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A Study of Virgilian Sediments in Coles County, Illinois—
The Indian Creek Section, Mattoon Formation

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Introduction

The Mattoon Formation (McLeansboro Group) is the youngest unit of Pennsylvanian age in Illinois (Fig. 1). The formation ranges in age from late Missourian

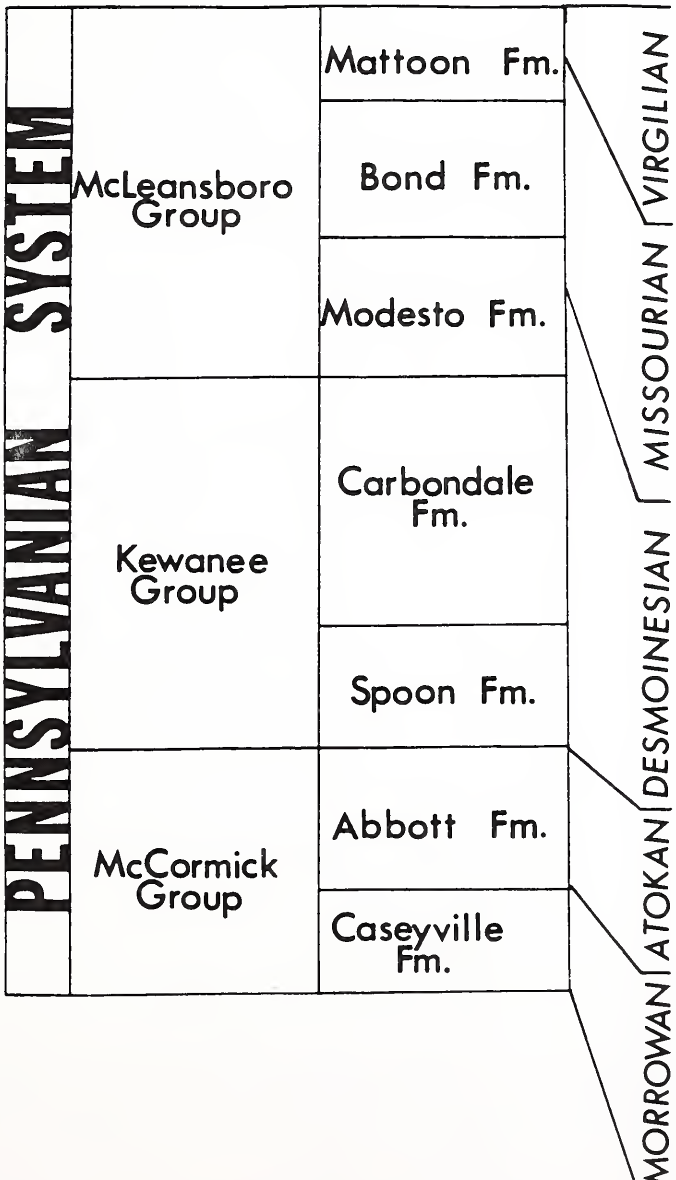

Figure 1. Stratigraphic column of the Pennsylvanian System in Illinois (modified from 3).

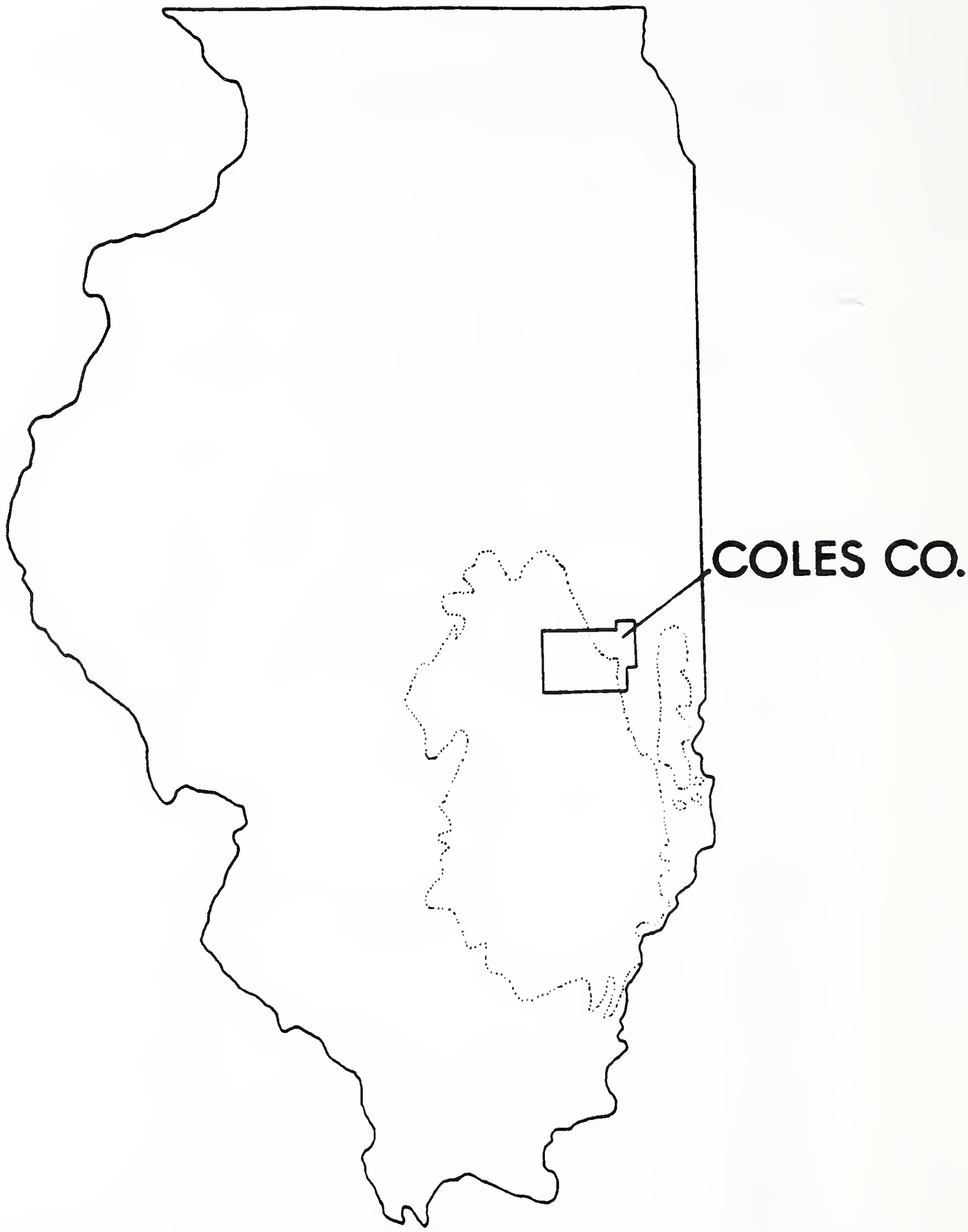

FIGURE 2. Location of Coles County, Illinois. Dotted line shows known extent of Mattoon Formation in southeastern Illinois (based on 17).

through Virgilian in age. Continous surface exposures are limited, owing to thick sequences of glacial drift which obscure the formation. In many areas, post-Pennsylvanian erosion has removed the formation entirely. As a result, major units are difficult to trace for any distance, and depositional and stratigraphic knowledge is limited. Paleontologic work, for the most part, has been limited to limestone members within the formation (3, 11, 16, 17). Though correlation of surface exposures with subsurface data has proven difficult, Wiebel (15) has been able to correlate black shales associated with some limestone members.

The objective of this study is to provide previously unpublished data about the fauna and depositional history of Virginian-age sediments in the Illinois Basin.

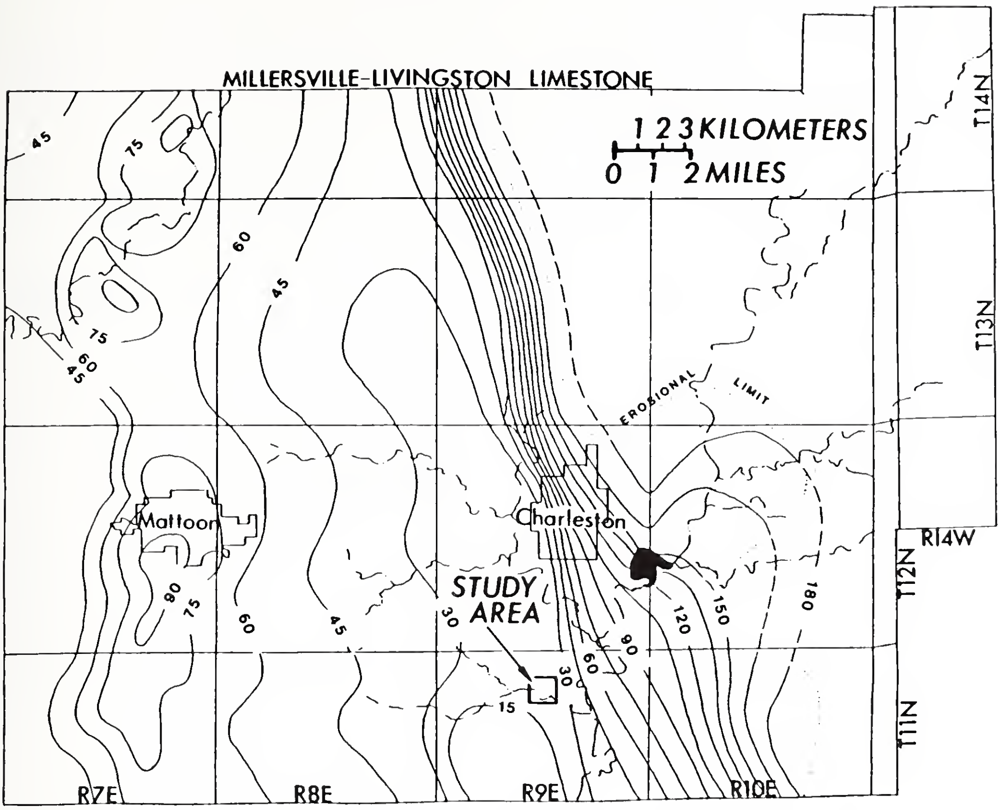

FIGURE 3. Structure on top of the Livingston-Millersville Limestones (top of the Bond Formation, base of the Mattoon Formation), Coles County, Illinois. Based on data at the Oil and Gas Section, Illinois State Geological Survey, Champaign, Illinois. Contour interval is 15 meters (50 feet).

Geologic Setting

The Indian Creek section, Section 10, T11N, R9E, is one of several sections of the Mattoon Formation exposed along the Embarras River and its tributaries in southern Coles County, Illinois (Fig. 2 and 3). These sections are conveniently located on the steep west flank of the LaSalle Anticlinal Belt (Fig. 3), which allows study of the formation at several points ranging from just above the Livingston-Millersville Limestone to the Indian Creek section, over 151 meters above the base of the formation. The Mattoon Formation reaches a maximum thickness of 181 meters in the subsurface of southeastern Illinois (17), hence the Indian Creek section may be the youngest Pennsylvanian sediments yet studied in Illinois. The high position of the section within the formation places it well above the Omega Limestone, the approximate location of the Missourian-Virgilian boundary (16).

Stratigraphy and Paleontology

The Indian Creek section consists of six separate stratigraphic units (Fig. 4). Unit 1 is a light gray, calcareous underclay overlain by a medium gray to brownish black, badly leached coal. Unit 2 is a gradational sequence of dark to medium light gray shales which are in sharp contact with the underlying unit. The shales form a resistant ledge at the bottom of the sequence which displays tight, thin fissility. The fissility decreases upward. Toward the top of Unit 2, a zone of ironstone concretions occurs, above which fissility is once again developed. The shales are calcareous

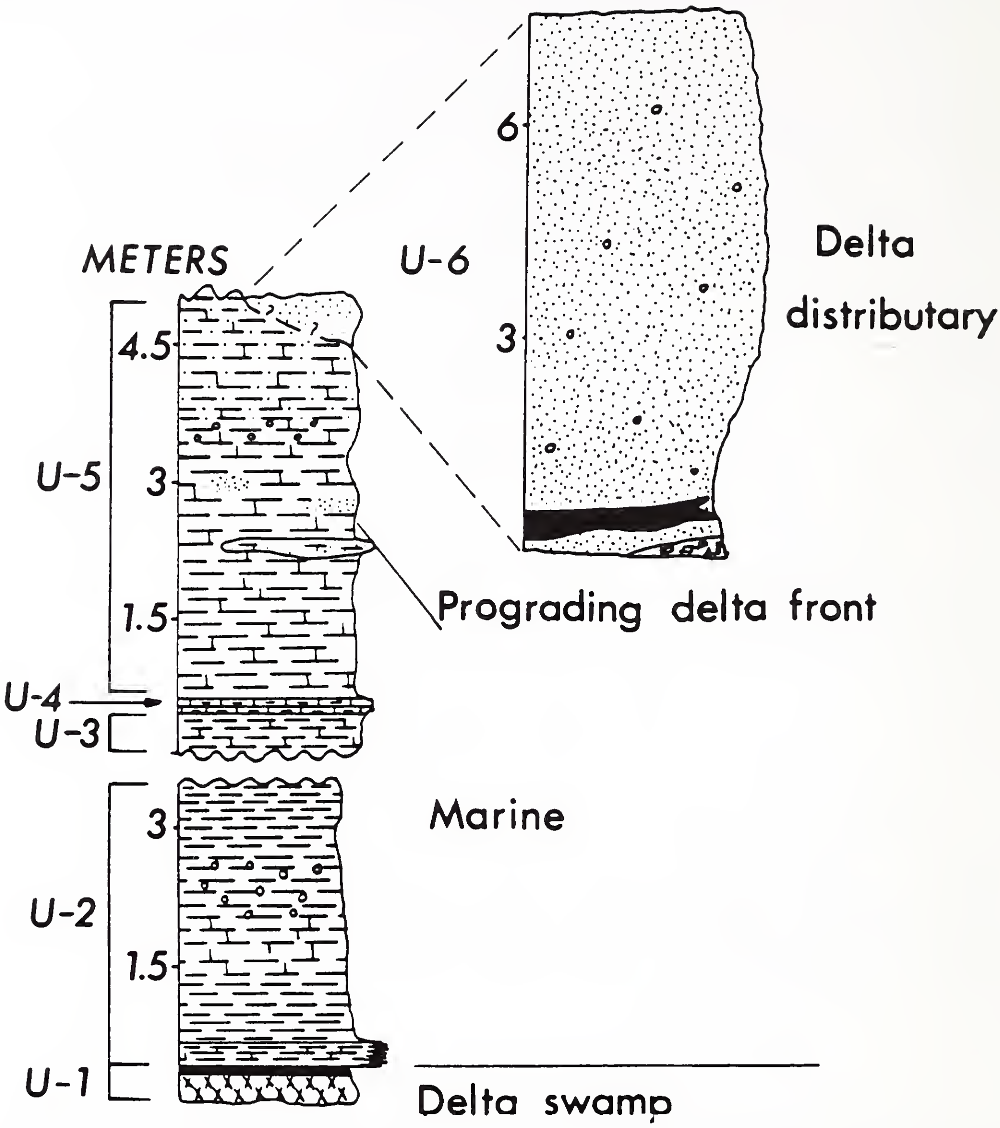

FIGURE 4. Indian Creek section, section 10, T11N, R9E. U-# indicates stratigraphic units described in text.

below the concretion zone, but lack carbonate content at the top of the unit. Units 3, 4, 5 and 6 occur in separate exposures, with any intervening strata missing.

Unit 3 is a dark gray, calcareous, carbonaceous to coaly shale which splits into fissile or platy sheets. Numerous microscopic pyrite nodules can be seen in disaggregated samples. Burrow mottling is evident throughout the shale. A light gray, micritic limestone, Unit 4, overlies Unit 3. The limestone displays vague parallel alignment of calcite crystals in thin section. Calcite veins and silty layers containing muscovite and carbonaceous matter part the limestone. The unit is thin but laterally continuous in exposure. Unit 5 is a gradational sequence of light gray shales which vary from thin bedded to fissile. Muscovite, carbonaceous debris and plant fragments are abundant. A thin, light gray sheet sandstone occurs in the lower part, forming a flat ledge that is laterally discontinuous. An ironstone concretion zone occurs toward the top of the shale sequence. Sandy lenses or patches are developed in the middle and upper parts of Unit 5. Carbonate content is lost as the unit coarsens upward.

Unit 6 is a thick, light gray to grayish-orange sandstone. The sandstone varies

TABLE 1. Paleontology of Indian Creek Section

Unit	Type of organism	No. of specimens-Genus species
2	Brachiopods	productids, productid spines unidentifiable
	Bryozoans	Fenestellid fragments
	Cephalopod	unidentifiable
	Conodonts	1-*Hindeodella* sp.
		14-*Streptognathodus* sp.
	Crinoids	arm plates, axialaries, stems, radial plates
	Foraminifera	1-*Pseudoammodiscus* sp.
	Gastropods	4-*Porcellia* sp.
	Holothuroids	*Eocaudina* sp. fragments
		2-*Paleochirodota* sp.
	Microcrinoid	*Kallimorphocrinus* sp. fragments
	Starfish	Ophiuroid fragments
	Trilobites	spines and fragments
	Echinoids	spines and plates
	Spores	
3	Brachiopods	1-*Phricodothyris perplexa*? unidentifiable
	Conodonts	1-*Spathonathodus minutus*
		3-*Streptognathodus* sp.
		1-*Streptognathodus elegantulus*
		4-*Adetognathus sp.*
		5-*Hindeodella* sp.
		1-*Ozarkodina* sp.
	Foraminifera	1-*Cyclogyra* sp.
		1-*Endothyra* sp.
		2-*Endothyranella* sp.
	Gastropods	1-*Donaldina* sp.
		2-*Streptacis* sp.
	Holothuroids	1-*Eocaudina* sp.
		1-*Eocaudina gutschicki*
		6-*Eocaudina mccormacki*
		2-*Paleochiridota* sp.
	Ostracodes	6-*Bairdia* sp.
		2-*Cavellina* sp.
		7-*Pseudobythocypris* sp.
		3-*Healdia* sp.
		8-*Amphissites* sp.
	Crinoids	stems and arm plates
	Fish	teeth
4	Bivalves	unidentified
5	Condonts	14-*Streptognathodus* sp.
		1-*Streptoganthodus gracilis*
		2-*Adetognathus* sp.
	Foraminifera	1-*Endothyra* sp.
	Gastropod	1-*Porcellia peoriensis*?
	Ostracodes	1-*Amphissites* sp.
		2-*Cavellina* sp.
		1-*Healdia* sp.
	Brachiopods	productid spines and fragments
	Crinoids	arm plates and stems
	Spores	

from lithic arenite to sublitharenite, with a basal conglomerate, faint parallel laminations, and ironstone concretions oriented randomly irrespective of bedding. A coal lense occurs near the base of the sandstone.

Invertebrate organisms recovered from the Indian Creek section are listed in Table 1. Disaggregation of the shales yielded 24 genera of marine fossils, such as conodonts, crinoids, brachiopods, foraminifera, microgastropods, holothuroids and ostracods. In addition, spores, fish teeth, a cephalopod, and fragments of crinoids, echinoids and brachiopods were found. Bivalves observed in Unit 4 were unidentifiable.

Environment of Deposition

The abundance of marine fossils (Table 1) proves that many of the rocks exposed at Indian Creek were deposited primarily in marine environments. Deposition seldom occurred far from shore, however, evidenced by the high carbonaceous content of the shales (4).

Several notable differences exist between marine fossils in Unit 2 and marine fossils in Units 3 and 5 (Fig. 4). Unit 2 shales contain the remains of fenestellid bryozoans, *Kallimorphocrinus*, and ophiuroid starfish; similar remains are missing in Units 3 and 5. On the other hand, ostracodes are numerous in some parts of the shale sequence but missing elsewhere. The presence and absence of certain marine fossils reflects changes that took place in the marine environment.

The presence of an underclay and thin coal at the base of the section suggests nonmarine environments (Fig. 4). The underclay is typically calcareous and lacks lamination. Lack of lamination can be due to 1) reorientation of micaceous clay mineral flakes, owing to root penetration, 2) massive flocculation of clay suspended in transport, owing to initial contact with brackish water electrolytes in a lagoon, delta setting or estuary, or 3) flocculation of clay in an aqueous medium which was drained before sufficient loading could cause consolidation or reorientation of clay flakes (13). No such zone is evident in the underclay, but the overlying thin coal is severely leached. Leaching may be due to either exposure by marine regression, or exposure above groundwater level (13). Therefore, subaerial exposure did occur prior to marine transgression.

The overlying shale at the base of Unit 2 was deposited by an influx of fresh or brackish waters. Parallel, fissile stratification implies that deposition took place in very quiet waters devoid of bottom currents. The high carbonaceous content may have created a reducing environment which prevented colonization by marine or brackish water organisms. Since bioturbation was lacking, fissility was preserved (8). Marine fossils are numerous in Unit 2. A great diversity of benthic and planktic forms are present. The presence of fenestellid bryozoans suggests that bottom waters were slowly circulated during deposition. Flume studies have revealed that the fenestelled genus *Polypora* fed from bottom currents that circulated at one to three centimeters per second. Faster velocities could not have occurred without damaging or breaking the feeding curtain. In addition, these currents were unidirectional (10). Ophiuroid starfish and crinoids also may have benefitted from bottom currents. Other bottom dwellers included productids, holothuroids and trilobites. Conodonts and foraminifera occupied the overlying waters. Ostracodes, usually quite common in marine strata, are missing in Unit 2. They do occur in association with conodonts and forminifera in Units 3 and 5; therefore, their absence from Unit 2 is peculiar, and implies that an environmental factor was present at the time of deposition which discouraged them from inhabiting the area. A lack of plant fragments suggests that direct terrigenous input from nearby deltas was weak. Fissility is also missing, owing to bioturbation and burrowing by organisms. Ironstone concretions and a lack of calcite at the top of the lower shale sequence suggests calcareous organisms were absent and deposition took place in poorly circulated, poorly oxygenated waters (8).

Unit 3 contains numerous and diverse microfossils, both benthic and planktic. Pyrite nodules and a large carbonaceous content suggest that deposition took place under strong reducing conditions brought on by decay of organic matter in quiet waters (4, 8). However, microfossil content and burrow mottling proves that organisms thrived on the ancient substrate, such as holothuroids and microgastropods (Table 1). Fenestellid bryozoan and starfish fossils are missing, indicating the ancient marine waters were quiet and poorly circulated. Overlying marine waters possessed abundant marine life, especially conodonts, foraminifera and ostracodes. The large frequency of conodonts reflects slow rates of sedimentation (5). The presence of the conodont *Adetognathus* (*Cavusgnathus* of Merrill) indicates a regressive, nearshore, shallow marine environment existed (5). The absence of productids also may imply shallow water deposition. For example, Stevens (9) discovered a great increase in brachiopod diversity occurred at depths of 15 or more meters, whereas very few brachiopods lived at shallower depths. Absence of brachiopods also may indicate lack of a muddy substrate (Horowitz, pers. comm.).

The presence of Unit 4, a limestone, indicates a significant but temporary change in the marine environment. Terrigenous imput was either weak or absent, allowing carbonate production to occur. The presence of bivalves, who are filter-feeders, also indicates that marine waters were clear and far removed from terrigenous imput. The limestone consists mostly of lime muds deposited in a calm, well oxygenated, low energy environment. The marine setting may have been lagoonal, since modern-day carbonate muds are rarely deposited in areas of a shelf open to oceanic influence (18). Silty partings present in the limestone may be debris washed into the local area by storms. This marine carbonate setting is short-lived, however, and the reason for its termination is apparent in Unit 5.

Fossils reflect less diversity in Unit 5 (Table 1). Productids are present again, but bottom dwelling holothuroids are missing. *Adetognathus* indicates nearshore conditions were present. Unit 5 exhibits an influx of silt and sand, an ironstone concretion zone, a coarsening upward sequence and a decrease in calcite content, all indicative of a prograding delta (2, 14).

The association of the sandstone facies, Unit 6, with a prograding delta sequence implies a deltaic origin. Poor to moderate textural and mineralogical maturity, poor sorting, coarse grain size, high carbonaceous content, enormous thickness, and a conglomerate at the base are characteristics of an elongate sandstone channel of fluvial-distributary origin (6, 7). Lenses of coal, such as the coal at the base, are common in distributary channels (14). Except for faint parallel laminations, the sandstone is massive. Other sedimentary structures are absent or poorly preserved. Massive sandstones deposited in a fluvial-distributary channel may occur at the top of a prograding delta sequence (2).

Conclusions

The Indian Creek section provides a view of the fauna and depositional history of little-known Virgilian-age sediments in the Illinois Basin. Rocks exposed along Indian Creek were deposited by a marine transgression, followed by a marine regression and delta progradation. The basal units were deposited by a marine transgression which flooded a coal swamp. Transgression probably resulted from delta shift or abandonment and subsequent advance of marine waters. Anoxic water conditions alternated with open, shallow water marine conditions. The point of maximum transgression is probably marked by the deposition of carbonate muds, far from terrestrial imput. The shales which followed were deposited in a nearshore, shallow water, regressive marine environment. Marine regression was a direct response to delta progradation into the area. A delta platform was established, across which distributary channels flowed. The marine-deltaic nature of the Indian Creek section is similar to previous assessments of the Virgilian Epoch in the Illinois Basin (1, 12).

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