STRATIGRAPHY, DEPOSITIONAL SETTING, AND PALEOECOLOGY OF THE THOMPSON FARM FOSSIL BED EXPOSURE (COON CREEK, CRETACEOUS) NEAR ENVILLE, TENNESSEE

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ABSTRACT--A 7.6-m section of the Coon Creek Formation (Upper Cretaceous) is exposed along Melton Creek near Enville, Tennessee, and has been designated a protected natural area by the Tennessee Department of Conservation. The stratigraphic sequence consists of glauconitic, fossiliferous clayey-sand that can be subdivided into four biofacies based upon species dominance. The lowermost biofacies contains an autochthonous invertebrate assemblage dominated by the bivalves *Cucullaea* and *Corbula*, with lesser amounts of turritellid gastropods, echinoids, scaphites, crabs, and sharks. Overlying the *Cucullaea-Corbula* zone is an undulatory ferricrete concretion layer containing molds of articulated bivalves and crabs. The next biofacies also occurs in a clayey-sand and is characterized by being extensively leached of fossil shell material leaving molds of *Cucullaea* and *Corbula*. The Mold zone grades vertically into a heavily bioturbated biofacies developed in a thixotropic substrate with *Echinocardium* dominating. The mold and *Echinocardium* zones contain 21 burrows infilled with highly fragmented shell debris, charcoal, and crab parts. The overlying 5.2-m of sediment consists of weathered sandy-clay with varying degrees of shell dissolution that is too weathered to provide information on the original depositional setting.

The Coon Creek Formation (Late Cretaceous, Navarroan Stage) has become internationally known for its excellent preservation of fossil marine invertebrates and vertebrates. In 1988, the site of the type section at the "old Dave Weeks place" was purchased by the Memphis Museum Board of Trustees, and the following year the Coon Creek Science Center was established on the site (Barnes, 1989). Other exposures of the classic Coon Creek exist that are ideal for studying the paleontology, paleoecology, and depositional setting of this unique formation. One such exposure is the "Thompson Farm Fossil Bed" (Conover, 1990) along Melton Creek near Enville, Tennessee (Fig. 1), which has been designated as a state natural area by the Tennessee Department of Conservation. The goals of the present study were to describe the stratigraphy of the Thompson site, document the vertical and lateral distribution of the biota preserved at the site, analyze the paleoecological relationships (e.g., animal-animal and animal-sediment) of the preserved fauna, and reconstruct the local paleoenvironmental setting represented by the Thompson Farm Fossil Bed.

The Coon Creek Formation is exposed in a northeast to southwest outcrop within the Mississippi Embayment in western Tennessee (Fig. 1). It consists primarily of $\leq$57.9 m of gray to dark-green, micaceous, glauconitic sands which are locally fossiliferous (Wade, 1926; Moore, 1974; Russell and Parks, 1975). The Coon Creek grades laterally and vertically into the McNairy Sand which consists of approximately 91.5 m of non-glauconitic sand, sandstone, and clay that represent regressive nearshore and shoreline deposits. The underlying Demopolis and Sardis formations represent an open marine transgressive sequence. These units consist of glauconitic sand (Sardis) grading upwards and laterally to sandy- and silty-marl with localized argillaceous chalk (Demopolis). The top of the Sardis is usually placed at the base of a transitional clay, the top of the highest Sardis marl, or the base of the first glauconitic sand of the Coon Creek.

Regionally, the Coon Creek Formation is composed of gray to dark-green, micaceous, glauconitic sand which is locally fossiliferous (Moore, 1974; Russell and Parks, 1975). Russell and Parks (1975) recognized two lithofacies within the Coon Creek, a stratigraphically lower calcareous sand and clay overlain by a concretion-bearing sand and clay.

The lower Coon Creek is massive-bedded, contains abundant glauconite creating a faint greenish tint in outcrop, and tends to weather reddish-brown. The upper Coon Creek was designated by Wade (1926) as the "ferruginous clay member" due to its reddish color and the presence of red siderite concretionary beds. The boundary between the lower and upper Coon Creek is marked by phosphatic concretions and platy ferruginous sandstone layers (Russell and Parks, 1975). The top of the Coon Creek is recognized by the appearance of relatively clean, very-fine sand deposits of the overlying McNairy Sand.

The Coon Creek Fauna was first recognized by Troost (1840) and described in detail by Wade (1926). Invertebrates and vertebrates are common, especially in the lower Coon Creek where the classic "Coon Creek Fauna" is concentrated, and have been studied intermittently over the years (Wade, 1917*a*, 1917*b*, 1917*c*, 1918*a*, 1918*b*, 1919, 1920, 1922, 1926; Berryhill, 1955; Granata, 1960; Sohl, 1960, 1964*a*, 1964*b*; Lerman, 1965; Moore, 1974; Russell and Parks, 1975; Bishop, 1983, 1985). Lerman (1965) placed the Coon Creek Formation in Tennessee straddling the biozone contact between the *Exogyra cancellata* zone and the overlying *Exogyra costata* zone. In spite of the wealth of study on the Coon Creek, most of these studies have consisted of using older literature to compile taxonomic lists. Surprisingly few studies exist dealing with updating the taxonomy of the fauna within the Coon Creek or with detailing paleoecology on a localized scale.

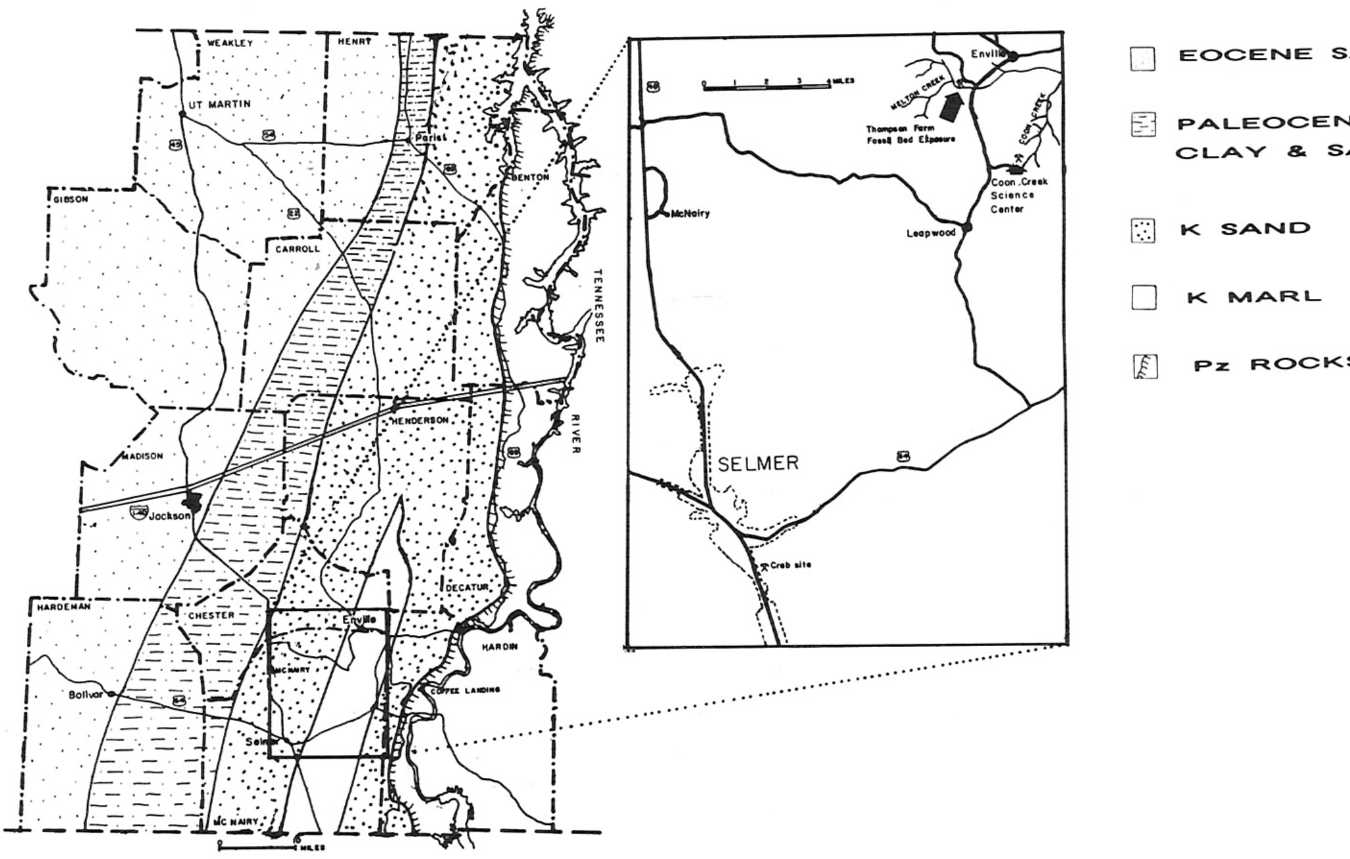

FIG. 1. Generalized geologic map of western Tennessee showing the location of the Thompson Farm study site. Inset map shows the po of the Thompson site relative to the Coon Creek Science Center. K = Cretaceous age rocks, Pz = Paleozoic age rocks.

MATERIALS AND METHODS

A stratigraphic section was compiled using standard measuring and sampling techniques, and lateral variations along the exposure were noted. Lithologic samples (approximately 10-cm bulk samples) were collected immediately above and below each lithologic change and from the middle of thicker beds (Fig. 2). Fossil content and biogenic and sedimentary structures were noted in the field, and bulk samples were collected for later identification in the laboratory. Concretionary horizons were sampled, and polished sections made to highlight internal sedimentary fabrics.

Taxonomic identification of fossil material was accomplished using the references previously cited. Moore (1974) was the primary source used to update the taxonomy of the mollusks. In describing paleoecology at the exposure of the Coon Creek Formation, the following were examined: stratigraphic distribution of the fauna; trophic and substrate position; paleocommunity changes; paleoenvironment.

Paleocommunities were studied using the substrate position and trophic level ternary plots designed by Scott (1976). Taxonomic diversity and rank abundance data were compiled from counts from 1-m^2 quadrants and counts from disaggregating bulk samples (Fig. 2; Table 1). Faunal zones were named for dominant species in each zone.

RESULTS AND DISCUSSION

Lithostratigraphy--The exposure measures 52.1 m in length 7.6 m in height. The face is oriented N81°W and was formed cutbank of Melton Creek (Fig. 3A).

The Thompson Farm exposure can be subdivided into two litho (Figs. 2 and 3A). Lithofacies A consists of fossiliferous gray to green, micaceous, glauconitic clayey-sand which can be further s vided based upon fossil content and mode of preservation. Litho A will be the primary focus of this paper. The lowermost 1 abundantly fossiliferous and preserves original shell material (F and 3A-C). Overlying the shell-rich portion is an iron-cem concretionary layer averaging 0.3 m in thickness with an undu surface (Figs. 2 and 3A,B). Overlying the concretionary layer is characterized by internal and external molds and casts of r mollusks but is otherwise identical to the underlying shell-rich u terms of lithology (Figs. 2 and 3A,B,D). The uppermost laye heavily bioturbated clayey-sand containing mollusk molds, abu horizontal and vertical burrows, and possible decapod domiciles 2 and 3A,E,F).

The overlying lithofacies B consists of a highly weathered, gray, massive bedded, micaceous silty-clay to clayey-sand that g upwards into a weathered soil horizon (Figs. 2 and 3A). Lithofa

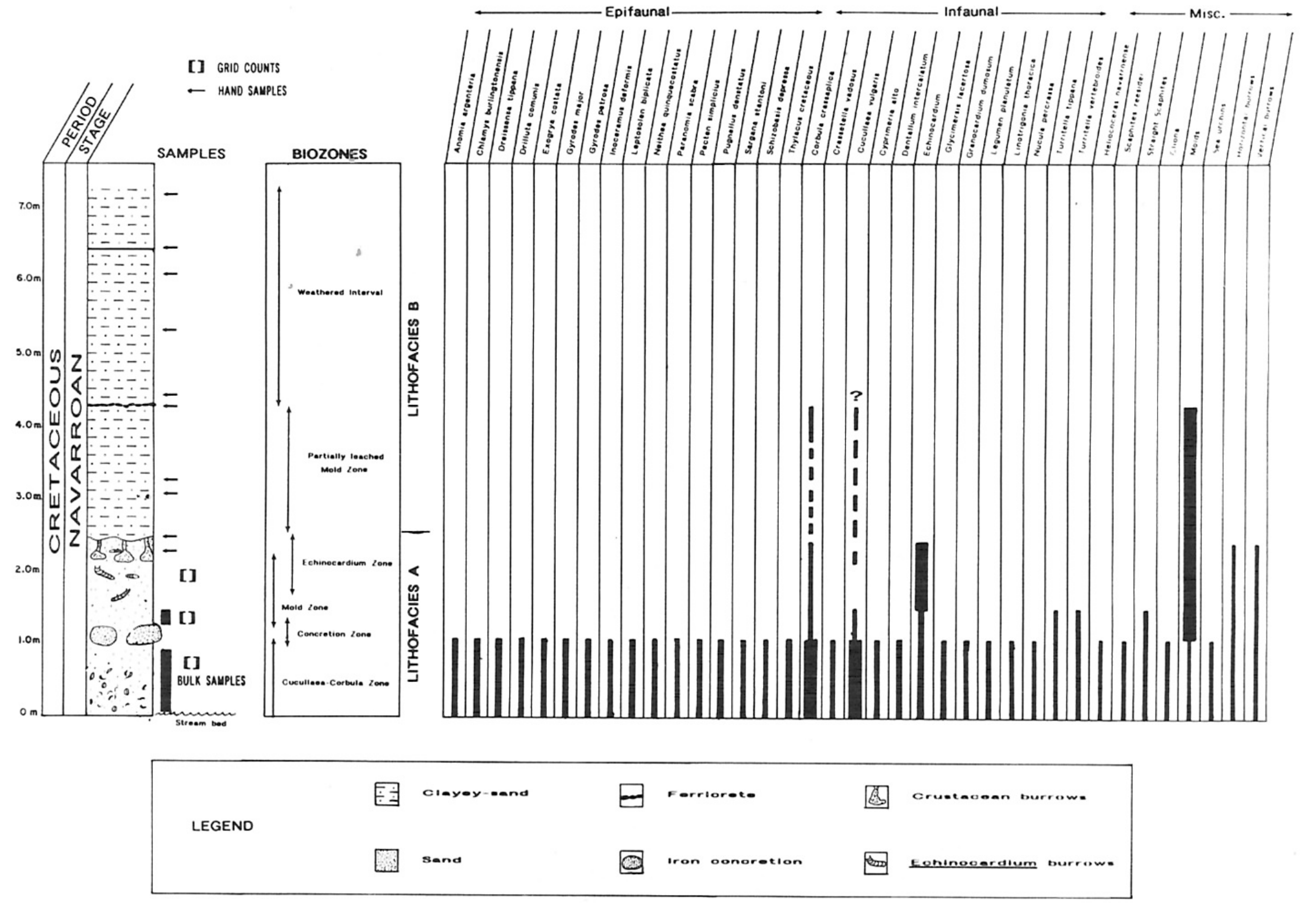

FIG. 2. Measured stratigraphic section showing the two basic lithofacies identified in the exposure, the position of samples collected for analysis, the stratigraphic ranges of the fossils identified from grid counts and bulk sample disaggregations, and zones established based upon faunal dominance.

contains only rare molds of leached fossil material, and most primary sedimentary structures have been destroyed by weathering processes. The numbers and quality of preserved fossil molds increases downward slightly in the section. The contact between lithofacies A and B is an irregular erosion surface with approximately 10-cm relief and truncated vertical burrows. Due to the weathered nature of this portion of the outcrop, paleoenvironmental and paleoecological analysis of lithofacies B will be excluded from this paper.

Biofacies--Four partially overlapping biofacies are recognized within lithofacies A (Fig. 2). The lowermost biofacies, termed the *Cucullaea-Corbula* zone, is a highly fossiliferous green-gray weathering, glauconitic and micaceous, clayey-sand that is dominated by the bivalves *Cucullaea* and *Corbula* (Table 1). Other fauna include turritellid gastropods, echinoids, scaphites, nautiloids, crabs, and sharks (represented by isolated vertebra). Some leaching of shell material occurs in the uppermost part of this biofacies locally.

The overlying concretionary zone contains little shell material; however, mollusk molds and casts are common. Articulated crabs are preserved along a single surface associated with the concretionary zone. A more detailed study of all of the crab-bearing beds and the crab burrows described in subsequent paragraphs is underway.

The third biofacies, termed the mold zone, extends from the top of the concretionary zone almost to the top of lithofacies A. This part of the lithofacies is dominated by bivalve and gastropod molds and casts. Vertical and horizontal burrowing increases upsection. Although much of the material is unidentifiable, grid counts and bulk samples suggest that the dominant invertebrate species are similar to that of the underlying *Cucullaea-Corbula* zone with one exception. The echinoid burrow *Echinocardium* begins to dominate near the top of the mold zone, contributing to the extent of bioturbation preserved in the outcrop face.

The fourth biofacies is called the *Echinocardium* zone due to the extensive galeries of *Echinocardium* (Table 1) with lesser amounts of *Cucullaea* and *Corbula*. The *Echinocardium* zone grades downward into the mold zone and also contains red clay- and shell debris-infilled burrows that resemble crab middens (Fig. 3E,F). Shell material within these burrows consists of a fine hash of broken shell debris and charcoal with some articulated crab remains. The middens are connected to the buried sediment-water interface (contact between lithofacies A and B) by vertical burrows.

Paleoecology and Depositional Setting--In the *Cucullaea-Corbula* zone, shells are preserved in several styles. Shell pods consisting of

TABLE 1. Rank abundance data based upon grid counts and bulk disaggregarions used to define the four biozones at the Thompson Farm Fossil Bed exposure.

Grid	Species	No. of individuals	Percentage
Cucullaea-Corbula zone	*Cucullaea vulgaris*	19	35.85
	Corbula crassaplica	14	26.42
	Linotrigonia thoracica	5	9.43
	Dentallum intercalatum	4	7.55
	Turritella tippana	3	5.66
	Turritella vertebroides	3	5.66
	Cliona	2	3.77
	Scaphite	2	3.77
	Granocardium dumosum	1	1.89
	Total	53	100.00
Mold zone	*Echinocardium*	4	50.00
	Cucullaea vulgaris	1	14.28
	Turritella	1	14.28
	Scaphite	1	14.28
	Total	7	99.98
Echinocardium zone	*Echinocardium*	3	50.00
	Cucullaea vulgaris	2	33.33
	Corbula crassaplica	1	16.66
	Total	6	99.99

broken and disarticulated shells are common. Other areas contain disseminated shells throughout the bed indicating that there has been some physical and perhaps biological reworking of the sediment (Fig. 3B). Other regions show articulated bivalves in living position and surrounded by matrix indicating no reworking after death of the organisms (Fig. 3B).

This zone consists of almost equal numbers of suspension and detritus feeders with infaunal organisms slightly more abundant than epifaunal organisms (Fig. 4). The mixture of fossils in living position with partially reworked shells attests to the dynamic nature of the substrate at this horizon suggesting a patchy distribution of living organisms and accumulating shell debris on the Coon Creek seafloor. This horizon also contains scaphites, nautiloids, and sharks. We interpret this horizon to represent a relatively quiet water or protected, marine- to brackish-salinity setting.

The overlying concretion zone is interpreted to represent a buried sediment-water interface that has been accentuated by the later development of digenetic concretions, which are discontinuous in parts of the outcrop. The overlying mold zone and the *Cucullaea-Corbula* zone contain the same biota (Fig. 2; Table 1) and sediment type. They differ only in that the shell material in the mold zone has been leached from the sediment.

The *Echinocardium* zone is dominated by burrowing echinoids with the *Echinocardium* burrows being infilled with a different sediment from the original (Table 1; Fig. 3E). The original sediment was the clayey-sand that was infilled with a cleaner sandy-mud. The burrows walls are sharp and uncollapsed (Fig. 3D,E) which indicates that the substrate in which the burrows were originally excavated was relatively firm or thixotropic rather than being a soft-bottom, muddy substrate. Lastly, this zone is intensely bioturbated which suggests that the sediment was being reworked on a wide scale.

Twenty-one burrows along a single lateral sequence were found in the *Echinocardium* zone which contain highly fragmented shell debris, charcoal, and articulated crab parts (Fig. 3E,F). These burrows are currently under study; however, we tentatively interpret these burrows to represent crab middens or domiciles because of the presence of articulated crabs within some burrows. These burrows terminate along the boundary between lithofacies A and B and represent habitation along a buried sediment-water interface.

We counted crabs as predators in our study and counted each midden as an individual. As seen in Fig. 4, the *Echinocardium* zone contains approximately equal numbers of suspension feeders, detritus feeders, and predators. Although most of the fauna in this zone occupied an infaunal substrate niche, a significant percentage of the fauna was represented by vagrant crabs.

We interpret the overall exposure as representing a relatively firm sand and mud substrate within a protected area of the regressive Coffee Lagoon described by Russell and Parks (1975). The exposure appears within the brackish water "inner Coon Creek environment" to which Russell and Parks (1975) referred based upon the fossil content and sediment type, but the presence of sharks and cephalopods suggest a more normal marine salinity. Within the biofacies is a recognizable vertical shift from a quieter water, mollusk-rich environment to one dominated by mobile organisms such as echinoids and decapods (Fig. 5).

We do not see the change in faunal composition as representing drastic changes in the overall depositional setting. Rather, the change in fauna probably reflects changes in ecological framework. The distribution of fauna, especially in the *Cucullaea-Corbula* zone, may be indicative of the original patchy distribution of the indigenous fauna on the seafloor. This is certainly true for the fauna of the *Echinocardium* zone and the crab burrows. As time progressed, the faunal patches migrated on the seafloor and is then recorded as a blanket deposit in the stratigraphic record. Patchy distribution of organisms and patch migration are common phenomena of modern, shallow marine systems (e.g., Aller and Dodge, 1977; Pickett and White, 1985; Sousa, 1985). We plan to test this hypothesis by correlating the Thompson Farm exposure with other nearby exposures.

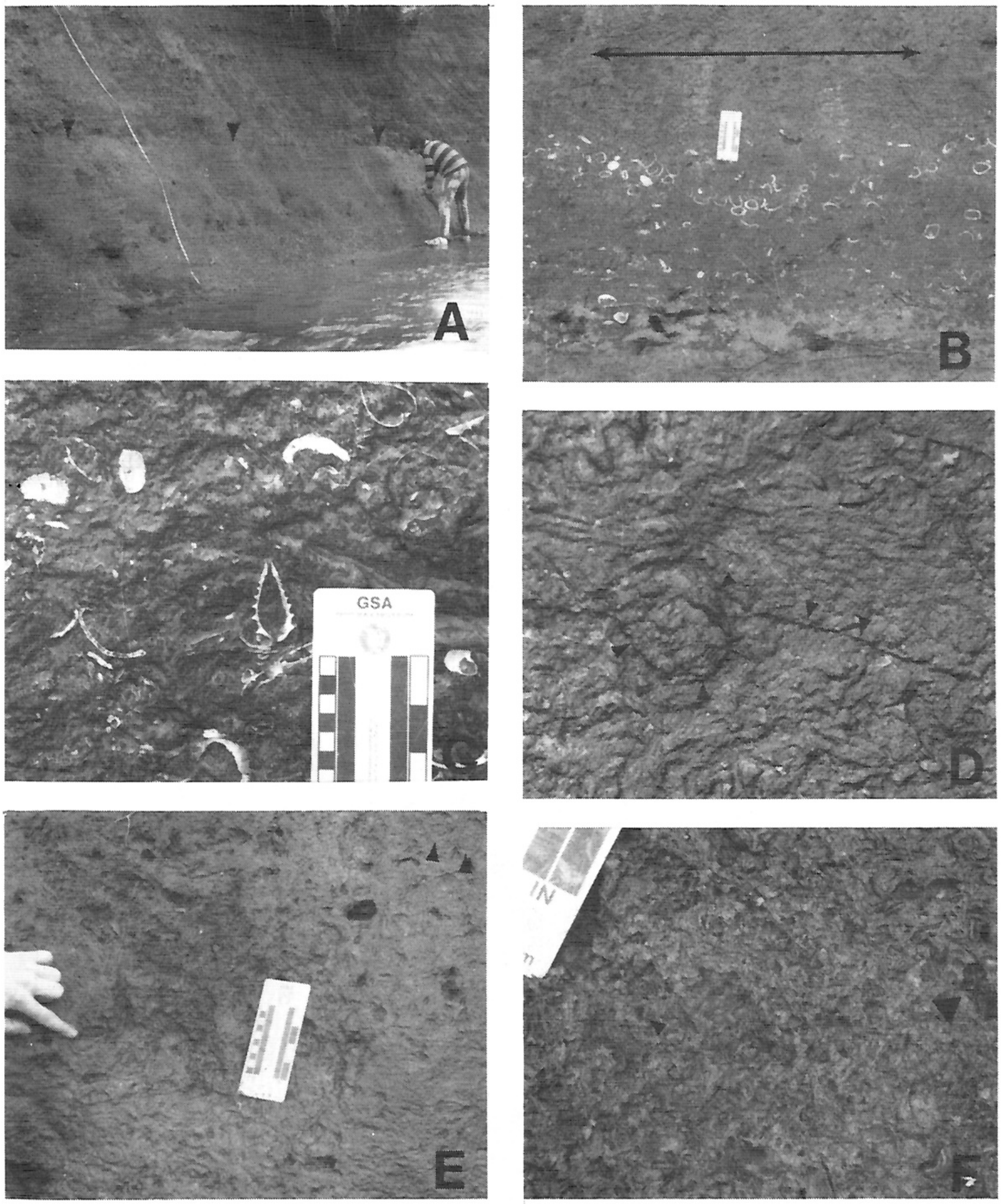

FIG. 3. A) Outcrop exposure at the Thompson Farm locality along Melton Creek showing the generalized stratigraphy. The contact between lithofacies A and B is indicated by the arrow. Compare with Fig. 2. B) *Cucullaea-Corbula* zone grading vertically into a mold-rich interval of the same zone, overlain by the concretion zone (arrow), and capped by the lower portion of the mold zone. Note the articulated nature of most of the bivalves, the distinct patchy clumping of shells, and the undulatory nature of the shell-mold contact. C) Close-up of *Cucullaea-Corbula* zone showing articulated *Linotrigonia* and in-living-position *Cucullaea* indicating a lack of extensive reworking. D) Close-up of Mold zone-*Echinocardium* zone gradational boundary showing leached nature of the fossil shell material and echinoid burrows. Note that the burrows are not collapsed and that the walls are sharp (arrow). E) *Echinocardium* zone showing a crab midden with highly comminuted shell debris and irregular burrow wall. Note the sharp nature of the *Echinocardium* burrow walls (arrow). The finger is pointing to an articulated crab leg found within the burrow. F) Close-up of a crab burrow showing the finely comminuted shell debris and charcoal (arrow).

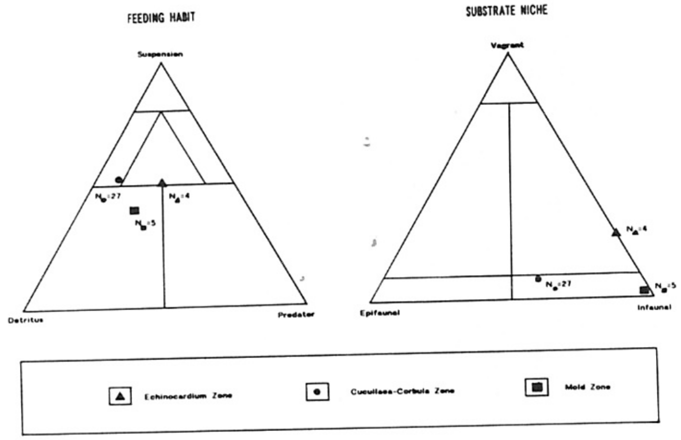

FIG. 4. Ternary plots of feeding habit and substrate niche for the biofacies identified in lithifacies A.

CONCLUSIONS

The Thompson Farm Fossil Bed exposure within the Coon Creek Formation (Upper Cretaceous) consists of glauconitic, fossiliferous clayey-sand deposited in a protected portion of the Coffee Lagoon. Four fossiliferous zones are delineated based upon species dominance (Fig. 5). The lowermost zone contains an autochthonous assemblage dominated by the bivalves *Cucullaea* and *Corbula*, with lesser amounts of turritellid gastropods, echinoids, scaphites, sharks, and crabs. Next occurs a ferricrete concretion layer interpreted to represent a buried sediment-water interface.

The overlying clayey-sand is extensively leached of fossil material leaving molds of *Cucullaea* and *Corbula* in the lower part, but the upper part is heavily bioturbated with *Echinocardium* traces indicating a thixotropic substrate at the time of echinoid activity. The upper 0.61 m contains approximately 21 burrows infilled with highly fragmented shell debris, charcoal, and crab parts. The burrows terminate along a buried sediment-water interface and are believed to represent crab domichnia. The overlying lithofacies B consists of weathered sandy-clay with varying degrees of shell dissolution.

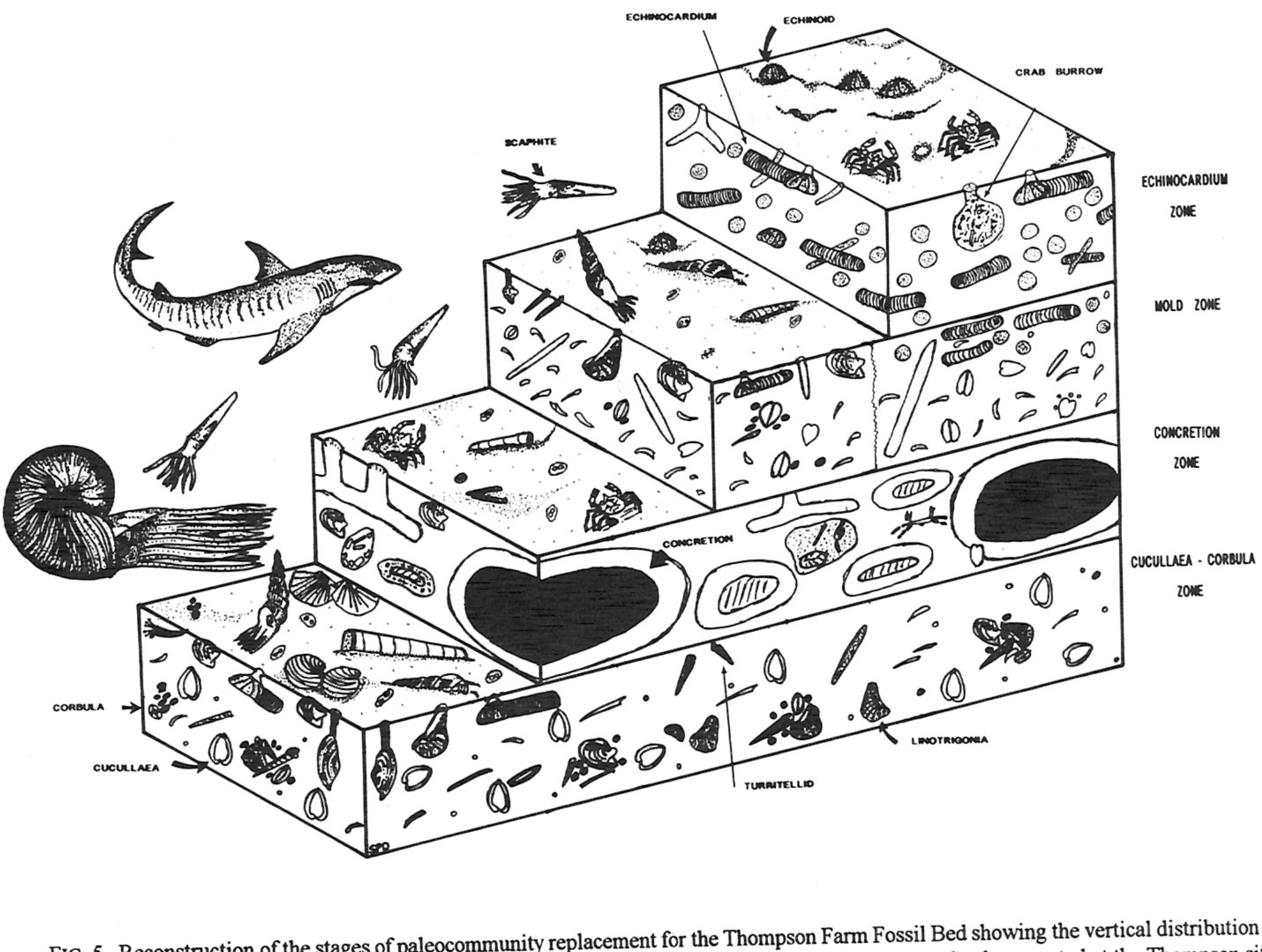

FIG. 5. Reconstruction of the stages of paleocommunity replacement for the Thompson Farm Fossil Bed showing the vertical distribution biofacies recognized in this study. Each layer (not drawn to scale) shows the dominant organisms that can be documented at the Thompson sit Large black ovals represent ferricrete concretions. The *Cucullaea-Corbula* zone is a mollusk-dominated assemblage with in-living-position a articulated shells. The Concretion zone represents a buried sediment-water interface. The Mold zone contains approximately the same fauna fou in the *Cucullaea-Corbula* zone represented by molds. The *Echinocardium* zone is heavily bioturbated by echinoid-burrowing and preserves cral

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