Proceedings of the Indiana Academy of Science
(1987) Volume 97 p. 361-372.

Paleontology and Paleoecology of Two Pennsylvanian Fossil Sites Near New Harmony, Indiana

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Introduction

The village of New Harmony was the focus of most of the early geological studies in the central United States. The town was the home of David Dale Owen as well as his associates Gerard Troost, William MacClure, F. B. Meek, E. T. Cox and B. F. Shumard, many of whom went on to become state geologists of surrounding midwestern states (12). One consequence of this was that the Pennsylvanian age rocks in the New Harmony area became fairly well known. Studies by McChesney (14,15), Norwood and Pratten (21,22), Meek and Worthen (18,19,20), and Hall (5), which included at least 26 new species from the Pennsylvanian rocks around New Harmony (Appendix 1), were among the earliest publications to deal with the paleontology of North American Paleozoic age rocks. These reports were principally taxonomic descriptions of marine invertebrate fossils.

Since the middle of the 19th century there have been no systematic studies of the old collecting sites in the New Harmony area. The purpose of work leading to this report was to locate original localities, compile a list of species whose type specimens came from these localities, and make modern paleoecological interpretations of the fossils found in the strata at the sites.

Localities

Four New Harmony-area fossil sites were identified from the publications cited above. Three localities, known as "the mouth of Rush Creek", "Big Creek", and the "Wabash Cutoff", are in Posey County, south of New Harmony. The fourth locality is at Grayville, in White County, Illinois (Fig. 1). Only two of the four sites were found, as explained below.

The present mouth of Rush Creek is situated in Harmonie State Park, south of New Harmony (SW 1/4, NW 1/4, Sec. 23, T.5S., R.14W., Solitude 7 1/2 min. quad.). The lower part of Rush Creek is on the Wabash River flood plain and is extensively alluviated. There is some evidence that the mouth of Rush Creek may have shifted through time. Mink Island, just off the mouth of the creek, is not shown on old maps. Thus, the old mouth of Rush Creek may have originally been on the west side of what is now an island. No outcrops of Pennsylvanian rocks were found anywhere in the vicinity of this old locality. Indeed, the outcrop was apparently already slumped and largely covered by the late 1800's (3).

Some uncertainty exists about the exact locality of the Big Creek site. Most references simply call the site "Big Creek", a name that makes any exposure along the creek a candidate for the original locality. According to Collett (3), a fossil site lay "along the road between New Harmony and Mt. Vernon". Today the main road is Indiana State Road 69, but the area where this road crosses Big Creek is overgrown and covered with alluvium. A nearby limestone quarry that was apparently initiated by the Rappites, the early 19th century settlers of New Harmony, as a source of

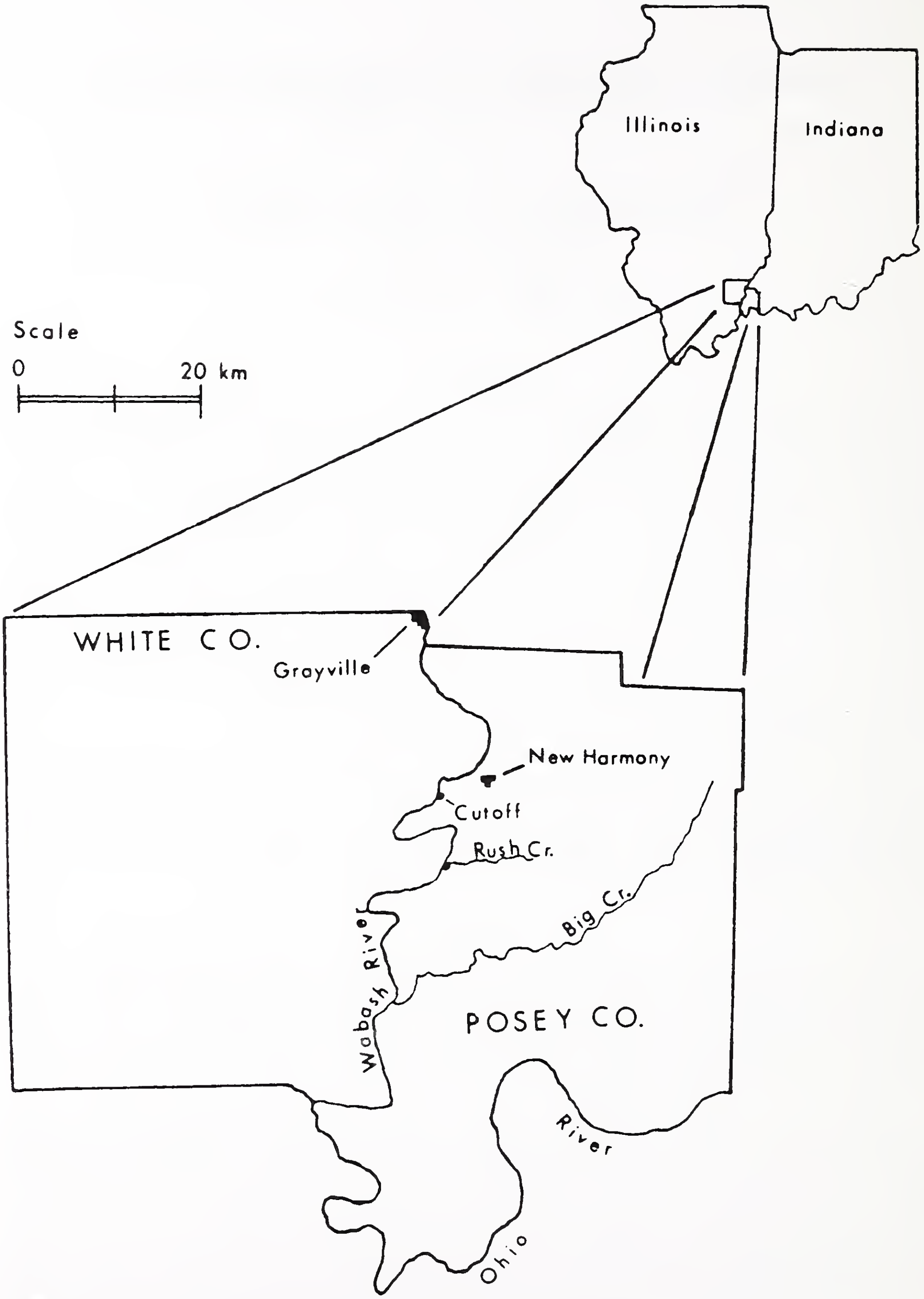

FIGURE 1. Map showing localities of the Grayville and Wabash Cutoff sites as well as the present position of Big Creek and Rush creek.

lime for plaster is now completely filled with sediment and no *in situ* rocks are exposed. This site is a likely, but unproven, candidate for the Big Creek site of early paleontologists. The quarry is situated in the SE 1/4, SE 1/4 Sec. 6, T.6S., R.13W., Solitude Quadrangle (23; locality 771). The old quarry is on the west side of the southeast flowing Solitude Run, and a side road off of SR 69 to a Conservation Club lake is just south of it.

The Wabash cutoff locality is situated on the Wabash River approximately one mile southwest of New Harmony (SE 1/4, NW 1/4, Sec. 11, T.5S., R.14W, Solitude Quadrangle). The thin bed of marine limestone and shale from which collections were obtained is near low water level of the Wabash River and is covered during times of flood. The bed is best studied during Fall months when the river level is low.

The Grayville, Illinois locality is situated along an incompletely cut off meander loop of the Wabash River at Grayville. The site is below the City Park on the southeast edge of Grayville, and along a low bluff below the Illinois Central Railroad tracks (NE 1/4, SW 1/4 Sec. 21, T.3S., R.14W., New Harmony, Ind.-Ill. Quadrangle). The site can be reached by crossing the railroad tracks in the park, driving as far as possible to the north, and then walking down to the river along the foot path. The exposure is completely covered during Spring floods. The meander loop was cut off in the Spring of 1985, but water still flows through the old channel. Presumably the loop will be completely cut off from the main river channel in the future and it is probable that the site will become overgrown in the absence of scouring by high water.

Geologic Setting

Rocks of the New Harmony area were deposited on the eastern margin of the Illinois Basin during Late Pennsylvanian time. Alternation of marine and nonmarine rocks resulted from periods of construction and destruction of a large deltaic complex that prograded across the area from northeast to southwest. Fluctuation between marine and nonmarine conditions resulted in deposition of sedimentary packages termed cyclothems. Correlation of the two statigraphic sequences is made difficult by the fact that they are very similar to many other cyclothems in the Pennsylvanian System as well as the fact that strata are locally disrupted by faults associated with the Wabash Valley Fault System.

The limestone at Grayville has been called the Grayville Limestone (4). This name is not formally accepted by either the Illinois Geological Survey (8) or the Indiana Geological Survey (26), but until better stratigraphic resolution is obtained the name will be used here in a strictly local but unambiguous sense for the marine limestone and shale that crop out at Grayville (Fig. 2). This avoids potentially erroneous cor-

MISSOURIAN SERIES	MATTOON FM	Grayville Limestone
		Mumford Hills Sandstone
		McCleary's Bluff Coal
		Friendsville Coal
		Merom Coal
		Cohn Coal
	BOND FM	Livingstone Limestone
		New Harmony Sandstone
		Riverview Limestone
		Fairbanks Coal
		St. Wendels Sandstone
		Shoal Creek Limestone

Figure 2. Approximate stratigraphic position of the Riverview Limestone and Grayville Limestone.

relation with rocks in other areas. The Grayville interval is usually considered to be in the Mattoon Formation (Missourian; 30).

At Grayville, the limestone is underlain by coal and black shale (Fig. 3). The limestone consists of two distinct beds that are separated, underlain, and overlain

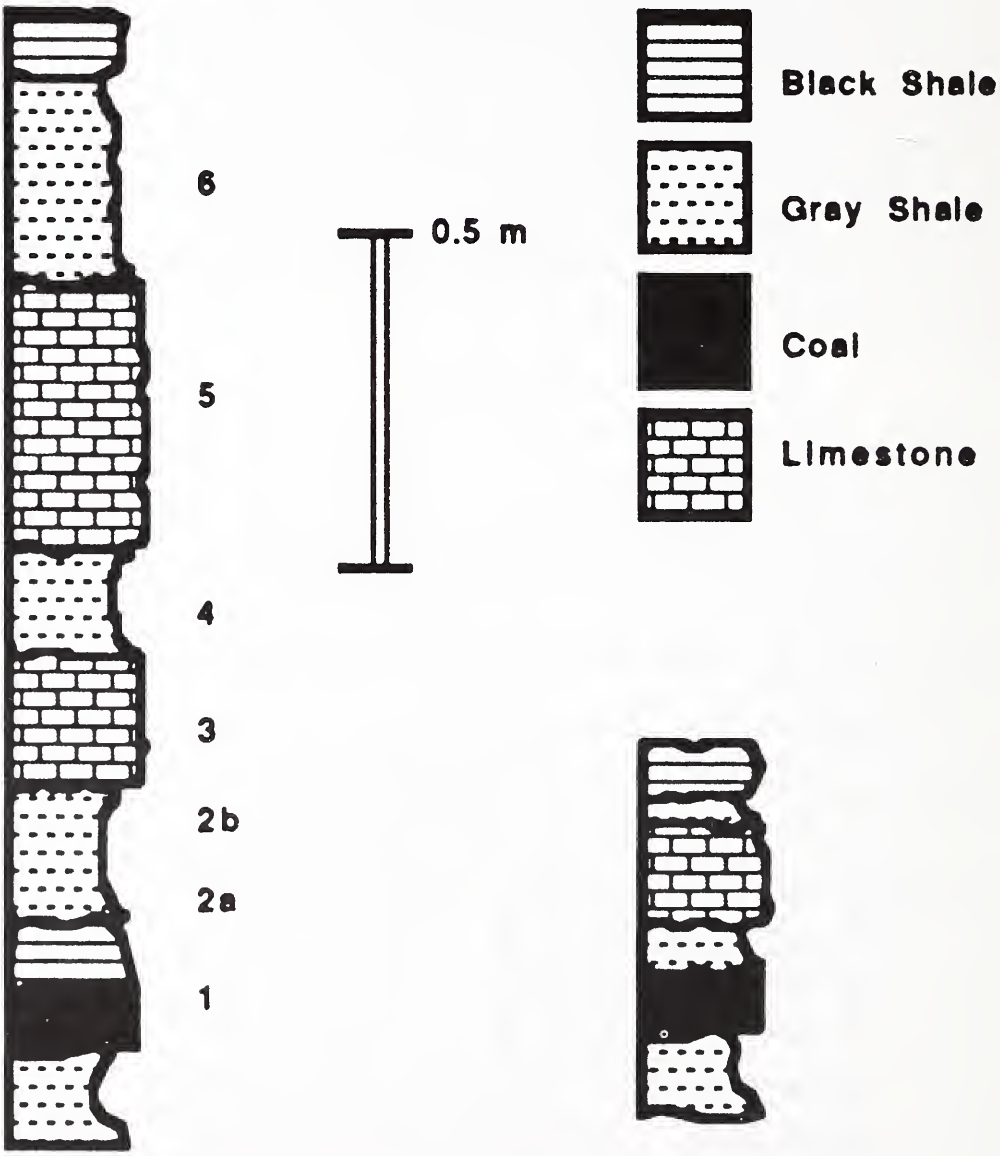

FIGURE 3. Graphic stratigraphic sections of the rocks that crop out at Grayville (left) and the Wabash Cutoff (right).

by calcareous shale. Six lithologic units have been differentiated within the section. Unit 2 has been divided on the basis of fossil content. This sequence of rocks is developed in at least two lense-shaped bodies of rock along the outcrop. All beds thin to near zero thickness from the center of a lense in a distance of 10 to 20 meters.

The limestone at the Wabash cutoff has been identified as the Riverview Limestone Member of the Bond Formation (Fig. 2; 30). Culbertson (4) considered this limestone to be equivalent to the Grayville Limestone on the basis of fossil content and lithology. Differences in fossil content and a statigraphic sequence, however, indicate that the two units are not correlative. A thick sequence of nonmarine sandstone, siltstone and conglomerate, termed the New Harmony Sandstone, overlies the limestone. A break, based on fossil content, was recognized within the limestone by Wier (30).

Field and Laboratory Methods

Faunal content of shales was determined by examining sieved portions of samples that had been disaggregated by soaking in paint thinner and boiling in water. Limestone and black shale samples could not be disaggregated, thus surface collections from weathered blocks had to suffice. Fossils were identified to generic level in all cases and to the species level when possible. Because shales could be bulk sampled and broken down in the laboratory, there is little chance that important fossil groups were missed, but because the limestone could not be bulk sampled there is a higher probability that some groups, especially microfossils, were missed. As a result, quantitative measurements are limited to classification of taxa as rare or common. Numerical counts, while more desirable, are not used.

Fossil Associations

Mixing of skeletal material between stratigraphically adjacent units is considered to have been minimal. Nevertheless, the term "community" is not used here because of the probability that collecting was incomplete. Instead, faunal groups are called "associations". Seven faunal associations were identified from the rocks of the two sites and are discussed below. The data collected from each unit is shown in Figures 4 and 5.

Dunbarella Association.—A well-defined association that contains the bivalve *Dunbarella whitei*, the brachiopod *Lingula* sp., the worm tube *Spirorbis*, and the ostracode *Geisina arcuata* is present in unit 1 at Grayville. A rare component of the association is the bivalve ?*Anthraconaia*. Fish parts and coprolites are also rare.

The *Dunbarella* association compares favorably with Johnson's (10) group IV assemblage and Hickey and Younker's (7) black shale phase. Components of the association are common in other Pennsylvanian rocks of nonmarine to marginal marine environments. *Dunbarella* is a common form in Pennsylvanian marginal marine facies (17) and may have invaded coastal lakes (16). This bivalve has also been used as an indicator of marine environments in British Upper Carboniferous rocks (2). *Geisina* inhabited fresh water (11) to marine water (2) and was probably euryhaline (24). *Spirorbis* is problematic because it occurs in both marine and nonmarine rocks in the late Paleozoic but is exclusively marine before and after this time interval. *Lingula* is commonly thought of as a marginal marine genus, but is found in marine environments as well.

Septimyalina Association.—A 3-4 cm thick, calcareous bed that overlies the black shale at Grayville is composed almost exclusively of shells of the bivalve *Septimyalina*. Most valves are whole, and many are articulated. *Geisina* and *Spirorbis* are rare. This bed of *Septimyalina* is similar to the *Orthomyalina* bank community of Rollins *et al.* (25), although the fossils reported here form more of a shell pavement and other species are less common. Both of these assemblages resemble modern oyster banks that occur in nearshore areas off of the east coast of North America.

Crurithyris Association.—Two species of the brachiopod *Crurithyris* (*C. planoconvexa* and *C. explanata*) dominate this community. Fenestrate bryozoan fragments are rare to common and *Derbya* is rare. The *Crurithyris* association occurs in the upper part of unit 2 at Grayville.

The mode of occurrence of *Crurityris* conforms to criteria used to recognize opportunistic species (13) and the genus has been found to be opportunistic in Pennsylvanian rocks elsewhere (7). The occurrence of an opportunistic form and the near exclusion of others is generally judged to indicated stressed environmental conditions.

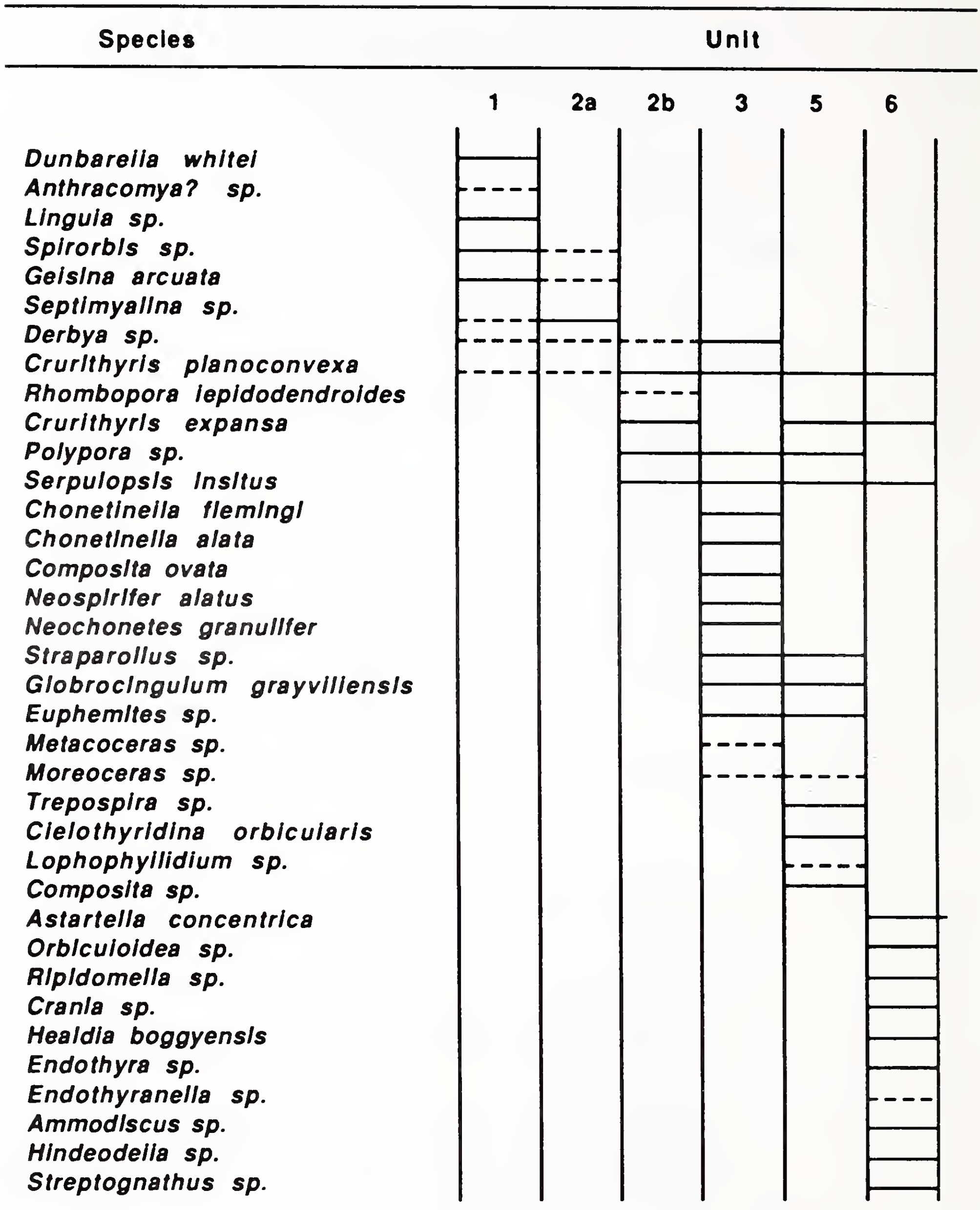

FIGURE 4. Fossils that occur in the rocks at Grayville and the lithologic units in which they occur (solid lines indicate common taxa and dashed lines indicate rare taxa).

The association also contains abundant, small intertwined tubes that are here assigned to *Serpulopsis insita* (White). *Serpulopsis* was originally considered to be the tubes of a serpulid worm, but was reassigned to the Foraminifera (6). Rocks in which it occurs in west-central Indiana are described as having "great numbers of *Serpulae* which fill the entire mass" (1). The fossil may have been an important sediment binding or trapping organism. *S. insita* is abundant in rocks above unit 2 at Grayville and in the Riverview Limestone at the Wabash cutoff.

Gastropod-Brachiopod Association.—This association is dominated by a diverse group of brachiopods. Associated are three species of gastropods, *Serpulopsis*, and rare orthoconic cephalopods. Epibenthonic suspension feeders dominate, but the gastropods were probably detritus feeders or scavengers (10). The high diversity in-

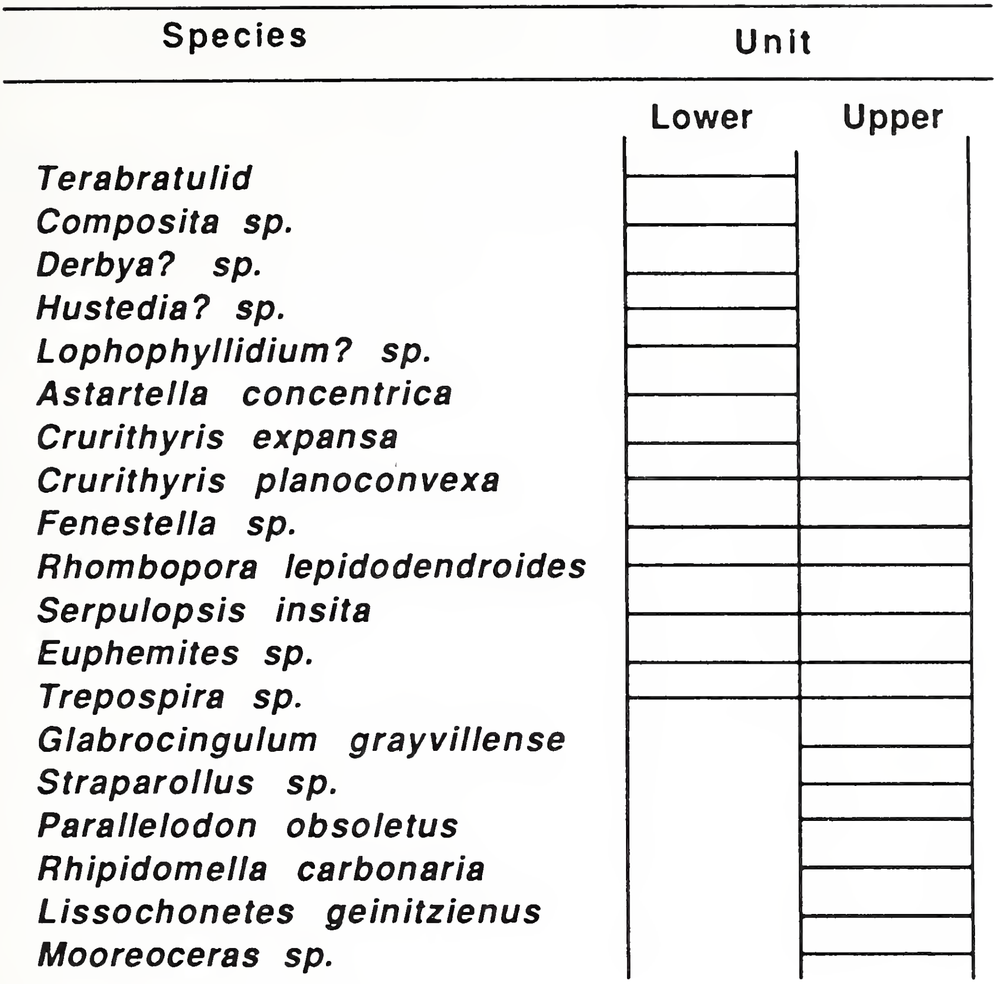

FIGURE 5. Fossils that occur in the rocks at the Wabash Cutoff and the lithologic units in which they occur (solid lines indicate common taxa and dashed lines indicate rare taxa).

dicates that the unit was deposited during a period of environmental stability. The association occurs in unit 3 at Grayville.

Gastropod Association.—This association is dominated by four species of gastropods. *Crurithyris* and *Serpulopsis* are abundant, and other brachiopods and bryozoan fragaments are rare. This association occurs in unit 5 at Grayville and in the upper part of the Riverview Limestone at the Wabash Cutoff.

This association was probably the result of marginal marine to slightly brackish water conditions. Unstable environmental conditions were probably responsible for both the lack of a diverse brachiopod component and the proliferation of *Crurithyris.* The gastropods were probably detritus feeders. They are most commonly considered to have prospered in marginal marine conditions during the Pennsylvanian Period. Slight differences between the two occurrences of the association exist (Fig. 4 and 5).

Foraminiferal Association.—This is the most diverse and equitable fossil association. Microfossils are an important element. Foraminifers are abundant, *Ammodiscus* being the most common. Conodonts are fairly common. With the exception of *Crurithyris* and *Serpulopsis* this association is dominated by species that do not occur in other units. The abundance of foraminifers suggests more offshore, normal marine conditions (27), and increased diversity supports this interpretation. The lack of corals and fusulinids suggests that fully normal marine salinities were not attained. The Formainiferal association occurs in unit 6 at Grayville.

Brachiopod-Coral Association—This association is very similar to the Gastropod-Brachiopod association that occurs in Unit 3 at Grayville. The main difference between the two is the presence of the coral *Lophophyllidium* in this association. The coral may indicate that more normal marine salinities were present during deposition of this association. The brachiopod-coral association occurs in the lower part of the Riverview Limestone at the Wabash Cutoff, and most of the fossils here are large and nearly whole.

Paleoecologic Interpretation

Grayville

The lithologic sequence at Grayville, Illinois is the product of transgression of marine waters over a nonmarine, deltaic environment. Nonmarine deposition took place in clastic swamp areas in which the conchostracan *Pemphilimnadiopsis* lived. Distributary channels cut through this swamp and lense-like characteristics of overlying marine units suggest that transgression took place largely within distributary channels. Vertical changes in faunal associations are the product of community replacement rather than autogenic community succession. Replacement was due to lateral shifting of environments, and not to *in situ* replacement resulting from transgression (9).

The species richness of the associations in terms of number of common species occurring in each lithologic unit is shown in Figure 6. Those species that are represented by only one or two specimens are not included because they may have been transported. Species richness is taken here to be an indicator of faunal diversity. Diversity may be controlled by a number of factors. Physically unstable, resource rich environments generally support low diversity faunas, but stable, resource poor habitats should be dominated by diverse faunas (28).

Faunal diversity increases from Unit 2a through Unit 6, after an initial decrease from Unit 1 to Unit 2a. Diversity increase may have been a result of increasing salinity, distance from shore, or both (27). The occurrence of corals, foraminifers and bryozoans in the uppermost unit supports the conclusion that the locus of deposition became increasingly saline through time.

The *Dunbarella* association thrived in brackish water created by mixing of fresh and marine waters. Salinity fluctuation contributed to environmental instability. The very low salinities prevented many marine species from colonizing this habitat. As marine waters transgressed up distributary channels the locus of black shale deposition moved landward and the *Dunbarella* association was replaced by the *Septamyalina* association. The latter occurrence resembles modern oyster banks that grow on any firm substrate in tidal channels (29). Increasing diversity in higher associations indicates increasing environmental stability.

Wabash Cutoff

Data collected from the Wabash cutoff occurrence of the Riverview Limestone member are less meaningful than are those for the Grayville section. Fossils were more difficult to remove from the limestone and a consistent lithologic break within the limestone was not obvious so that reliable diversity-based trends were not observed.

Two associations occur in the limestone: the brachiopod-coral association in the lower part and the gastropod association in the upper part. The most important difference between the two associations is the presence of corals, bryozoans and a diverse

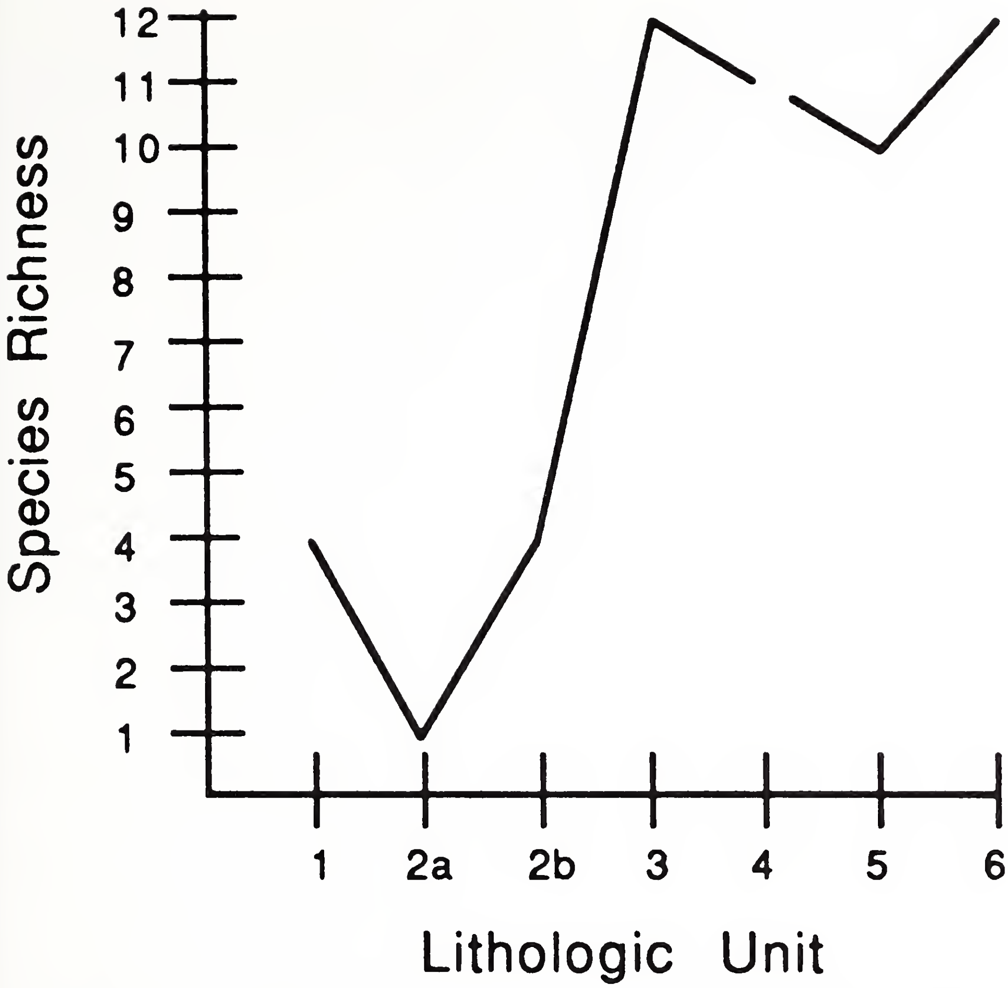

FIGURE 6. Graph showing diversity in terms of species richness (number of common species) plotted against stratigraphic position at Grayville.

brachiopod fauna in the lower association, and absence of most of these fossils in the upper. These organisms are generally regarded as being associated with fully normal marine conditions. The upper association is more restricted in habitat and components generally regarded as inhabiting normal marine waters are not present.

At the Wabash cutoff locality, the Riverview Limestone records a marine transgression. Transgressing marine waters encroached over a nonmarine coal swamp that is recorded by a thin coal bed that lies next below the limestone. The occurrence of normal marine fossils in the lower part of the limestone, just above the coals, indicates that transgression was rapid. No transitional brackish water or marginal marine fossils were found, as would be expected if transgressions was slow enough to allow preservation of replacement communities. Cataclysmic, possibly storm related, inundation of a coastal coal swamp may have been responsible for the sequence seen at the cutoff, but large fossil fragments in the lower association indicate that energy levels were neither high enough nor persistently strong enough to break up the fossils. An abrupt marine transgression with fully marine waters may have been responsible for the lower association, followed by downgrading of the environment and numerous storms, resulting in the low diversity and numerous shell fragments of the upper association.

Conclusions

Two of the four original New Harmony area collecting sites are still exposed. The other two apparently are covered by alluvium or filled in. Our collections from the two available sites yielded topotypes of three gastropod species that were described in early reports: *Euphemites blaneyanus, Euphemites vittatus*, and *Glabrocingulum (Glabrocingulum) grayvillensis.*

The marine rocks at both collecting sites were deposited during transgressional marine phases. Both lay above coal and clastics that were deposited in nonmarine environments. The two sites differ in style of marine transgression.

Deposition of the Grayville Limestone was slow, leaving a good record of fossil replacement through time. A brackish water association at the base was overlain by progressively more marine faunas. Slight changes in environmental stability affected the occurrence of specific fossils and the species richness of individual units.

Marine transgression that resulted in deposition of the Riverview Limestone at the Wabash cutoff was rapid. An association of normal marine fossils directly overlies coal, suggesting that marine inundations was sudden, possibly catastrophic. After marine inundation, the environment was downgraded and a relict community persisted for a short time. Nonmarine deltaic siltstone and sandstones replaced the shallow marine environments.

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APPENDIX 1

List of original species names and localities for species that were originally described from the New Harmony area.

	McChesney, 1860
Rhynchonella algeri	Big Creek
Edmondia concentrica	Big Creek
Zeacrinus mucrospinus	Mouth of Rush Creek
Leda oweni	Mouth of Rush Creek
Bellerophon vittattus	Mouth of Rush Creek; Grayville
Orthoceras rushensis	Mouth of Rush Creek
Rhynchonella eatoniaeformis	Grayville
Nautilus quadrangulus	Grayville
Nautilus nodocarinatus	Grayville
Rhynochonella explanata	"New Harmony"
Leda gibbosa	"Five miles below New Harmony"
	Norwood and Pratten, 1855a
Pleurotomaria grayvillensis	Mouth of Rush Creek; Grayville
Bellerophon monfortianus	"Five miles below New Harmony"
Loxonema hallii	"Five miles below New Harmony"
Natica ventrica	"One mile south of New Harmony"
	Norwood and Pratten, 1855b
Productus splendens	Big Creek
Productus portlockianus	Grayville
Productus clavus	Grayville
Productus wabashensis	"New Harmony"
	Meek and Worthen, 1860
Solemya radiata	Grayville
Platystoma? tumida	Grayville
Cyrtoceras curtum	Grayville
Pleurophorus? angulatus	Wabash cutoff
Conocardium obliquum	Wabash cutoff
Schizodus curtus	Wabash cutoff
	Hall, 1858
Edmondia radiata	Grayville