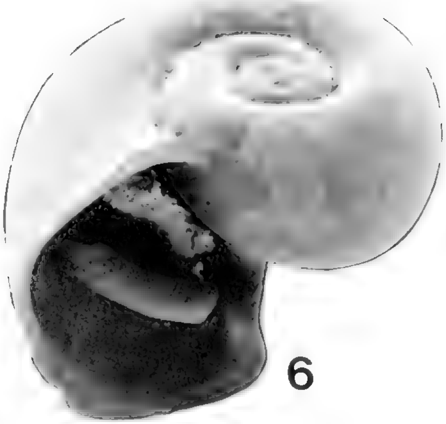

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EXPLANATION OF PLATE 4

Figure — Page

1. ***Limacina stenzeli*** Garvie, new species ... 19
   Locality 2, Reklaw Formation, Marquez Shale Member. Holotype (USNM 180498), ventral view, ×23 [SEM].
2. ***Limacina taylori*** (Curry) ... 20
   Locality 3, Reklaw Formation, Marquez Shale Member. Hypotype (USNM 180499), ventral view, ×32 [SEM].

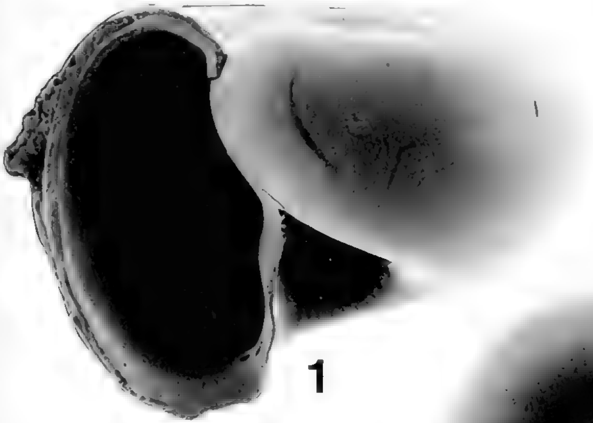
3–6. ***Limacina texana*** Garvie and Hodgkinson, new species ... 20
   Locality 3, Reklaw Formation, Marquez Shale Member.
      3. Paratype (USNM 180501), apertural view, ×29 [SEM].
      4–6. Holotype (USNM 180500). 4, dorsal view, ×30 [SEM]; 5, apertural view, ×30 [SEM]; 6, oblique dorsal view, ×30 [SEM].

7, 8. ***Limacina tutelina*** (Curry) ... 20
      7. Well locality 48 (cuttings). Hypotype (USNM 180502), apertural view, ×37 [SEM].
      8. Well locality 50 (cuttings). Hypotype (USNM 180503), apertural view, ×28 [SEM].

9. ***Limacina voluta*** Hodgkinson, new species ... 21
   Well locality 49 (cuttings recovered from Cretaceous interval, but probably from caved-in Eocene sediments). Holotype (USNM 180504), apertural view, ×26 [SEM].

EXPLANATION OF PLATE 5

Figure		Page
1–7.	***Limacina wechesensis*** Hodgkinson, new species	21
1–3.	Locality 8, Weches Formation. Lost specimen, with narrow rounded umbilicus. 1, apertural view, ×65 [SEM]; 2, ventral view, ×65 [SEM]; 3, dorsal view, ×65 [SEM].	
4–6.	Holotype (USNM 360337), note teardrop shape of aperture. 4, ventral view, ×69 [SEM]; 5, apertural view, ×67 [SEM]; 6, dorsal view, ×63 [SEM].	
7.	Enlargement showing crossed-lamellar shell structure, ×3,500 [SEM].	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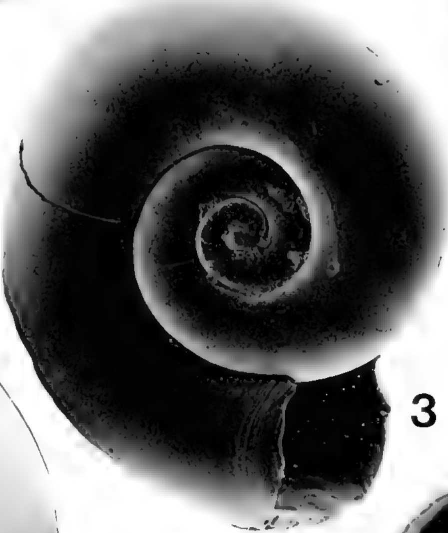
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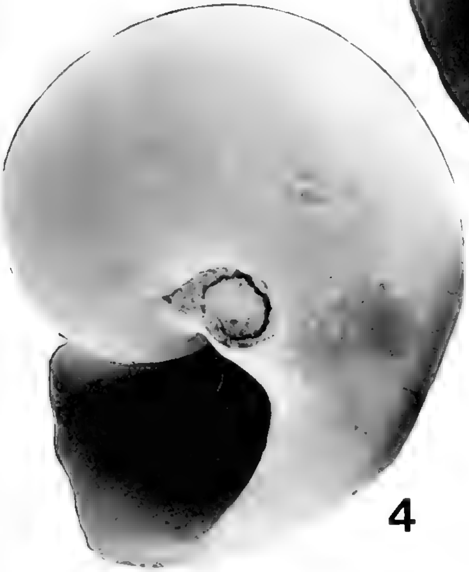
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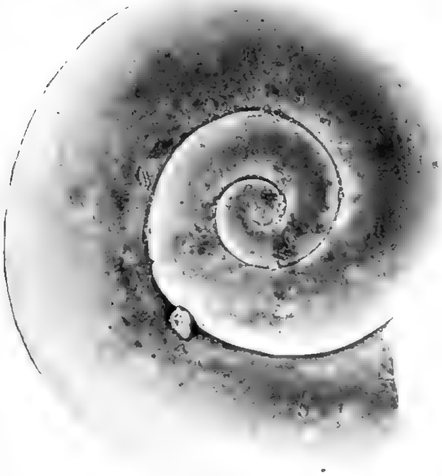
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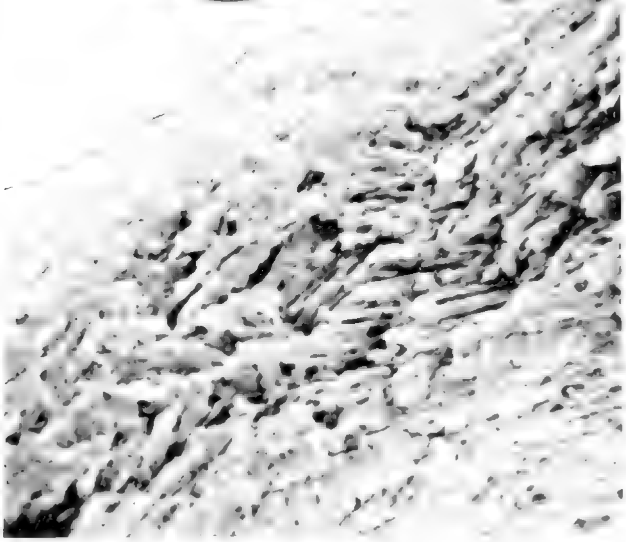
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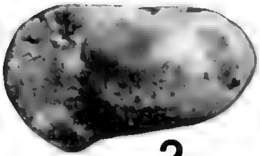
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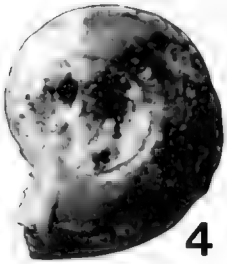
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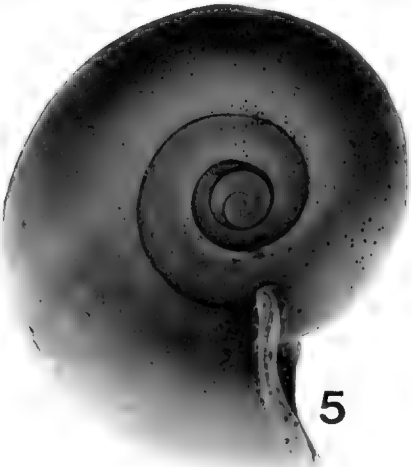
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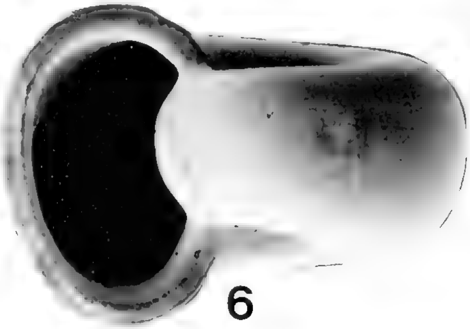
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EXPLANATION OF PLATE 6

Figure		Page
1.	***Limacina wechesensis*** Hodgkinson, new species Enlargement showing crossed-lamellar shell structure ×3,500 [SEM].	21
2–4.	***Skaptotion andersoni*** (Gardner) Locality 15, Cook Mountain Formation. Holotype (USNM 369235). 2. Apertural view, ×15 [LM]. 3. Dorsal view, ×15 [LM]. 4. Ventral view, ×15 [LM].	22
5–10.	***Skaptotion nitens*** (I. Lea) 5–7. Locality 26, Gosport Sand. Hypotype (USNM 360338). 5, dorsal view, showing nuclear whorls, ×43 [SEM]; 6, apertural view, ×40 [SEM]; 7, ventral view, ×43 [SEM]. 8–10. Locality 18. Hypotype (USNM 360339). 8, dorsal view, showing character of the nuclear whorls, ×36 [SEM]; 9, apertural view, showing the elongate reniform shape of the aperture, ×37 [SEM]; 10, ventral view, ×40 [SEM].	22

EXPLANATION OF PLATE 7

Figure Page

1–4. ***Skaptotion*? *reklawensis*** Garvie, new species 23

1, 2. Locality 2, Reklaw Formation, Marquez Shale Member. Holotype (USNM 360340). 1, dorsal view, ×23 [SEM]; 2, apertural view, ×23 [SEM].

3, 4. Locality 8, Weches Formation. Figured specimen [crushed following SEM photography]. 3, apertural view, ×28 [SEM]; 4, dorsal view, ×30 [SEM].

5–8. ***Skaptotion spirale*** Hodgkinson, new species 23

Well locality 51 (cuttings). Holotype (USNM 360341).

5. Dorsal view, ×69 [SEM].
6. Apertural view, ×36 [LM].
7. Dorsal view, ×33 [LM].
8. Ventral view, ×36 [LM].

9, 10. ***Bovicornu eocenense*** Meyer 24

Locality 34, Red Bluff Formation (early Oligocene). Holotype (USNM 644596).

9. Enlarged view of apex, ×34 [SEM].
10. Lateral view, ×17 [LM].

11, 12. ***Bovicornu gracile*** Meyer 25

Locality 31, Moodys Branch Formation. Holotype (USNM 638880).

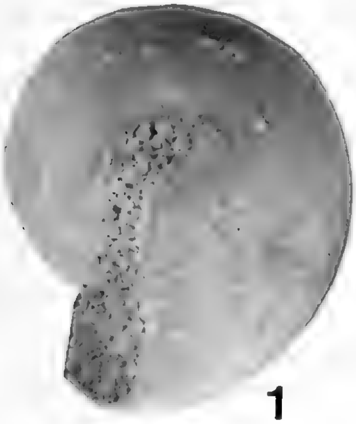
11. Lateral view, ×17 [LM].
12. Enlarged view of the apex, ×50 [LM].

13–15. ***Camptoceratops americanus*** Garvie, new species 25

Locality 2, Reklaw Formation.

13. Paratype (USNM 360343), ×33 [SEM].

14, 15. Holotype (USNM 360342). 14, oblique view, ×33 [SEM]; 15, lateral view, ×33 [SEM].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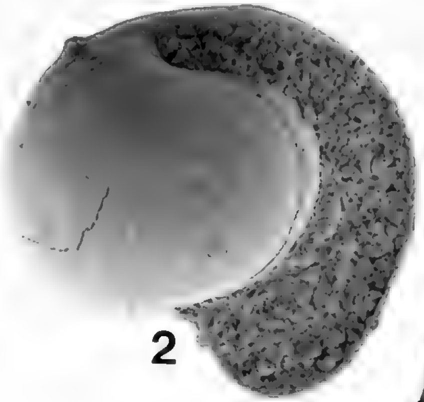
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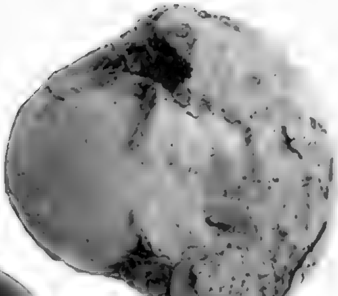
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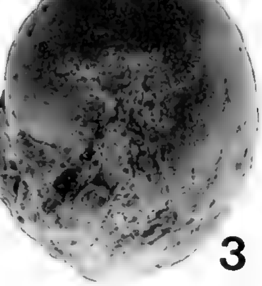
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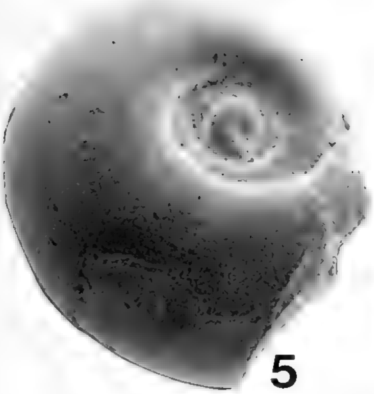
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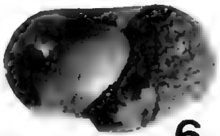
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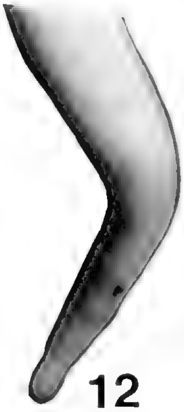
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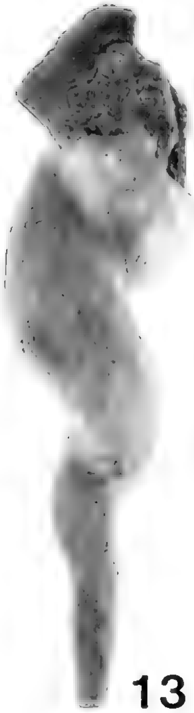
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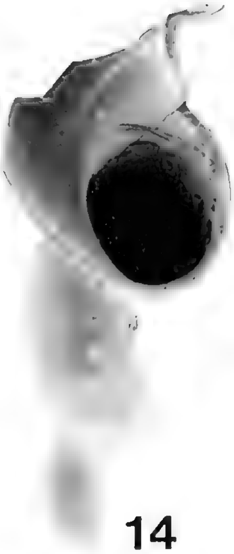
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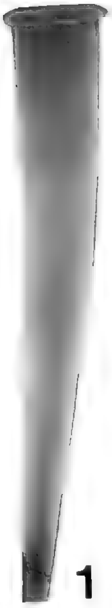
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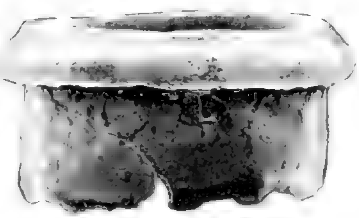
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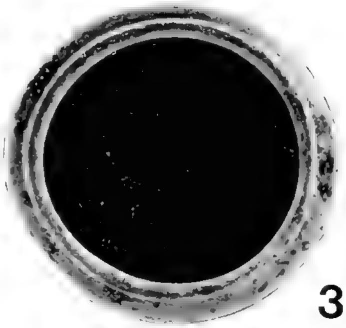
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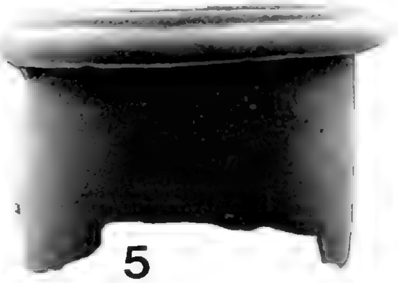
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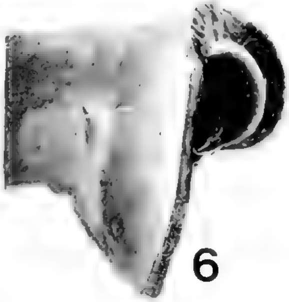
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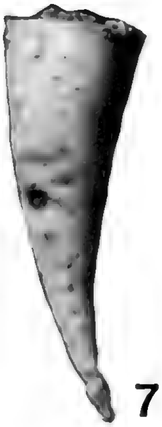
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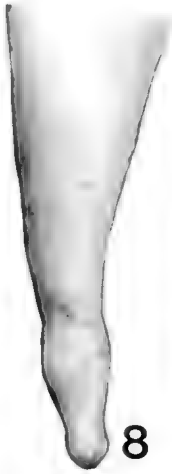
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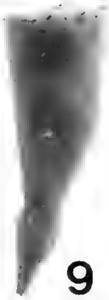
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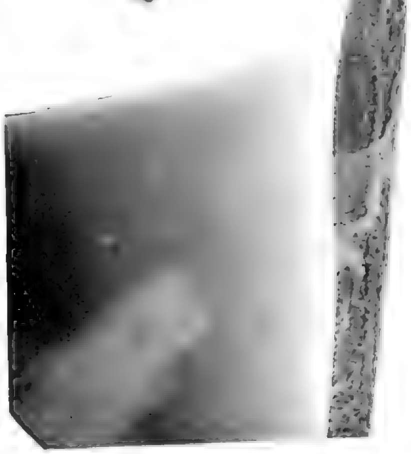
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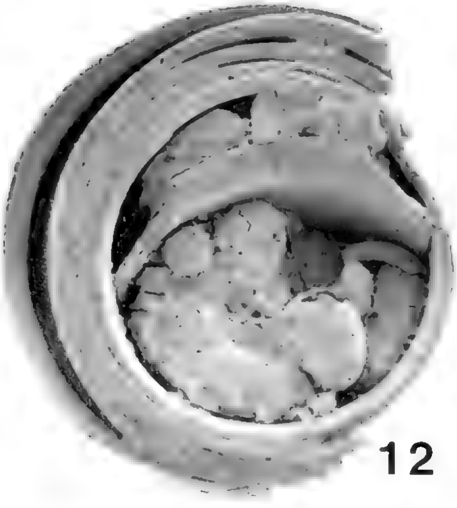
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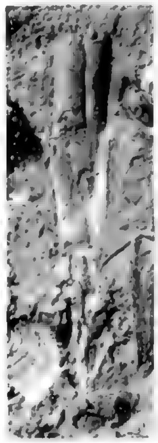
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EXPLANATION OF PLATE 8

Figure Page

1–6. ***Cheilospicata repanda*** Hodgkinson and Garvie, new species 26

Stone City Formation.

1. Locality 12, holotype (USNM 360344), ×11 [SEM].

2, 3. Locality 12, paratype (USNM 360345), apertural fragment. 2, lateral view, ×32 [SEM]; 3, apertural view, ×30 [SEM].

4. Locality 12, paratype (USNM 360346), fragment showing nature of flanged aperture, ×100 [SEM].

5. Locality 11, paratype (USNM 360347), ×40 [SEM].

6. Locality 12, paratype (USNM 360348), showing nature of apertural flange, and groove almost enclosed beneath flange, ×55 [SEM].

7–9. ***Creseis corpulenta*** (Meyer) 26

7, 8. Locality 31, Moodys Branch Formation. Holotype (USNM 638879). 7, lateral view, ×17 [LM]; 8, detail of apex, ×49 [LM].

9. Locality 44 (early Oligocene). Hypotype (USNM 360349), ×31 [SEM].

10–14. ***Creseis cylindrica*** Hodgkinson, new species 27

Cook Mountain Formation, Wheelock Member.

10. Locality 18, paratype (USNM 360351), fragment of apertural end showing nature of thickened lip [Note that shell material is added to the inside of the shell.], ×130 [SEM].

11. Locality 18, holotype (USNM 360350), ×33 [SEM].

12. Locality 18, paratype (USNM 360352), showing "nesting" of several individual specimens, a common occurrence where specimens are abundant [This phenomenon is especially common in this species of *Creseis*, partly because of the simple conical shape that allows one specimen to fit well within another.], ×34 [SEM].

13. Locality 18, lost fragment showing thickening at apertural end, ×50 [SEM].

14. Locality 17, paratype (USNM 360353), specimen in matrix, ×5 [LM].

EXPLANATION OF PLATE 9

Figure Page

1–3. ***Creseis hastata*** (Meyer) 27

1, 2. Locality 35, Oligocene (Vicksburgian) strata. Holotype (USNM 644595). 1, lateral view, ×18 [LM]; 2, details of apex, ×32 [LM].

3. Locality 29, Moodys Branch Formation. Specimen showing details of the apical bulb. Specimen one of six in the Aldrich Collection at the United States National Museum (no assigned USNM number or type designation), ×40 [LM].

4–9. ***Creseis simplex*** (Meyer) 28

4, 5. Locality 31, Moodys Branch Formation. Holotype (USNM 638841). 4, enlarged view of apex, ×35 [LM]; 5, lateral view, ×18 [LM].

6. Locality 11, Stone City Formation. Highly inflated specimen (lost), ×12 [SEM].

7. Locality 8, Weches Formation. Hypotype (USNM 360354) with slight coiling, ×22 [SEM].

8, 9. Locality 18, Cook Mountain Formation, Wheelock Member. Less-inflated specimen (lost). 8, lateral view, ×15 [SEM]; 9, detail of inflated end showing small, oval, apical bulb and two faint constrictions, ×75 [SEM].

10, 11. ***Creseis*** species A 28

Well locality 52 (cuttings). Figured specimen (USNM 360355).

5. Lateral view, ×35 [SEM].

6. Detail of apex, showing heart-shaped bulb and two constrictions, ×100 [SEM].

12–17. ***Euchilotheca succincta*** (Defrance) 29

Locality 19, Cook Mountain Formation, Wheelock Member.

12, 13. Lost specimen. 12, apertural view, ×75 [SEM]; 13, lateral view, ×71 [SEM].

14, 15. Hypotype (USNM 360356). 14, lateral view, ×40 [SEM]; 15, apertural view, ×38 [SEM].

16. Apertural fragment (lost), lateral view, ×40 [SEM].

17. Hypotype (USNM 360357), lateral view, ts41 [SEM].

18, 19. ***Hyalocylis*** species A 29

Well locality 41, Sparta Formation. Figured specimen (USNM 360358).

18. ×34 [SEM].

19. ×28 [LM].


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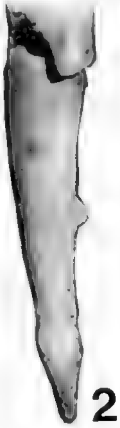
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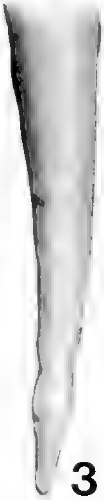
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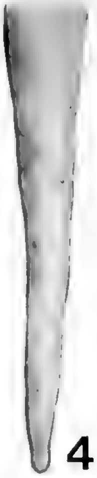
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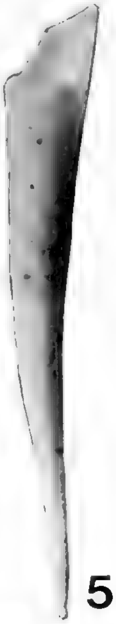
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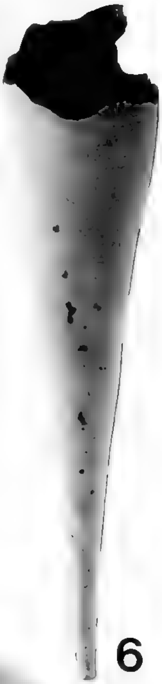
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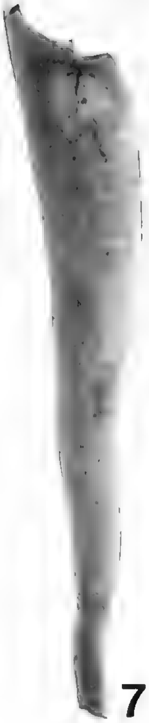
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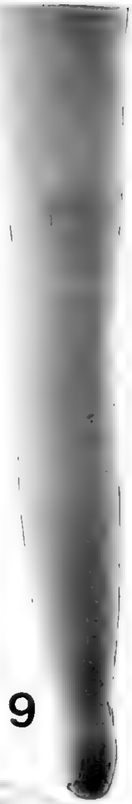
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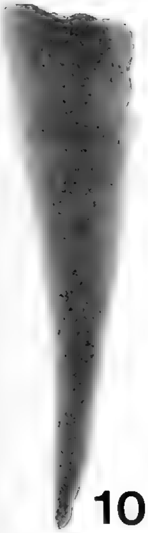
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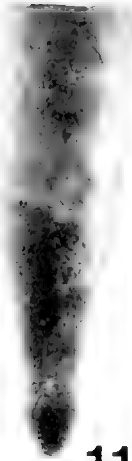
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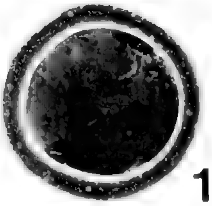
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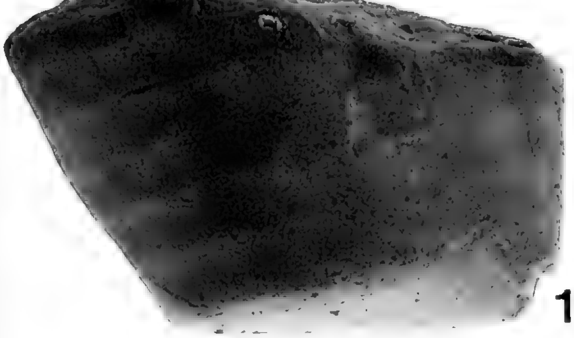
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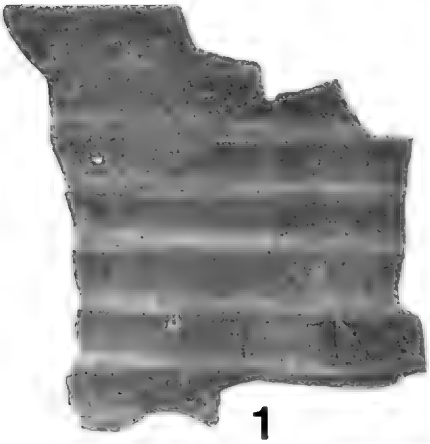
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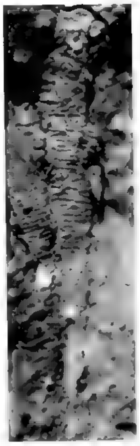
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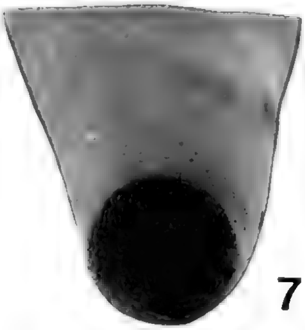
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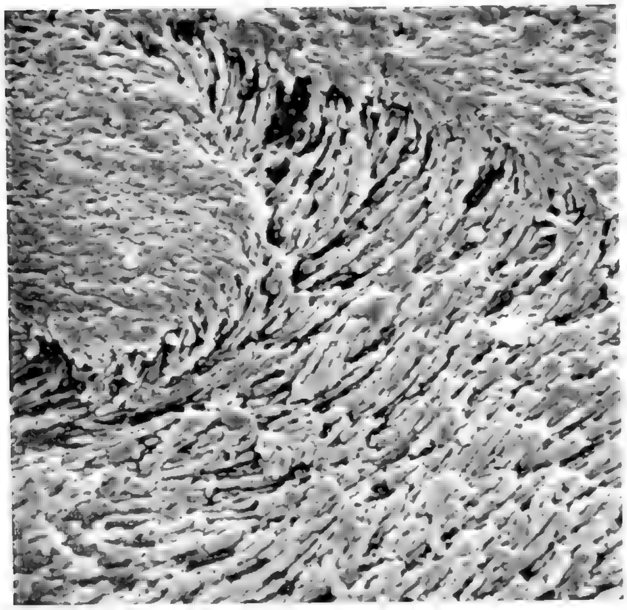

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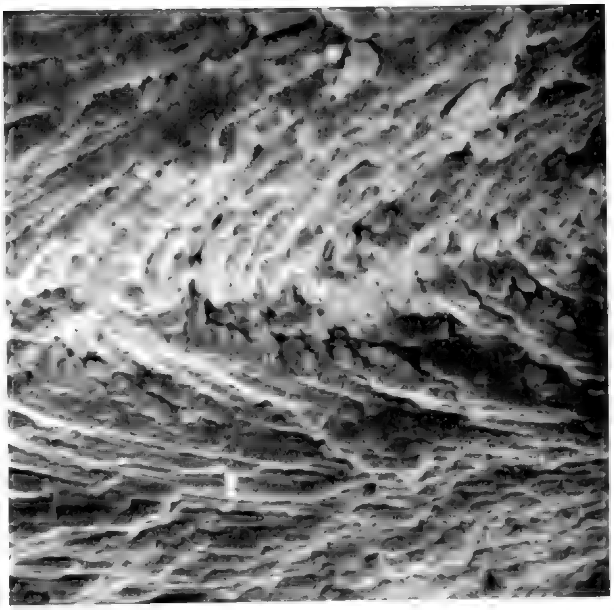


EXPLANATION OF PLATE 10

Figure Page

1–5. ***Praehyalocylis maximus denseannulatus*** (Ludwig) 30

Locality 17, Cook Mountain Formation, Wheelock Member.

1. Hypotype (USNM 360359), detail of shell, ×50 [SEM].
2. Hypotype (USNM 360360), ×6 [LM].
3. Figured specimen (USNM 360361), showing ornamentation and lipped aperture, ×6 [LM].
4. Lost specimen, showing annulations and lipped aperture, ×6 [LM].
5. Composite drawing based on available specimens, approximately ×4.

6–10. ***Bucanoides basiannulata*** Hodgkinson, new genus and new species 31

Locality 8, Weches Formation.

6, 7. Holotype (USNM 360362). 6, lateral view, ×32 [SEM]; 7. oblique view showing basal septum, ×46 [SEM].

8. Paratype (USNM 360363), apical fragment, showing basal annulations, ×32 [SEM].

9, 10. Enlargements showing helical microstructure of shell wall. 9, ×1,750 [SEM]; 10, ×4,000 [SEM].

EXPLANATION OF PLATE 11

Figure Page

1–3. ***Bucanoides divaricata*** Hodgkinson, new genus and new species 31

  1, 2. Locality 18, Cook Mountain Formation, Wheelock Member. 1, paratype (USNM 360365), lateral view, ×43 [SEM]; 2, holotype (USNM 360364), lateral view, ×24 [SEM].

  3. Locality 17, Large specimen (USNM 360381) in rock matrix, on same rock fragment as a figured specimen (USNM 360351), of *Creseis cylindrica*, n. sp., ×6 [LM].

4–6. ***Bucanoides tenuis*** Hodgkinson, new genus and new species 32

  4. Locality 12, Stone City Formation. Paratype (USNM 360367), showing inflated form, ×21 [SEM].

  5, 6. Locality 23, Cook Mountain Formation, Hurricane Lentil. 5, paratype (USNM 360368), ×26 [SEM]; 6, holotype (USNM 360366), ×18 [SEM].

7–10. ***Cuvierina gutta*** Hodgkinson, new species 32

  7, 8. Locality 23, Cook Mountain Formation, Hurricane Lentil. Paratype (USNM 360370), broken specimen, showing aperture. 7, dorsal view, ×44 [SEM]; 8, apertural view, ×44 [SEM].

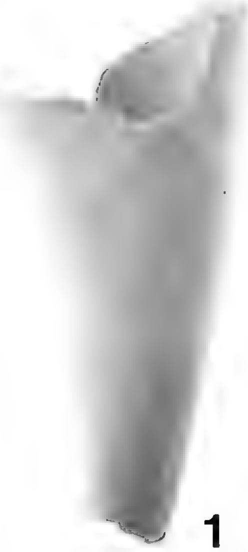
  9, 10. Locality 18, Cook Mountain Formation, Wheelock Member. Holotype (USNM 360369). 9, ventral view, ×24 [SEM]; 10, lateral view, ×29 [SEM].

11–15. ***Cuvierina lura*** Hodgkinson, new species 32

  11. Locality 8, Weches Formation. Holotype (USNM 360371), ×51 [SEM].

  12, 13. Locality 7, Weches Formation. Paratype (USNM 360372). 12, lateral view, ×44 [SEM]; 13, apertural view, ×44 [SEM].

  14, 15. Locality 8, Weches Formation. Specimen (lost) truncated a short distance from the basal septum. 14, septal detail, ×144 [SEM]; 15, lateral view, ×70 [SEM].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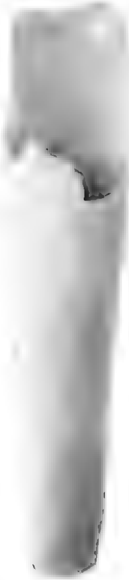
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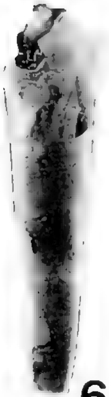
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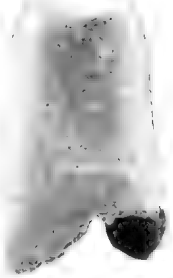
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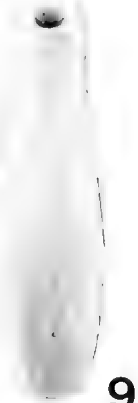
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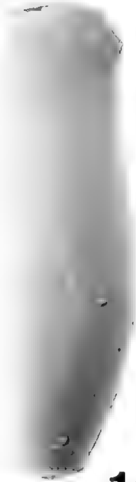
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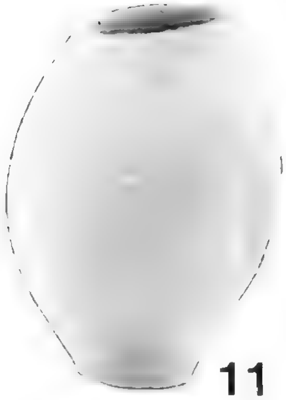
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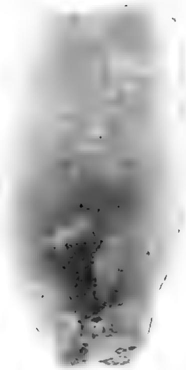
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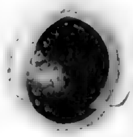
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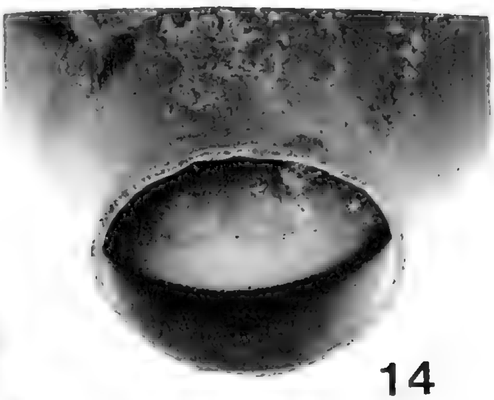
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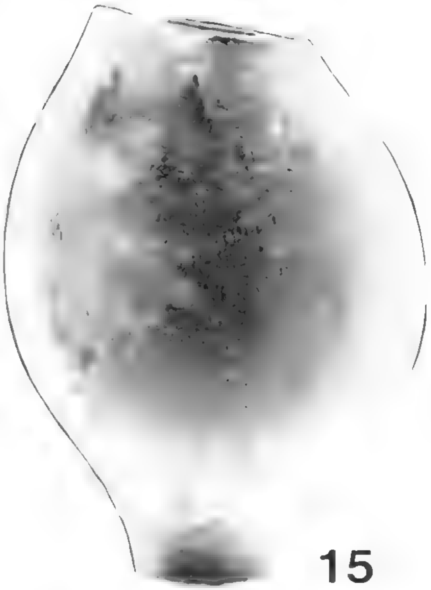
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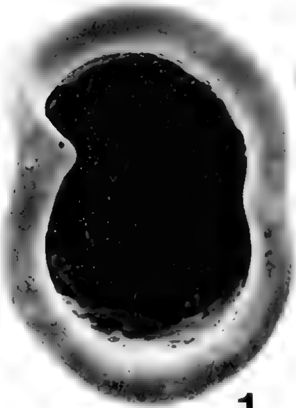
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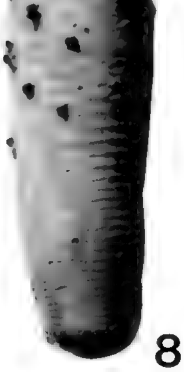
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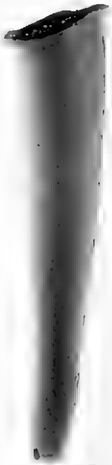
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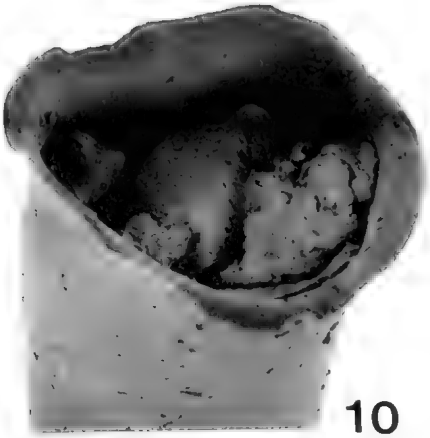
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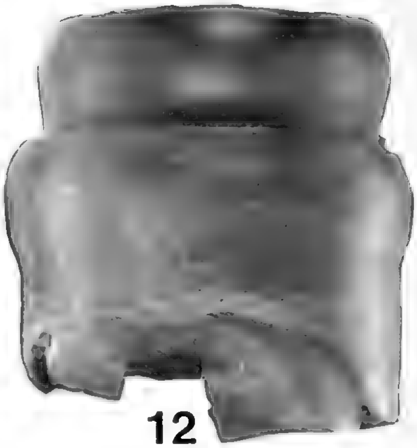
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Explanation of Plate 12

Figure — Page

1–5. ***Loxobidens aduncus*** Hodgkinson, new genus and new species 33
Locality 19, Cook Mountain Formation, Wheelock Member.
1, 2. Holotype (USNM 360373). 1, apertural view, ×73 [SEM]; 2, lateral view, ×73 [SEM].
3–5. Lost specimen. 3, ventral view, ×85 [SEM]; 4, apertural view, ×85 [SEM]; 5, lateral view, ×85 [SEM].
6. Apical fragment, paratype (USNM 360374), questionably assigned to *L. aduncus*, ×31 [SEM].

7, 8. ***Tibiella annulata*** Garvie, new species 34
Locality 10, Weches Formation, Viesca Member. Holotype (USNM 360375).
7. Lateral view, ×17 [LM].
8. Ventral view, ×17 [LM].

9, 10. ***Tibiella marshi*** Meyer 34
Locality 26, Gosport Sand. Neotype (USNM 360376).
9. Lateral view, ×12 [SEM].
10. Enlargement showing trigonal aperture, ×45 [SEM].

11, 12. ***Tibiella reflexa*** Hodgkinson, new species 35
Locality 12, Stone City Formation.
11. Lost specimen, oblique view, showing thickened aperture, ×40 [SEM].
12. Paratype (USNM 360378), "nested" specimens, lateral view, ×33 [SEM].

EXPLANATION OF PLATE 13

Figure Page

1–3. ***Tibiella reflexa*** Hodgkinson, new species 35

Locality 12, Stone City Formation.

1. Holotype (USNM 360377), lateral view, × 34 [SEM].

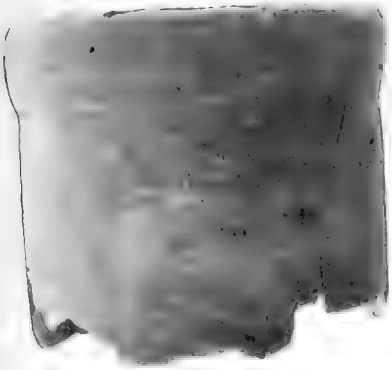
2, 3. Fragment (lost), showing reflexed shell at aperture. 2, × 48 [SEM]; 3, × 190 [SEM].

4–8. ***Tibiella texana*** Collins 35

Locality 8, Weches Formation.

4. Topotype (USNM 360379), lateral view, × 13 [SEM].
5. Topotype (USNM 360383), apertural fragment, showing recurved flange, × 90 [SEM].
6. Topotype (USNM 360384), apertural fragment, without recurved flange, × 87 [SEM].

7, 8. Apertural fragment (lost). 7, apertural view, × 50 [SEM]; 8, lateral view, × 50 [SEM].



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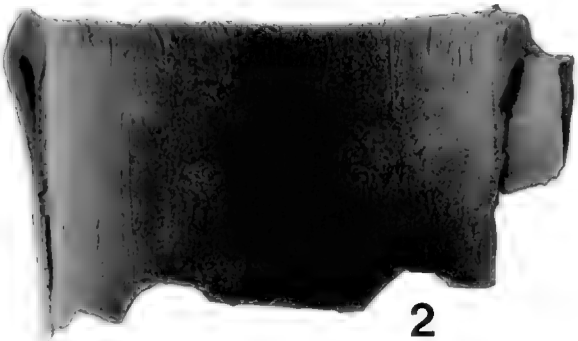

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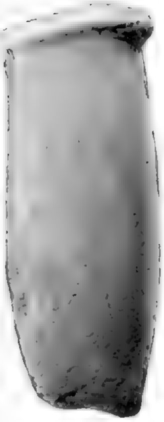

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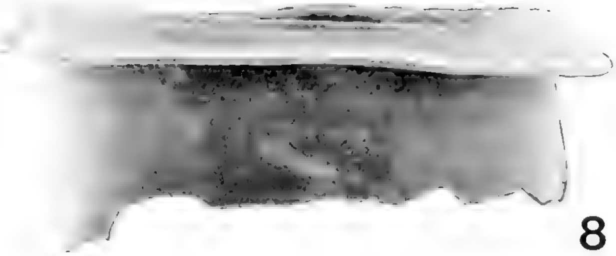

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INDEX

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PREPARATION OF MANUSCRIPTS

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Collinson, J.

1962. *Size of lettering for text figures.* Journal of Paleontology, vol. 36, p. 1402.

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