NON-FUSULINID FORAMINIFERA OF THE UPPER PENNSYLVANIAN FINIS SHALE, INCLUDING THE DESCRIPTION OF AN ENIGMATIC TAXON

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ABSTRACT

The Upper Pennsylvanian Finis Shale Member of the Graham Formation, Cisco Group (Virgilian Series) can be characterized by its foraminiferal assemblage. Although the chronostratigraphic position of the Finis Shale has been disputed for most of this century, the occurrence of Virgilian age foraminifera supports recent research placing the Finis at the base of the Cisco Group. The mid-unit shales of the Finis contain the highest generic diversity of foraminifera, and also contain an enigmatic taxon, *Finisia martini*, described herein.

Key words: Finis Shale, foraminifera, Pennsylvanian.

INTRODUCTION

The Finis Shale Member crops out in Jack and Young Counties, Texas. The shale may be traced sporatically over an area of approximately 2700 km^2. Foraminifera for this investigation were collected from sites within a 20 km radius of Jacksboro, Jack County, Texas (Text-figure 1).

The study has been undertaken in order to further characterize the chronostratigraphic position of the Finis Shale by providing an account of the foraminifera present. Preliminary investigations of Upper Pennsylvanian foraminifera by Cushman and Waters (1928, 1930) established many genera and species of the Cisco Group, but foraminifera typical of the different stratigraphic members of this group have never been catalogued.

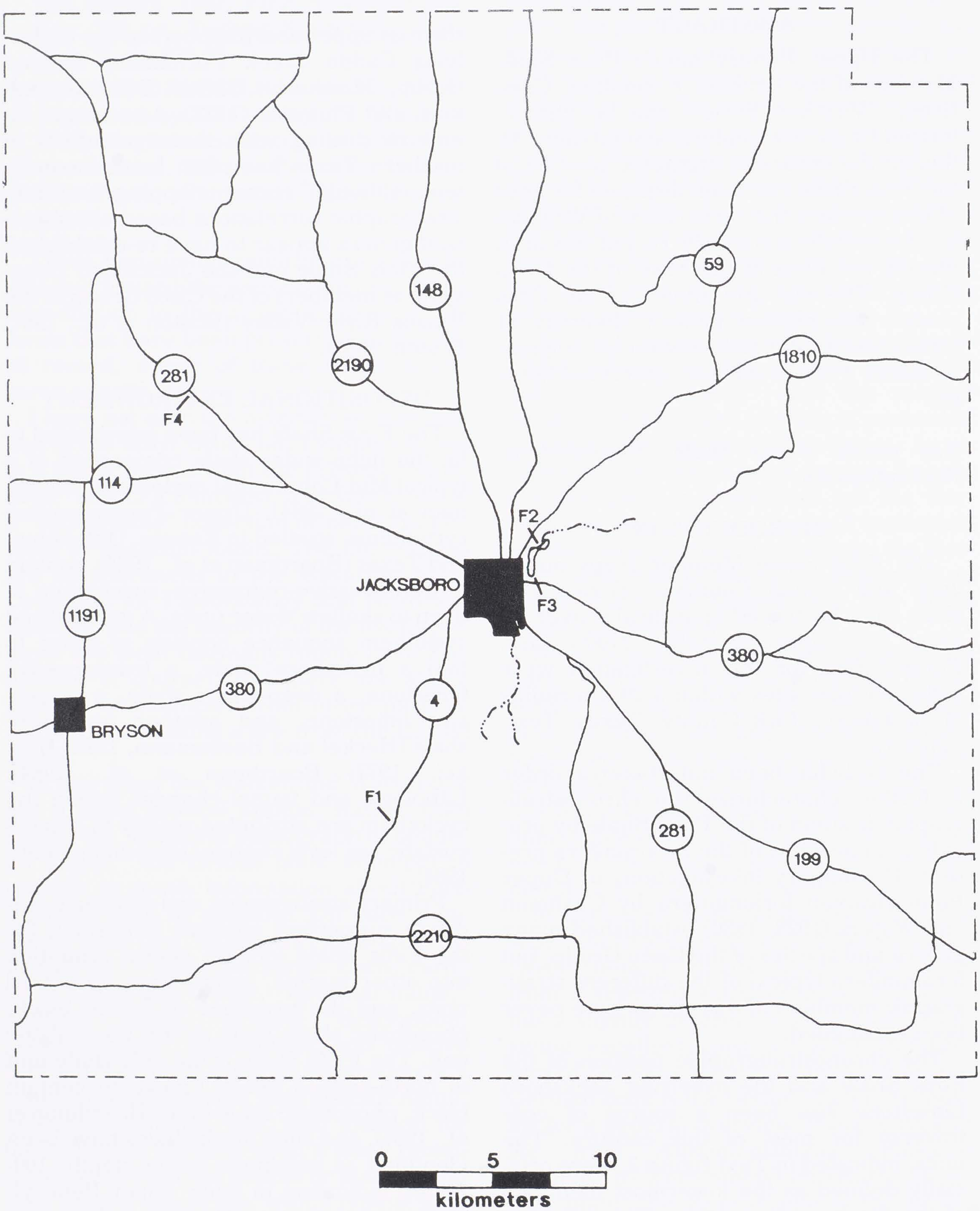
The chronostratigraphic position of the Finis Shale and the overlying Jacksboro Limestone has been a source of controversy for most of this century. The units, indicated in Text-figure 2, were originally defined as the lowermost members of the Graham Formation, Cisco Group, Virgilian Series (Plummer and Moore, 1921). Subsequent researchers considered them as uppermost members of the underlying Caddo Creek Formation, Canyon Group, Missourian Series (Sellards, Adkins, and Plummer, 1932). As a result, literature dealing with these members in northern Texas has often been inconsistent, although recent mapping and biostratigraphic correlations based on ammonoid genera appear to have re-established the Finis Shale and the Jacksboro Limestone as members of the Cisco Group in the Brazos River Valley (Boston *et al.*, 1987; Boston, 1988).

DEPOSITIONAL ENVIRONMENT

The Finis Shale has been interpreted to be the deep-water shale component of a typical Mid-Continental cyclothem (Boardman *et al.*, 1984). Upper Pennsylvanian cyclothems, studied in Kansas, Oklahoma, and Texas (Boardman *et al.*, 1984), contain a transgressive-regressive succession of deep to shallow water units. A generalized cyclothem sequence consists of (base to top) a nearshore shale, a transgressive limestone, a deep-water shale, a regressive limestone, and another nearshore shale (Heckel and Baesemann, 1975; Heckel, 1977; Boardman *et al.*, 1984). Lithologic and faunal changes within the cyclothem are attributed mainly to glacial-eustatic sea level change (Boardman *et al.*, 1984).

Primary stratigraphic and lithologic evidence supporting offshore deposition for the Finis Shale include lateral gradation into other marine, rather than terrestrial units, and the presence of fissile, black, phosphatic shale beds at the base of the unit. The Finis Shale is the only shale unit in north-central Texas known to contain black, phosphatic shale beds (Boardman *et al.*, 1984), and such black shales have been identified as maximum water depth (100-200 m) indicators in other upper Pennsylvanian cyclothems (Heckel and Baesemann, 1975; Heckel, 1977; Boardman *et al.*, 1984).

A depositional model proposes that the phosphatic, black shales found in many mid-continental cyclothems were deposited in anoxic waters below a thermocline, which developed in deeper epicontinental seas (Heckel, 1977; Boardman *et al.*, 1984). A quasi-estuarine type circulation would cause cold, phosphate-rich, oxygen-poor waters below the thermocline to upwell, carrying nutrients for phytop-



Text-figure 1. Map of Jack County, Texas, showing sample localities (F1, F2, F3, and F4).

lankton blooms (Heckel, 1977). Deep water phosphate formation in some modern environments, such as off of the coast of Peru, occurs under similar conditions near oxygen-minimum zones associated with upwelling (Veeh *et al.*, 1973). Subsequent settling and decay of pelagic organisms would perpetuate the cycle, providing phosphate and further depleting bottom-water oxygen content (Heckel, 1977). The black color of the shales and the presence of pyrite in the Finis Shale attest to a high rate of organic decomposition and bacterial interaction (Blatt *et al.*, 1972).

Another indication of low bottom-water oxygen content during deposition is the general lack of benthic fossils in the phosphatic, black shale beds. Most fossils reported from these shales are pelagic or nektonic, such as ammonoids, radiolarians, conulariids, and certain bivalves (Boardman *et al.*, 1984). Compared to the the rest of the unit, the basal black shales of the Finis are sparsely fossiliferous with low diversity at higher taxonomic levels.

Overlying the phosphatic black shales are medium to dark gray shales (2-3 m), which were generally deposited under shallower, oxygenated conditions favorable to a wide variety of taxa. These mid-unit shales contain the highest diversity of invertebrates at higher taxonomic levels. Numerous genera of ammonoids, nautiloids, gastropods, bivalves, brachiopods, bryozoans, crinoids, corals, sponges, and ostracods have been noted (Boardman *et al.*, 1984; Boston, 1988). Low current activity and sedimentation rates enabled *in situ* preservation of many delicate specimens. Alhough bottom waters were probably oxygenated, pyritization of some fossils and the dark color of the shales show reducing conditions prevailed in the upper layers of the sediment (Blatt *et al.*, 1972).

The upper part of the Finis Shale consists of medium to light gray shales (1-2 m) (Boardman *et al.*, 1984; Boston, 1988). These shales are also highly fossiliferous, with pyritization of some specimens, reflecting a depositional environment similar to that of the mid-unit shales. The fossil assemblage, mainly brachiopods, bryozoans, crinoids, and fusulinids, is indicative of yet shallower-water deposition (Boardman *et al.*, 1984). There is a notable increase in fusulinids when compared to the shales of the middle unit.

METHODS AND MATERIALS

As mentioned above, the Finis Shale can be divided into 3 distinct sedimentary units, although all of these units may not be present or well defined at a specific locality (Text-figure 1). A sample of the basal black shales was collected at the F1 locality, a small hill 0.5 km west of Route 4, at a point 10.5 km south of the intersection of Route 380 and Route 4, west of Jacksboro. Three samples of the mid-unit, dark to medium gray shales were obtained from three horizons (F2a, F2b, and F2c) of an outcrop located at the Lake Jacksboro spillway. These shales are now flooded due to a new dam on Lost Creek, which expanded the Lake Jacksboro reservoir. In a roadcut at the southeastern corner of the lake, there is a poorly exposed sequence of the upper unit, medium gray shales (F3). Better samples of the upper shales were collected at

SERIES	GROUP	FORMATION	MEMBER
VIRGILIAN	CISCO	GRAHAM	SOUTH BEND SH
			BUNGER LS
			GONZALES SH
			JACKSBORO LS
			FINIS SH
MISSOURIAN	CANYON	CADDO CREEK	HOME CREEK LS
			COLONY CREEK SH
		BRAD	RANGER LS
			PLACID SH

Text-figure 2. Stratigraphic column of the Upper Pennsylvanian in northern Texas (Brazos River Valley).

the P and S Stone Quarry, located on the south side of Route 281, 16 km northwest of Jacksboro. Sample F4a came from talus piles, and sample F4b came from beds below the contact with the overlying Jacksboro Limestone. Ten kg of matrix from each sample were wet-sieved through a series of screens (0.841, 0.250, 0.149, and 0.074 mm mesh), using Calgon (TM) as a deflocculant. Most of the foraminifera were present on the 0.149 mm mesh screen.

DISCUSSION OF FORAMINIFERAL POPULATION

Foraminifera occur throughout the Finis Shale (Table 1), with three suborders (Textulariina, Fusulinina, and Miliolina) and seven families represented (Loeblich and Tappan, 1988). Since the Finis Shale outcrops in several other localities in Jack and Young Counties, which were not sampled, Table 1 should be considered a representative, though not exhaustive, listing of the foraminifera present.

The basal black shales were nearly devoid of fossils; very few whole microfossils or shell fragments were found in the matrix, as would be expected in a low oxygen depositional environment. The only foraminifera were *Ammodiscus* and *Endothyra*, and these two genera persist throughout the section.

The middle unit, consisting of medium to dark gray shales, has the highest diversity of foraminifera at the generic level, corresponding to the overall maximum faunal diversity reported for this environment (Boardman *et al.*, 1984). In the medium to light gray strata of the upper Finis Shale, generic diversity decreases and the miliolids are not as well represented as they are in the middle unit shales, perhaps in relation to shallower water depths. Both the middle and upper unit shales have attached, porcelanous forms, such as *Ap-*

	LOCALITY						
SUBORDER/ GENUS	BASAL SECTION	MIDDLE SECTION			UPPER SECTION		
	F1	F2a	F2b	F2c	F3	F4a	F4b
Textulariina							
Ammodiscus	X	X	X	X	X	X	X
Glomospira		X	X	X			
Glomospirella		X	X	X			
Ammobaculites					X		
Fusulinina							
Paleotextularia			X			X	
Globivalvulina							X
Endothyra	X	X	X	X	X	X	X
Tetrataxis		X	X	X	X	X	X
Miliolina							
Apterinella		X	X	X			
Calcitornella		X	X	X	X	X	X
Calcivertella		X	X	X	X		
Hemigordius		X	X	X			
Orthovertella		X	X	X			

TABLE 1. Non-fusulinid foraminifera of the Finis Shale. Generic names according to Loeblich and Tappan, 1988.

terinella, *Calcitornella*, and *Calcivertella*, which are indicative of low current activity and slow sedimentation rates (Loeblich and Tappan, 1964).

The five genera of miliolids prove to be valuable chronostratigraphic indicators. *Calcitornella* and *Calcivertella* are exclusively Virgilian. *Apterinella* begins its range in the Virgilian, and *Hemigordius* ends its range in the Virgilian. Based on the ages of these taxa, the range of *Orthovertella*, which has been considered to end in the Missourian (Loeblich and Tappan, 1988), should be extended to the Virgilian.

SYSTEMATIC PALEONTOLOGY

INCERTAE SEDIS

FINISIA, new genus

Type species: Finisia martini, new species.

Diagnosis: Flattened, elongate test consisting of four external, overlapping chamber-like regions. Small spines around edge of basal chamber-like region, and part way around aperture.

Etymology: Genus named for the Finis Shale member, where the new taxon was found.

FINISIA MARTINI, new species
Text-figure 3

Diagnosis: As for the genus.

Description: Test free, ranging in size from 0.3 to 0.8 mm. Wall calcareous, translucent; pseudosutures horizontal, curved, depressed. Externally, basal chamber-like region with rounded edge; bases of overlapping chamber-like regions flared at sides; final chamber-like region tapering toward rounded terminal aperture. Internally, six to seven evenly spaced longitudinal septae, originating from a thicker side septum (Text-figure 3).

Etymology: Species named for Martin A. Buzas, paleobiologist at the U.S. National Museum of Natural History, in recognition of his continuing foraminiferal research.

Types and occurrence: Holotype, USMN 467523, and paratypes, USNM 467524-467527, are deposited at the NMNH. About 1000 specimens of *Finisia martini* were present in Sample F2c, but none were present in any of the other samples.

Remarks: Since the size and external morphology of *Finisia martini* resemble certain foraminifera, the taxon originally was thought to be a new species of either *Lingulina* or *Frondelina*. However, thin sections revealed an internal wall structure quite different from that of any known foraminifera; internal septae are not horizontal, and do not correspond to the walls of the chamber-like regions visible externally. Instead, internal septae are longitudinal, separating the organism into a series of long, thin internal chambers; hence affinity with the Foraminiferida is doubted (Buzas, pers. comm.). Different taxonomic specialists on fusulinids, ostracods, corals, plants, and *incertae sedis*, associated with the U.S. National Museum examined specimens, thin sections, and photomicrographs of *Finisia martini*, but none were able to categorize the organism within their field of expertise.

CONCLUSIONS

The foraminiferal assemblage of the Finis Shale contains several time-sensitive genera, which are reliable indicators for Virgilian age, information that could prove valuable to subsurface investigations. The distribution of foraminifera throughout the unit concurs with depositional models proposing a deeper-water origin for the Finis Shale, with shallowing upward in the unit. Although the Missourian-Virgilian boundary is presently between the Canyon and Cisco Groups, Virgilian age ammonoids and fusulinids found in the Colony Creek Shale of the upper Canyon Group indicate that the boundary should be placed in the middle of the Canyon Group, at the base of the Ranger Limestone (Boardman and Mapes, 1984). A survey of the non-fusulinid foraminifera present in the Colony Creek Shale may provide additional evidence to support this suggestion.

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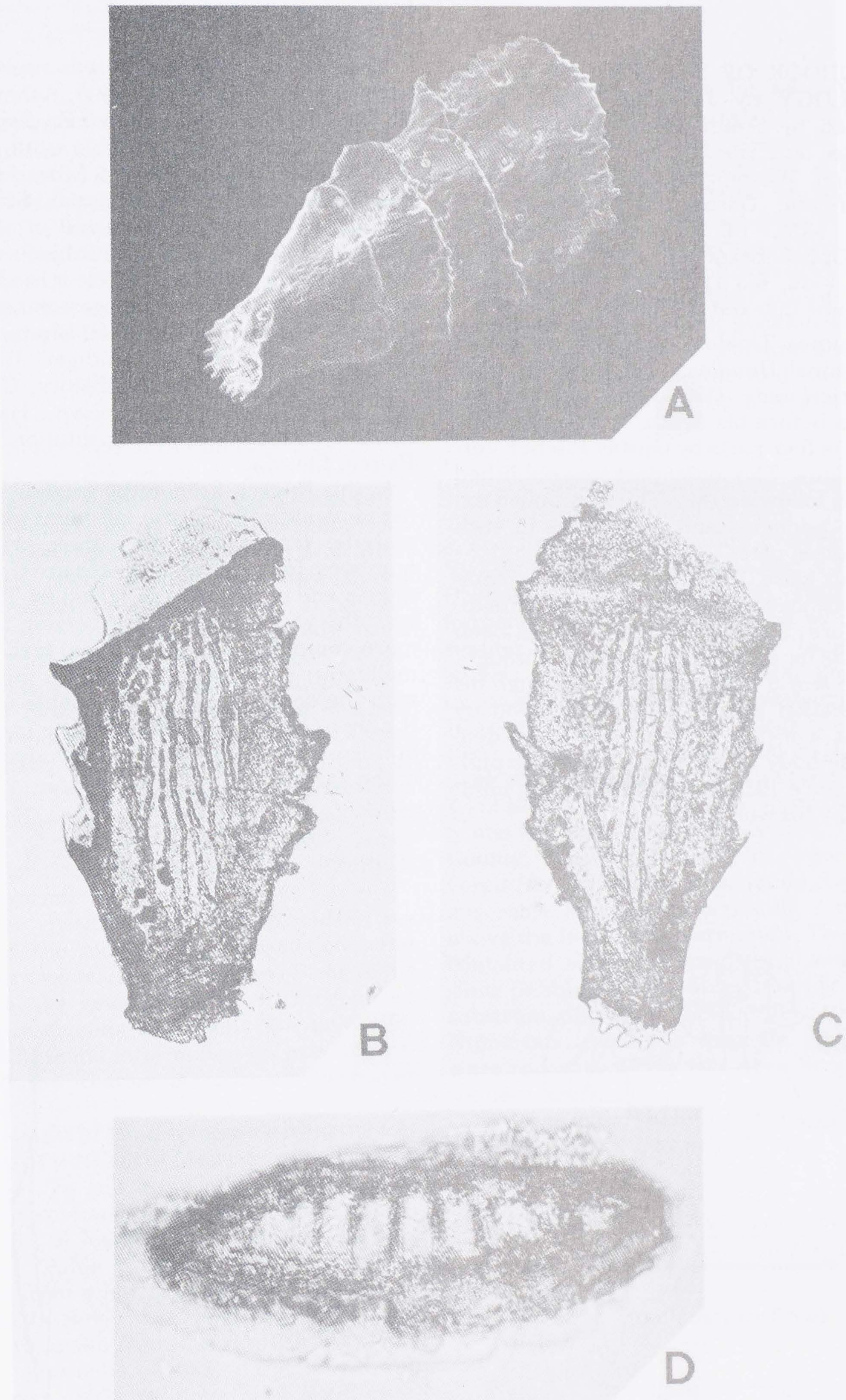
Text-figure 3. *Finisia martini*, new taxon. (A) Photomicrograph of holotype (USNM 467523) showing external chamber-like regions (X 215). (B) Longitudinal thin section of paratype (USNM 467524) showing internal septae (X 200). (C) Longitudinal thin section of paratype (USNM 467525) showing internal septae arising from thicker side septum (X 200). (D) Cross-sectional thin section of paratype (USNM 467526) showing internal chambers (X 250).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