Marine Invertebrate Fossils in Pennsylvanian Coal Balls from Southern Indiana

ROGER F. BONEHAM
Department of Geology
Indiana University at Kokomo, Kokomo, Indiana 46901

Abstract

Coal balls from three localities in Warrick County, Indiana were found to have numerous marine invertebrate fossils intermixed with plant debris in their matrix. The shells of these animal fossils have been replaced by pyrite which makes it possible to separate them from the carbonate matrix.

Apparently this association of plant and animal fossils is indicative of marshes near tide water level which were occasionally inundated by storm waves which carried marine animals or their shells some distance inland. A similar process occurs today along the Gulf Coast Region of the United States.

Introduction

During the course of an investigation of coal ball plants from Coal V (Upper Des Moines Series) in southwestern Indiana the remains of animal fossils in some of the coal balls were noted. The occurrence of animal remains is so rare in coal balls the author decided to pursue the investigation further. This paper summarizes the results.

A number of localities yielded coal balls but only three mines, all in Warrick County, contained coal balls with animal fossils. The three sites are shown on Figure 1:

Locality K—Boon Coal Co. Mine, NW¼, NW¼, sec. 30, T.5S., R.8W., 4 miles west of Boonville (Boonville Quad.).

Locality G—Abandoned Houston Mine, SW¼, SW¼, sec. 11, T.5S., R.8W., 3¼ miles north of Boonville (Boonville Quad.).

Locality F—Abandoned strip mine, NW¼, NW¼, sec. 34, T.3S., R.7W., 1½ miles northeast of Scalesville (Folsomville Quad.).

Mamay and Yochelson (15) reported marine animal remains in coal balls. They gave four collection localities for their material. One of these, Berryville, Illinois, is approximately 50 miles northwest of Boonville. The coal balls which Mamay and Yochelson reported were of four types:

1. Normal coal balls containing only plant fossils.
2. Homogeneous mixed coal balls containing unsegregated plant and animal fossils.
3. Heterogeneous mixed coal balls containing segregated plant and animal fossils.
4. Faunal coal balls containing only animal fossils.

The coal balls found during the course of this study were mainly of the normal variety. That is they contained plant material only. Those coal balls which contained animal fossils were mainly of the homogeneous variety. They contained plant and animal remains mixed together

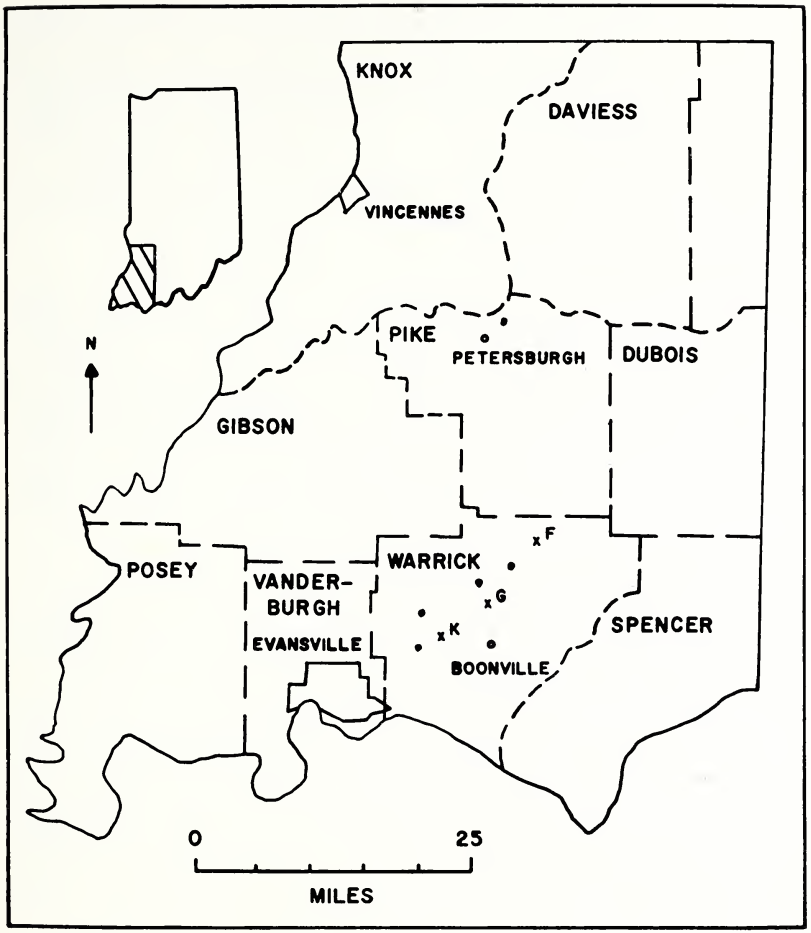


FIGURE 1. *List of coal ball localities. The X's indicate sites where coal balls with animal fossils were collected. The back dots indicate where coal balls with plant remains only were collected.*

throughout the coal ball matrix. This mixing was not complete however. Often in one area of the matrix there would be a preponderance of plant fragments while another part would contain a preponderance of animal remains. In many of the coal balls the color of the sediment indicated whether there would be a majority of plants or animals in a given part of the coal ball matrix. Areas where plant parts were in the majority were usually a light brown color. Areas where animal fossils predominated had sediment colors which ranged from dark brown to light black. One specimen (K5) is actually a small nest of normal coal balls. Incorporated within the cementing coaly matrix are some animal remains. A number of the faunal coal balls contain large amounts of iron sulfide in the matrix. In some of the coal balls

(K8, K37, G24, G29, F1) iron sulfide replacement of the matrix occurs along the periphery of the coal ball and has advanced toward the central portions with various degrees of replacement. The replacement order appears to have been first the fossil shells and second the carbonate matrix of the coal ball. The plant material has not been replaced to any significant extent, if at all. Pyritization has apparently had the effect of destroying plant matter rather than replacing it. In those coal balls which have large portions of the matrix replaced by iron sulfide there are significantly fewer plant fragments in the replaced areas than in the areas of carbonate matrix.

The occurrence of animal fossils in coal balls is apparently quite rare. In the present study not more than 5 per cent of the coal balls collected did contain animal remains. During the course of collecting the material it became clear that there was a subtle color difference of the outer matrix of many of the coal balls which contained animals. The coal balls were a somewhat lighter brown color than those which exclusively contained plant fossils. It may be that this color difference allowed me to collect a higher percentage of coal balls containing animal fossils than would have been the case with an entirely random collection.

Geologic History

The southwest region of Indiana lies along the eastern edge of the Eastern Interior Coal Basin which also underlies portions of northwestern Kentucky and central and southern Illinois. There are a number of coal seams presently being mined that were mined in the past. Ashley (1) proposed a scheme for naming the Indiana coal seams which was subsequently adopted in somewhat modified form by the Indiana Geological Survey. Essentially each principal coal seam is given a Roman numeral based upon its stratigraphic relationship to all other principal coal seams. In case one or more minor coal seams occur between two principal seams, these minor seams take the Roman numeral of the lower principal seam along with the suffix of a lower case letter. For example Coals Va and Vb occur between Coals V and VI, also Coal Va is below Vb.

Although coal has been mined in Indiana for approximately 150 years there have been very few paleobotanical papers on Pennsylvanian rocks of Indiana until the last twenty years. The first papers on Pennsylvanian paleobotany in Indiana were reports (19, 20) on some fossil tree trunks from Posey County. Lesquereux (12) published the first extensive paper on Pennsylvanian plants from Indiana. He also published the only paper on Pennsylvanian marine plants in Indiana (13). Although not intended as a research paper, Lesquereux (14) mentions Pennsylvanian plant specimens from Indiana in a number of fossil descriptions in what must be considered the first paleobotanical text published in the United States. White (23) published a paper on the flora of the Hindostan whetstone beds in the lower part of the Mansfield Formation of Morrowan age. Jackson published two papers (8, 9) on some floras from shale layers and sandstone layers within the Mansfield Formation. He correlated these floras with those of the

Pottsville Series in the Appalachian Region. Reed (22) published the first report on plant remains from Indiana coal balls found in Coal V. She described the anatomy of two specimens of *Pachytesta gigantea* Brongniart collected by Noé near Brownsville, Indiana. Benninghoff (3) published the first coal ball flora from material collected in Coal V near Petersburg, Indiana.

During the last decade paleobotanical research in Indiana has undergone a revival in comparison with the period following Lesquereux's studies. Baxter (2), Morgan and Delevoryas (17, 18) and Phillips (21) all published papers on plants from Indiana coal balls. It should be noted that the coal balls of Morgan and Delevoryas came from the Parker Coal of the Patoka Formation of Missouri Series age. Canright (5) published the only comprehensive modern study of Indiana plant fossils. He lists 93 collecting sites many of which are new. Guennel (6, 7) published two papers on the spores found in the Pottsville and Allegheny coals of Indiana. Wood (24) published a study of plant fossils found in ironstone concretions from a shale just above the Lower Block Coal in the lower part of the Brazil Formation in the Atoka Series. Boneham (4) did a study of an ironstone concretion flora from the Busseron Sandstone Member of the Shelburn Formation in the upper part of the Des Moines Series. The latest study on coal ball plants from Indiana was done by Judd and Nisbet (11). Although the authors do not say what coal seam the coal balls come from, the thesis of Judd (10) implies they are from Coal V. This paper is the first report of animal fossils in Indiana coal balls.

As stated earlier, all of the material for this report came from Coal V. Coal V or the Petersburg Coal of Indiana marks the top of the Petersburg Formation. This formation is in the Upper Des Moines Series of the Midcontinent Region. Coal V correlates with the No. 9 Coal of western Kentucky, the Harrisburg Coal of southern Illinois, the No. 5 or Springfield Coal of central Illinois and the Summit Coal of Iowa and Kansas (16).

Laboratory Techniques

Each coal ball was sawn in half in the laboratory. One of the sawn faces was polished and etched with dilute HCl. An acetate peel was prepared from the specimen by flooding the surface with acetone and rolling a piece of acetate film on it. This is standard technique used by many paleobotanists.

After the peel was removed it was quite easy to see if there were any invertebrates within the coal ball. The animal remains were nearly always replaced by iron sulfide. As a result they were unaffected by the acid etch and were not incorporated—within the acetate film. Their impressions could, however, be easily seen as clear outlines surrounded by the darker carbonate matrix which had been pulled off with the film.

As this study progressed it became obvious that the coal balls would have to be dissolved in order to obtain complete specimens for study. The decision was made to use dilute acetic acid rather than dilute hydrochloric acid since there was much less effervescence which might damage delicate forms and since one of the peels showed a

conodont it was best not to dissolve any more which might still have been in the coal balls.

Many of the coal balls dissolved satisfactorily in the acid. Some of those which contained a high percentage of iron sulfide were relatively unaffected and were not considered further. The sludge from the acid digestion was carefully screened through a 140-mesh sieve and washed. The fossils which remained on the sieve were picked off and placed in containers for further study.

Summary

It is unfortunate that none of the coal balls collected for this study were found in place. All were gathered from waste dumps around the mines. So the position of these coal balls within the coal seam is unknown. There is, however, little doubt that most were enclosed with the coal since most of them are at least partially enclosed within a thin veneer of coal. There is no reliable method of telling in the field whether a particular specimen is a normal coal ball or mixed coal ball. Occasionally a mixed coal ball if broken with a hammer will tend to split around some of the larger shell fragments. However, this is by no means a reliable guide. Each coal ball must be sawn through and examined in the laboratory before one can positively say whether or not it contains animal fossils.

The most probable explanation of how marine fossils came to be in the coal balls is that given by Mamay and Yochelson (15). Namely, the fossils were originally deposited offshore in a shallow bay. At various times storms coming onshore were violent enough to carry some of bottom mud into the low lying swamps which bordered this ancient sea. Some of the mud was dispersed in the waters of the swamp and the enclosed shells were incorporated within the vegetative mass which would ultimately become coal. If at a later date coal balls formed which included some of this vegetable material along with the invertebrate fossils the coal balls would be of the heterogeneous variety. On the other hand some of the mud may have not been dispersed completely but may have had enough cohesive strength to remain a discrete mass. If such mud balls were deposited within the vegetable debris this would explain how the homogeneous variety of coal balls were formed. Apparently a certain amount of intermixing of the marine mud balls with the mud from the swamp occurred since the zone of separation between the darker colored marine matrix and lighter colored nonmarine matrix has a feathered appearance with stringers of one matrix trailing into the matrix of the other type.

Table 1 is a list of the specimens found in each coal ball which contained invertebrate fossils. The list does not contain quantitative information since I believe that adding numbers of specimens to the table would give a false sense of preciseness. The specimens are small species or the juvenile stages of larger species. Apparently these shells were subjected to winnowing action by currents which preferentially concentrated shells of a certain size range together in the bottom mud of bays along the coast. Therefore the percentage of a given species at

a locality probably has no relation to its frequency in the living population.

TABLE 1. *List of fossils in coal balls from Localities F, G, and K.*

	F	G	K
Protozoa:			
Nubicularia sp.	X	X	X
Echinodermata:			
Crinoid stems	X		X
Brachiopoda:			
Mesolobus sp.	X	X	X
Marginifera sp.		X	X
Derbyia sp.			X
Linoproductid indet.			X
Linguloid indet.	X		X
Orbiculoid indet.			X
Brachiopods sp. indet.	X	X	X
Mollusca:			
Cf. *Euphemites* sp.	X	X	X
Steinkern cf. *Girtyspira*	X	X	X
Steinkern cf. *Shansiella* type A	X	X	X
Steinkern cf. *Shansiella* type B	X	X	X
Steinkern cf. *Donaldina* type A	X	X	X
Steinkern cf. *Donaldina* type B		X	X
Glabrocingulum sp.			X
Cf. *Cardiomorpha*			X
Pelecypods indet.		X	X
Orthoconic cephalapod			X
Arthropoda:			
Pseudobythocypris pediformis		X	X
Amphissites centronotus		X	X
Pseudoparaporchites sp.			X
Bairdia sp.			X
Hollinella sp.	X	X	X
Cf. *Hypotetragona* sp.			X
Conodonts:			
Idiognathodus cf. *claviformis*			X
Idiognathodus cf. *delicatus*	X		
Gnathodus cf. *roundyi*	X		
Hindeodella sp.	X		
Barlike conodont indet.	X		
Platformlike conodont indet.	X		
Plantae:			
Triletes auritus	X	X	X
Triletes triangulatus	X	X	X
Triletes glabratus			X
Monoletes sp.			X
Seed coats indet.	X	X	X
Resin rodlets	X		

In the interest of completeness the specimen frequency should be mentioned since it is readily available. *Mesolobus* sp. specimens are the most common of the brachiopods. Whenever they are present in a coal ball, they compose the bulk of brachiopod specimens. The snails are the most common molluscs. Those present in the greatest numbers are cf. *Euphemites* sp. and cf. *Shansiella* spp. The most numerous of the ostracods is *Pseudobythocypris pediformis*. The conodonts are not

plentiful. But the most common are *Hindeodella* sp. and *Idiognathodus* cf. *delicatus*. Interestingly enough, practically all of the conodont specimens were found in coal balls from locality F. *Triletes auritus* and *Triletes triangulatus* are both plentiful megaspores in many of the coal balls.

Table 1 indicates that there are few differences in the fossils from the three localities. As Figure 1 shows, all the sites which had coal balls with invertebrate fossils are in Warrick County. It also shows other nearby coal ball sites which contain coal balls of the normal type—that is with plant fossils only.

The question of why animal remains are not found more frequently in coal balls is difficult to answer. Mamay and Yochelson (15) speculated upon this point also. They came to no very satisfactory conclusion and the author cannot either. The combination of a coal swamp nearly at tide water level on a coast subject to hurricanes does not seem to be a particularly unusual environment. Apparently there must have been other factors which are not yet recognized since coal balls containing animal fossils are rare.

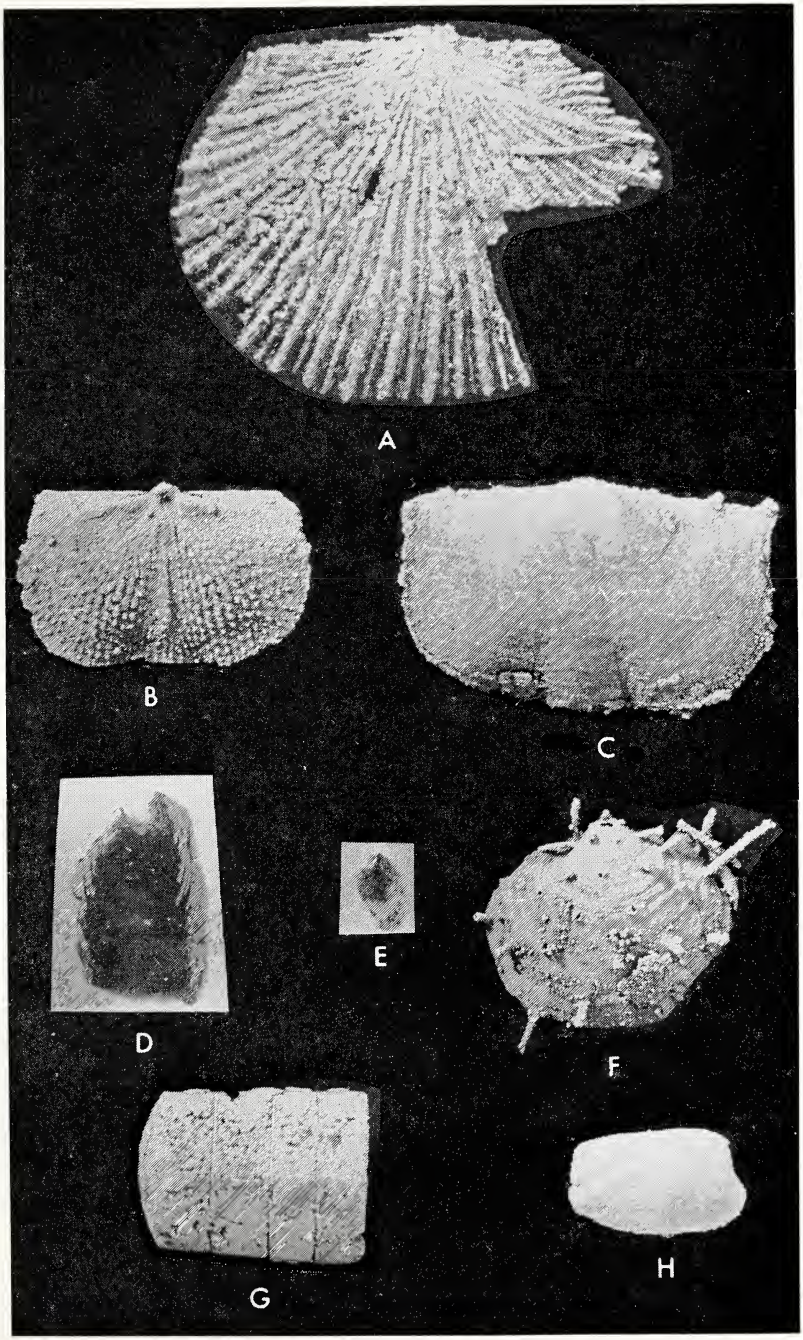
Acknowledgements

This work was done with the aid of a Summer Faculty Fellowship from Indiana University. Funds for field work were supplied by the Indiana University Foundation, Grant No. 11-601-10. The author wishes to thank Alan S. Horowitz, Thomas G. Perry, Carl B. Rexroad and Robert H. Shaver of the Indiana University Geology Department for their aid in identifying many of the fossils in this study.

PLATE 1

All figures X6

A. *Derbyia* sp., IU 12150; *B. Mesolobus* sp., interior of brachial valve, IU 13351; C. *Mesolobus* sp., IU 13352; D. Linguloid brachiopod, IU 13353; E. Orbiculoid brachiopod, IU 13354; F. *Marginifera* sp., IU 13355; G. Orthoconic cephalapod, IU 13356; H. Cf. *Cardiomorpha* sp., IU 13357.


A
B
C
D
E
F
G
H

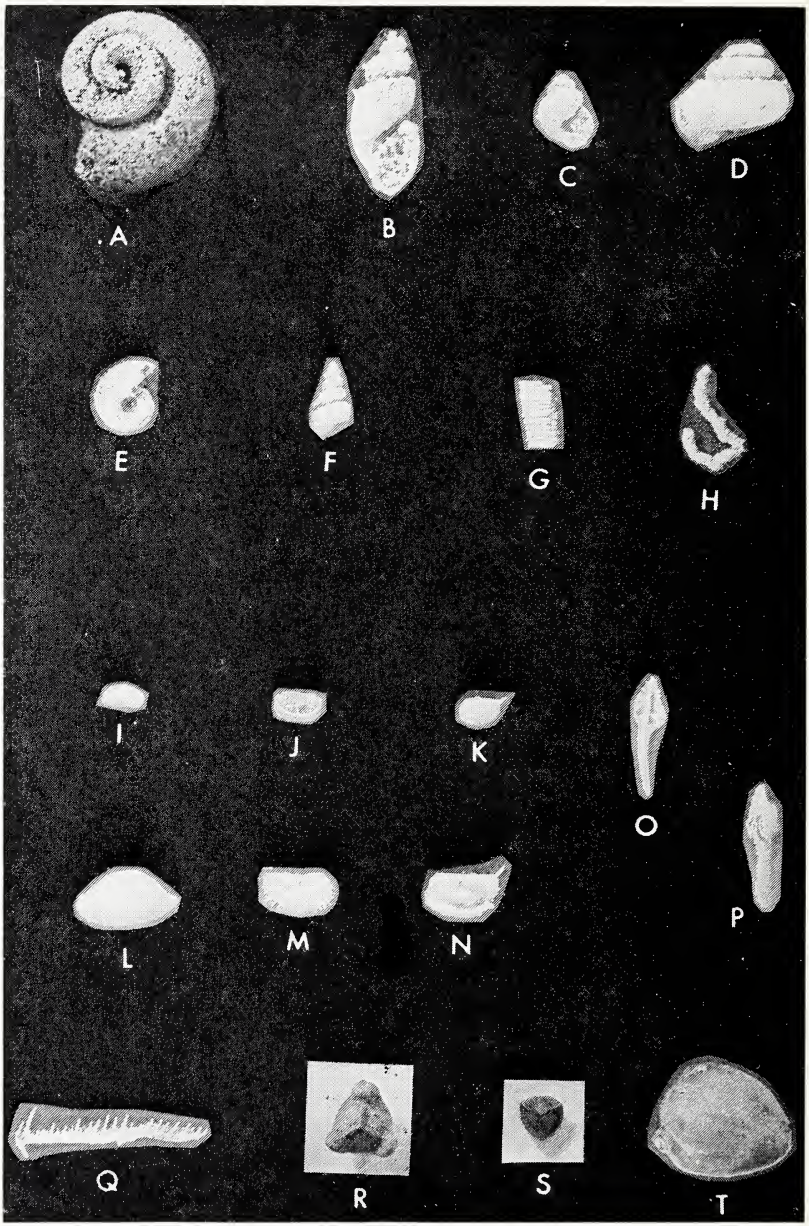


PLATE 2

All figures X6 unless otherwise specified.

A. Steinkern cf. *Shansiella* type B. IU 13358; B. Steinkern cf. *Girtyspira* sp., IU 13359; C. Steinkern cf. *Shansiella* type A, X9, IU 13360; D. Steinkern cf. *Donaldina* type A, IU 13361; E. cf. *Euphemites* sp., IU 13362; F. Steinkern cf. *Donaldina* type B, X7, IU 13363; G. Crinoid stem, IU 13364; H. *Nubicularia* sp., IU 13365; I. *Pseudobythocypris pediformis*, X9, IU 13366; J. *Amphissites centronotus*, X9, IU 13367; K. *Pseudoparaporchites* sp., X9, IU 13368; L. *Bairdia* sp., X9, IU 13369; M. *Hollinella* sp., X9, IU 13370; N. *Hollinella* sp., X9, IU 13371; O. *Gnathodus* cf. *roundyi*, X9, IU 13372; P. *Idiognathodus* cf. *delicatus*, X9, IU 13373; Q. *Hindeodella* sp., X9, IU 13374; R. *Triletes auritus*, IU 13375; S. *Triletes triangulatus*, X9, IU 13376; T. Seed coat, IU 13377.

PLATE 3

All figures X1

All coal ball figures are made from negative prints in order to enhance the contrast between the invertebrate fossils and matrix. The disadvantage of this photographic technique is that it lessens the contrast between the plant fossils and matrix.

A. Coal ball F9 is a heterogenous, mixed coal ball. Note the darker matrix in the bottom one-third. This portion contains plant fossils and very few animal remains. The rest of the coal ball contains abundant animal remains. The two matrices have different colors and this specimen shows quite well that the bottom muds which formed these coal balls were not always homogenized before lithification; B. A portion of coal ball K40. This is a homogenous, mixed coal ball. It mainly contains animal fossils but there are some plant fossils as well; C. Another portion of coal ball K40. This was a nest of small coal balls cemented together by the surrounding coal.

Literature Cited

1. ASHLEY, G. H. 1899. The coal deposits of Indiana. Dep. of Geol. and Natur. Resources, 23rd Annu. Rep. p. 67-91.
2. BAXTER, R. W. 1950. *Peltastrobus Reedae*: A new sphenopsid cone from the Pennsylvanian of Indiana. Bot. Gaz. 112:174-182.
3. BENNINGHOFF, W. S. 1943. Preliminary report on a coal ball flora from Indiana. Proc. Indiana Acad. Sci. 53:62-68.
4. BONEHAM, R. F. 1975. Chieftain No. 20 flora (Middle Pennsylvanian) of Vigo County, Indiana. Proc. Indiana Acad. Sci. 84:89-113.
5. CANRIGHT, J. E. 1959. Fossil plants of Indiana. Indiana Geol. Surv., Rep. of Progress 14. 45 p.
6. GUENNEL, G. K. 1952. Fossil spores of the Alleghenian coals in Indiana. Indiana Geol. Surv., Rep. of Progress 4. 40 p.
7. ————. 1958. Miospore analysis of the Pottsville coals of Indiana. Indiana Geol. Surv. Bull. 13. 101 p.
8. JACKSON, T. F. 1914. The paleobotany of the Bloomington, Indiana quadrangle. Proc. Indiana Acad. Sci. 30:395-398.
9. ————. 1916. The description and stratigraphic relationships of fossil plants from the lower Pennsylvanian rocks of Indiana. Proc. Indiana Acad. Sci. 32:405-428.
10. JUDD, R. W. 1968. Pennsylvanian coal ball flora of Indiana. Unpublished Ed.D. thesis, Ball State Univ., Muncie, Indiana. 81 p.
11. ————and J. J. NISBET. 1969. Pennsylvania coal ball flora of Indiana. Proc. Indiana Acad. Sci. 78:120-138.
12. LESQUEREUX, LEO. 1862. Report on the distribution of the geological strata in the coal measures of Indiana. p. 269-341. *In* Richard Owen [ed.]. Report of a geological reconnaissance of Indiana, made during the years 1859 and 1860. Indianapolis. 368 p.
13. ————. 1876. Species of fossil marine plants from the Carboniferous Measures. Indiana Geol. Surv. Annu. Rep. 7:134-145.
14. ————. 1884. Principles of Palezoic botany. Indiana Dep. Geol. and Natur. Resources Annu. Rep. 13:1-106.
15. MAMAY, S. H., and E. L. YOCHELSON. 1962. Occurrence and significance of marine animal remains in American coal balls. U. S. Geol. Surv. Prof. Pap. 354:193-224.
16. MOORE, R. C., H. R. WANLESS, J. M. WELLER, J. S. WILLIAMS, C. B. READ, W. A. BELL, G. H. ASHLEY, M. G. CHENEY, L. M. CLINE, G. E. CONDRA, R. H. DOTT, C. O. DUNBAR, M. K. ELIAS, L. C. GLENN, F. C. GREENE, T. A. HENDRICKS, J. M. JEWETT, J. H. JOHNSON, P. B. KING, J. B. KNIGHT, A. I. LEVORSEN, H. D. MISER, N. D. NEWELL, F. B. PLUMMER, M. L. THOMPSON, C. W. TOMLINSON, and JEROME WESTHEIMER. 1944. Correlation of Pennsylvanian formations of North America. Geol. Soc. Amer. Bull. 55:657-706.
17. MORGAN, J., and T. DELEVORYAS. 1952a. An anatomical study of Stipitopteris. Amer J. Bot. 39:474-478.
18. ———— and ————. 1952b. *Stewartiopteris singularis*: a new psaroniaceous fern rachis. Amer. J. Bot. 39:479-484.
19. OWEN, D. D. 1843a. Fossil palm trees found in Posey County, Indiana. Amer. J. Sci. 45:336-337.
20. ————. 1843b. On some fossil trees from New Harmony, Indiana. Proc. Acad. Nat. Sci. 1:270-271.
21. PHILLIPS, T. L. 1959. A new sphenophyllalean shoot system from the Pennsylvanian. Ann. Missouri Bot. Garden. 46:1-17.
22. REED, F. D. 1939. Structure of some carboniferous seeds from American coal fields. Bot. Gaz. 100:769-787.
23. WHITE, D. 1896. Report on the fossil plants from the Hindostan whetstone beds in Orange County, Indiana. Ind. Dep. Geol. and Nat. Resources Annu. Rep. 12:354-355.
24. WOOD, J. M. 1963. The Stanley Cemetery flora (early Pennsylvanian) of Greene County, Indiana. Indiana Geol. Surv. Bull. 29. 73 p.