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CONODONTS FROM COAL BALLS IN THE SPRINGFIELD COAL MEMBER OF THE PETERSBURG FORMATION (DESMOINESIAN, PENNSYLVANIAN) IN SOUTHERN INDIANA

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ABSTRACT: A well-preserved and moderately diverse conodont faunule was recovered from five coal balls in the Springfield Coal Member of the Petersburg Formation from Peabody Coal Company's Eby Pit, Lynnville Mine, in Warrick County, Indiana. The presence of *Neognathodus roundyi* and the other species recorded in this study is compatible with the middle Desmoinesian age of the Springfield. *Idioprioniodus conjunctus* is the most ecologically diagnostic of the conodonts and suggests organic-rich, quiet water with a low pH, which in turn suggests that the conodonts lived in a salt-water marsh bordered on one side by coal swamps and on another by near-normal marine waters. Apparently coal balls had multiple origins, and the origin of the conodont-bearing ones is uncertain.

INTRODUCTION

Because marine fossils are commonly associated with plant fossils in some coal balls, it is not surprising that conodonts have been reported from them. A half-dozen well-preserved conodonts from Pennsylvanian coal balls from three different States were figured by Mamay and Yochelson (1962), but no other conodonts were figured; therefore, the overall conodont content in coal balls is unknown.

To better understand the distribution of conodonts and their paleoecologic importance in coal balls, samples were processed from coal balls of the middle Desmoinesian Springfield Coal Member of the Petersburg Formation from the Eby Pit of Peabody Coal Company's Lynnville Mine (SW1/4, SW1/4, NE1/4, Sec. 2, T5S, R8W), Warrick County, southern Indiana (Figure 1). The presence of diverse, well-preserved, and relatively abundant conodonts (about 350 identifiable conodonts per kilogram) indicates the value of additional study of the conodont content of coal balls, particularly in terms of analysis of the environment of deposition of the coal balls.

GEOLOGIC SETTING

Friedman (1956, 1960) interpreted the Springfield coal as a deltaic deposit mostly on the basis of linear sand bodies, the first of which was recognized by Cady (1919). Hopkins (1968) mapped this channel in detail and determined that it was partly contemporaneous with the Springfield coal because in places the coal is split by sediment derived from the channel. In 1979, Hopkins, *et al.* named the deposit the Galatia Channel. The marine roof normally found above the Springfield rises and pinches out above this clastic wedge that thickens toward the channel. Subsequently, Wanless, *et al.* (1969, 1970) mapped a system of distributary channels, apparently interconnected; they also held the view that the Springfield is a model deltaic coal, a model reaffirmed by Eggert, *et al.* (1983).

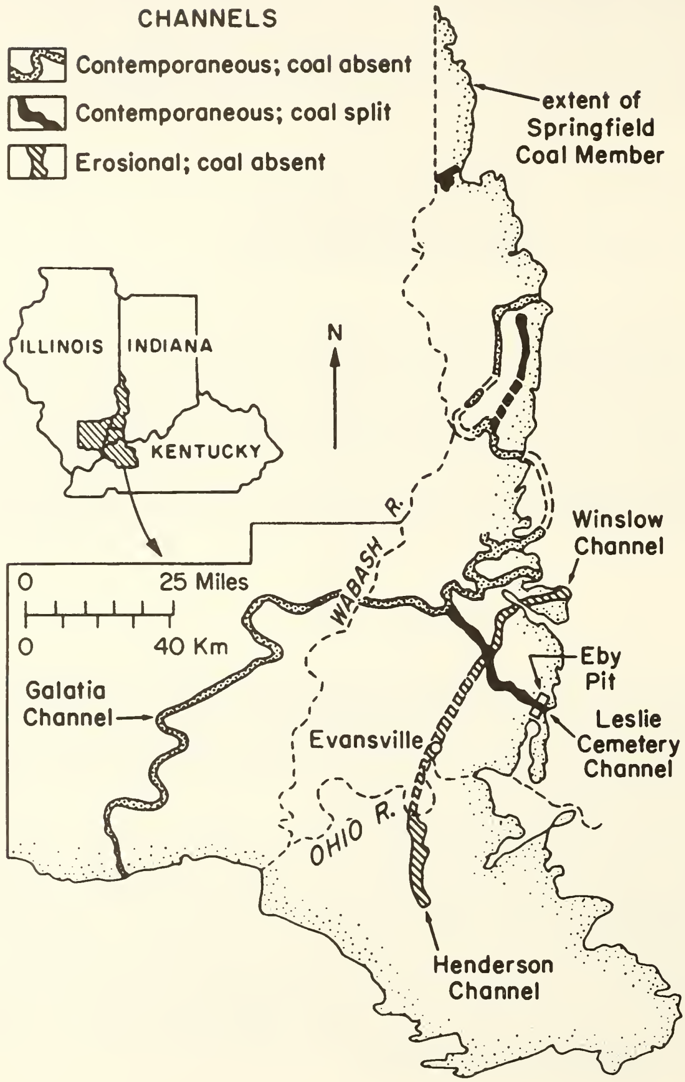

Figure 1. Map showing the location of the Eby Pit, the extent of the Springfield Coal Member in southwestern Indiana and part of western Kentucky, and the channels that affect Springfield coal (slightly modified from Eggert, *et al.*, 1983).

Eggert (1982) found that sediment from the Leslie Cemetery Channel (Figure 1) in Warrick and Gibson Counties, Indiana, (the Folsomville Member of the Petersburg Formation) split the coal into two seams separated by clastics as much as 40 feet thick. When the channel was abandoned and overbank deposition ceased, peat-forming plants began re-colonizing the former channel area so that a thinner upper seam of coal rides up over the Folsomville. This was true of the Eby Pit, and there the coal balls were limited to the upper part of the relatively thin upper split. The upper split from which the coal balls were collected was overlain in the Eby Pit by black, organic-rich, pyritiferous shales of

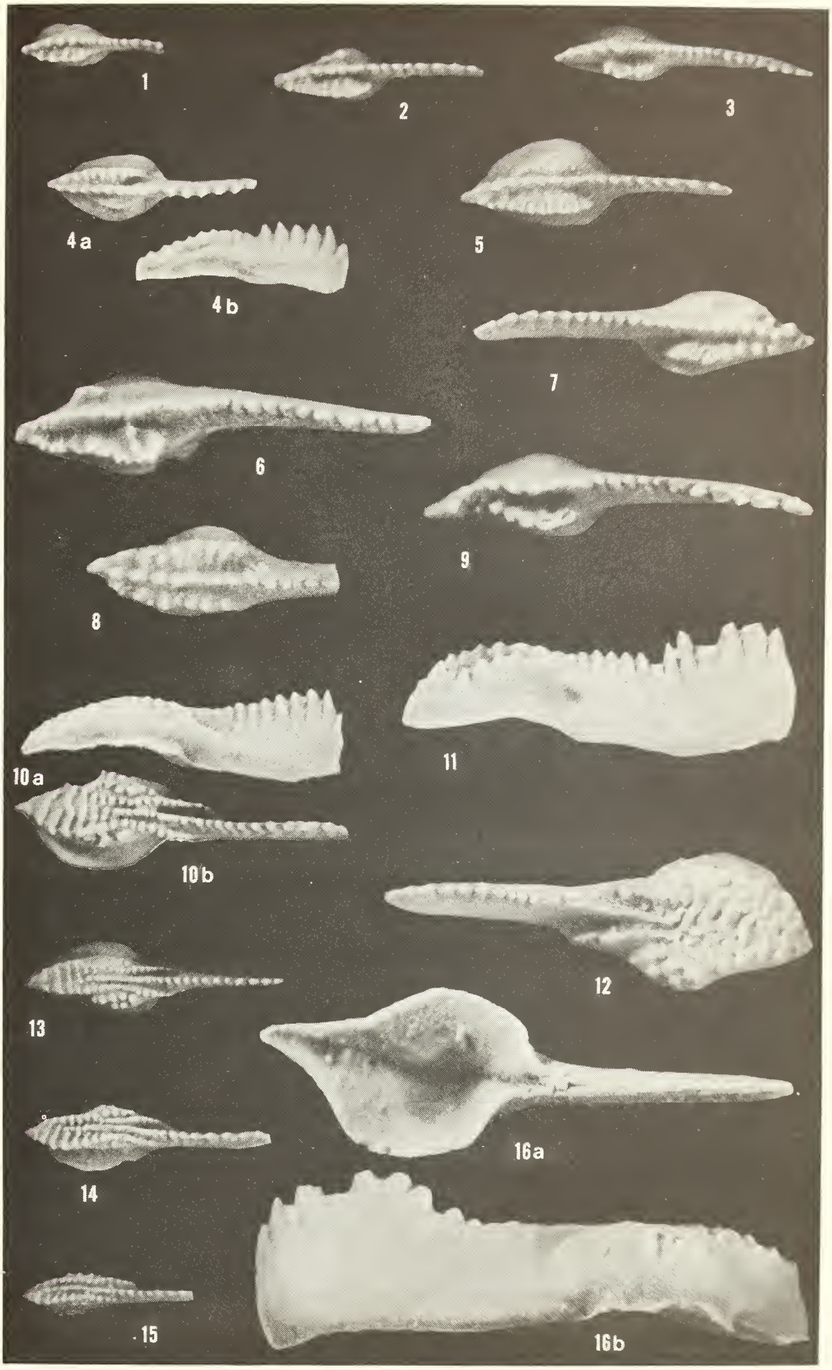

Figure 2. 1-7, 9. *Neognathodus roundyi* Pa elements: 1, 2; 17,876 and 17,877. 3. *metanodous* morphology: 17,878. 4, 9. *dilatus* morphology: 17,879 and 17,880. 5, 6, 7: 17,881-17,883. 8. *Neognathodus medadultimus* Pa element: 17,884. 10-16. *Idiognathodus claviformis* Pa elements: 17,885-17,891, respectively. All figures are x 40; the five-digit numbers are repository numbers.

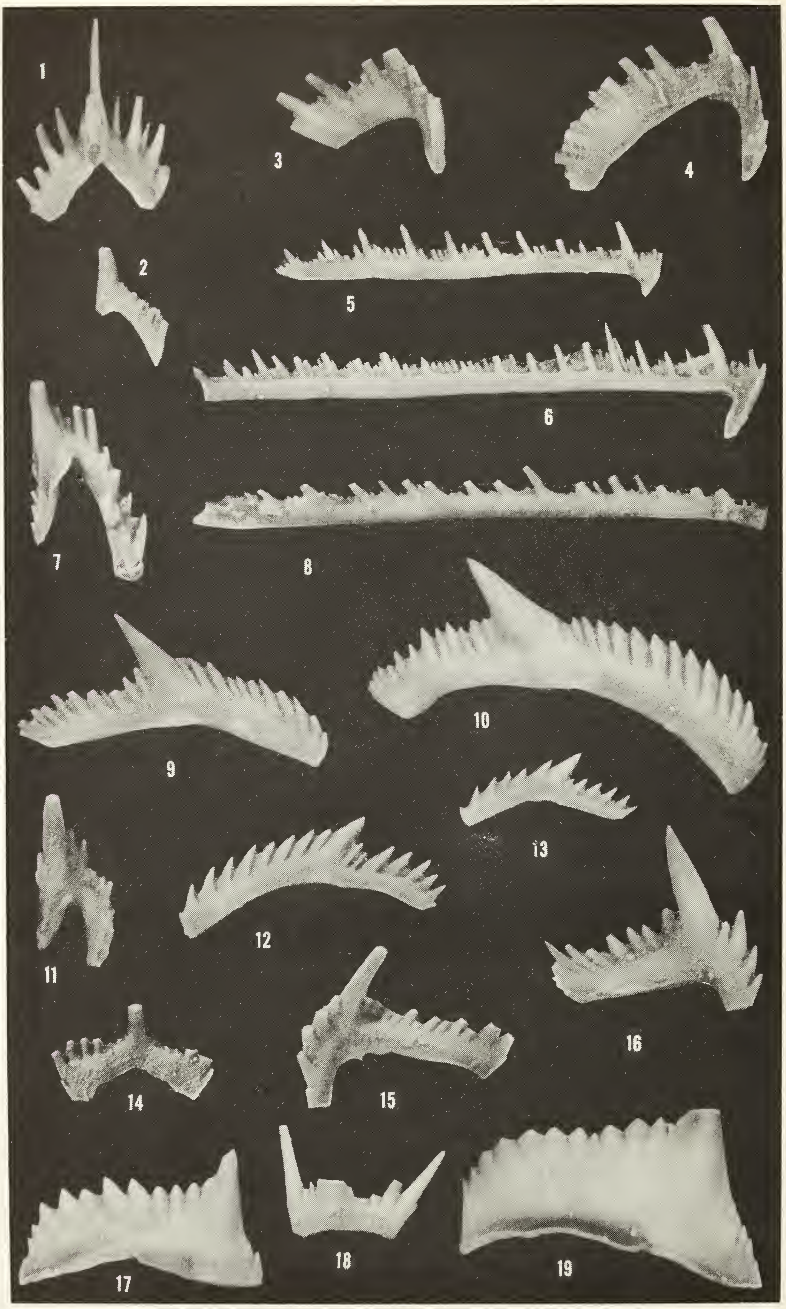

Figure 3. 1, 2. *Adetognathus* sp.: 1, Sa element, 17,903; 2, M element, 17,904. 3-13. Ramiform elements of *Neognathodus* and *Idiognathodus* undifferentiated: 3, 4, Sa elements, 17,892 and 17,893; 5, 6, Sc elements, 17,894 and 17,895; 7, 11, M elements, 17,896 and 17,897; 8, Sb element, 17,898; 9, 10, 12, 13, Pb elements, 17,899-17,902. 14-17, 19. *Hindeodus minutus:* 14, Sa element, 17,903; 15, 16, Pb elements, 17,904 and 17,905; 17, 19, Pa elements, 17,906 and 17,907. 18. *Aethotaxis?*: Sb element, 17,908. All figures are x 40; the five-digit numbers are repository numbers.

marine or marginal marine origin.

Both the thickness of the coal and its sulfur content are closely related to channel position. Sulfur content in Indiana ranges from about 0.5 to 7.5% and is lowest beneath the thick non-marine sediments derived from the distributary channels. Thus, the lower bench in the Eby Pit was a low-sulfur coal beneath the Folsomville, but the upper seam from which the coal ball samples came was a high-sulfur coal. In general, the Springfield is thickest adjacent to the channels, and this was true in the Eby Pit.

THE CONODONT FAUNULE

Preservation of conodonts in the coal balls is variable but is generally good. The conodonts recovered are dominated by *Idiognathodus claviformis* (Figure 2), which retains some morphologic features of ancestral *I. incurvus. Neognathodus roundyi* (Figure 2), *Hindeodus minutus* (Figure 3), and *Idioprioniodus conjunctus* (Figure 4) are common. Two ramiform elements referred to *Adetognathus* (*Cavusgnathus* of some authors; Figure 3) were recovered as were six specimens of unassigned *Ligonodina*-like Sc elements, a single Pa element of *Neognathodus medadultimus* (Figure 2), and an *Aethotaxis*-like Sb element (Figure 3). Included in *N. roundyi* are specimens approaching a *dilatus* morphology and rarely even a *metanodosus* morphology.

The presence of *Neognathodus roundyi*, *Idiognathodus claviformis*, and the longer-ranging species is compatible with the middle Desmoinesian age of the Springfield Coal Member, although the *dilatus* and *metanodosus* morphologies suggest an age slightly younger than the common correlation, whereas *N. medadultimus* and the *I. incurvus* morphology suggest a slightly older correlation.

The distribution of conodonts within the sampled coal balls is shown in Table 1. All specimens are reposited in the Indiana Geological Survey-Indiana University repository.

With the exception of sample 1, the proportions of species and the quality of preservation are generally similar among the samples. Having the fewest conodonts per kilogram, sample 1 was unusual for the excellent preservation of very delicate features, particularly of the bars and denticles of the hindeodelloid S elements. Also, although the overall proportion of *Neognathodus* in the coal balls is much higher than one would expect from its rarity in the overlying Alum Cave Limestone Member of the Dugger Formation, the proportion of *Neognathodus Pa* elements to those of *Idiognathodus* was strikingly high in sample 1. Sample 1 also contained the highest proportion of ramiform elements of *Neognathodus* and *Idiognathodus*, which in conjunction with the excellent preservation, suggests that at least some of the conodonts may have been carried into the coal ball area within conodont carcasses. One would not necessarily expect full representation of the conodont elements in transport of carcasses, however, because their position within the animal appears to have varied sufficiently that different elements might have been released at different times, as suggested by Mark Kleffner (pers. comm., 1991).

PALEOECOLOGY

Conodonts of the *Idiognathodus/Streptognathodus* plexus are found in nearly all marine environments except in the most restricted *Cavusgnathus* biofacies (Merrill and von Bitter, 1984). *Hindeodus* similarly has a wide tolerance, although it seems to be more abundant in the *Aethotaxis* biofacies, which is not represented in this faunule, and to be less abundant in association with *Idioprioniodus. Idioprioniodus* is commonly interpreted

Figure 4. 1-14. *Idioprioniodus conjunctus;* 1, M1 element, 17,909; 2, M2 element, 17,910; 3, Sc3 element, 17,911; 4, Sb2 element, 17,912; 5, Sb1 element, 17,913; 6, Sb3 element, 17,914; 7, Sc1 element, 17,915; 8, Sc2 element, 17,916; 9, 10, Sa elements, 17,917 and 17,918; 11, 12, Pa? elements, 17,919 and 17,920; 13, 14, Pb? elements, 17,921 and 17,922. All figures are x 40; the five-digit numbers are repository numbers.

Table 1. Distribution of conodonts in coal ball samples.

Sample	1	2	3	4	5
Weight (kg)	1	1	.42	.8	.36
Idiognathodus claviformis					
Pa	16	323	72	131	20
Neognathodus roundyi					
Pa	9	52	6	9	2
N. medadultimus					
Pa	0	1	0	0	0
Idiognathodus/Neognathodus					
Pb	4	60	3	12	4
M	6	5	2	1	0
Sa	1	4	0	1	0
Sb/Sc	38	57	34	58	5
Hindeodus minutus					
Pa	0	3	3	5	2
Pb	0	0	4	2	2
M	0	2	2	1	1
Sa	0	1	0	2	0
Sb	0	1	1	1	0
Sc	0	0	0	1	0
Idioprioniodus conjunctus					
Pa?	2	8	1	4	0
Pb?	1	2	0	0	0
M1	0	4	0	0	0
M2	0	6	1	0	0
Sa	0	9	2	2	0
Sb1	0	3	2	1	1
Sb2	1	4	0	1	0
Sb3	0	1	0	1	0
Sc1	0	5	0	1	0
Sc2	0	10	1	0	0
Sc3	0	4	0	0	0
undifferentiated	5	23	6	9	4
Adetognathus					
M	0	0	0	0	2
Sa	0	1	0	0	0
Aethotaxis?					
Sb	0	0	1	0	0
Ligonodina-like Sc elements	1	3	0	1	1
Totals	84	592	141	244	44

as preferring an organic-rich, quiet-water environment having a low pH, which is commonly represented in the geologic record by dark shales (e.g., Merrill, 1973; Merrill and von Bitter, 1976, 1984). The ecologic requirements of *Neognathodus* are less certain as it seems to have tolerated diverse environments, but it is commonly associated with organic-rich deposits, including organic-rich shales, which suggests a marshy environment for some occurrences.

Variations in *Idioprioniodus conjunctus* strongly support the concept that the genus is dimorphic (Merrill and Merrill, 1974), but the variations in the Sb, Sc, and M elements differ from the suggested normal dimorphs. This may well be ecophenotypic, but it does not provide any additional information for interpreting the environment of deposition.

Eggert, *et al.* (1983) summarized the plant associations in the Eby Pit. The peat composition in the coal balls is generally 65 to 75% aerial plant material, consisting of stems, bark, leaves, and reproductive structures. *Medullosa* (a seed fern) and lycopods such as *Lepidodendron hickii* and *Sigillaria* are most abundant within the coal balls. The associated coal is characterized by the overwhelming dominance of *Lycospora*, a spore produced by lycopods that grew in standing water. These kinds of trees are generally rare in midcontinent coal swamps. The second most abundant taxon is *Laevigatosporites minutus*, a spore derived from a tree fern that also apparently favored wet habitats. *Thymospora pseudothiessenii*, a spore believed to have been produced by a tree fern favoring drier habitats, was far less abundant at the Eby Pit than at other Springfield coal localities.

On the basis of this evidence, I suggest that the majority of the conodonts found in the coal balls came from animals that lived in a nearby mud-trapping, salt-water marsh of near-normal salinity not subject to major fluctuations in salinity. Away from the adjacent area of coal accumulation, this marsh opened onto a shallow sea of near-normal salinity. Thus, distance of transport into the coal swamp need not have been great.

This picture fits well with the one proposed by Perkins (1976) for the environment of coal ball deposition. He suggested that within a coastal marsh, perhaps similar to the southwest Florida mangroves, varied energy conditions ranging from low energy, through tidal or seasonal influxes, to very high energy storms may have been a factor in the accumulation of organic material in the coal balls. In addition to corals, brachiopods, bryozoans, and molluscs, Perkins found fusulinids, sponge spicules, ostracodes, and crinoid columnals in the coal ball fauna he studied. Perhaps the mode of transport of some of the latter group would be similar to that of discrete elements of the conodonts, but it would be quite different from the transport of carcasses.

Mamay and Yochelson (1962) were the first to detail marine animal content of coal balls. They suggested that the coal balls are at least partly of clastic origin and that those containing marine animals were formed when mud rollers or mud slurries containing their remains were brought into the coal swamp during unusual temporary marine inundations, probably catastrophic, as might be caused by violent storms or tidal waves. Both Mamay and Yochelson's (1962) and Perkins' (1976) papers emphasized the variety of coal balls, which suggests multiple-originating causes with variety in the energy levels as suggested by Perkins. A middle range in energy levels should be sufficient for inclusion of conodonts in coal balls.

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