

Acritarchs (*Leiosphaeridia*) in the New Albany Shale of Southern Indiana

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Abstract

The Devonian-Mississippian New Albany Shale of southern Indiana is one of the numerous black shale facies in central and eastern North America. The shale is divided into five lithologically distinct members. These members contain varying percentages of two acritarchs *Leiosphaeridia plicata* Felix and *L. linebacki* sp. n. The mean percentages of these two species are sufficiently different in the uppermost Clegg Creek and Camp Run Members to separate them from the lower members. *Leiosphaeridia* may be a useful genus for stratigraphic separation of other black shales.

This study was made to determine whether the green alga *Tasmanites* and the acritarch *Leiosphaeridia* (of unknown biological affinity) might be used to differentiate the various members of the New Albany Shale in Indiana.

The New Albany Shale was originally named by Borden (2) from exposures along the Ohio River in Floyd County. The lithology is characteristic of the Devonian-Mississippian dark shales which outcrop in many parts of the eastern United States and Ontario.

The New Albany Shale contains intermittent layers of dolomite and occasional silty layers high in quartz. The formation contains pyrite scattered throughout its layers although the pyrite, for the most part, is minute crystals seldom being larger than a few millimeters. The shale has two aspects: a brownish-black to black carbon-rich facies and a greenish-gray to gray carbon-poor facies. In the area of southern Indiana from which the samples of this report came, the brownish-black to black carbon-rich facies is the predominant one.

The New Albany Shale is continuous over much of north-central United States. Its equivalents in Ohio are the Huron, Ohio, Cleveland, Bedford and Sunbury shales and in Michigan the Antrim and Ellsworth shales (4).

Campbell (3) divided the New Albany Shale into a number of formations and members. A recent study by Lineback (15) has subdivided the New Albany Shale into five members. At the top of the uppermost member (Clegg Creek), Lineback has four beds which are only recognizable locally.

The New Albany Shale contains *Tasmanites* and *Leiosphaeridia* specimens scattered throughout its various members (3, 15). The genus *Tasmanites* has been enigmatic for many years being classified as worm eggs, trilobite eggs, land plant spores, hystrichospheres, algal spores, and green algae. I believe that Wall (19) has offered convincing arguments for placing *Tasmanites* in the class Chlorophyceae as single cell algae. The same diverse origins have been proposed for *Leiosphaeridia* as for *Tasmanites*. Indeed, *Leiosphaeridia* was not recognized as a distinct genus

Lower Mississippian	New Providence Shale	New Albany Shale
	Rockford Limestone	
Upper Devonian	Clegg Creek Member	
	Camp Run Member	
	Morgan Trail Member	
	Selmier Member	
	Blocher Member	
Middle Devonian	North Vernon Limestone	

FIGURE 1. Column showing stratigraphic position of the New Albany Shale and its members in southern Indiana.

until fairly recently (8). Eisenack (8) placed *Leiosphaeridia* with the hystrichospheres while others (6, 7, 10, 16) have placed the genus in the group Acritarcha (a group of unknown and possible diverse biological affinities).

The Devonian-Mississippian boundary is apparently present near the top of the New Albany Shale. Huddle (12) thought the uppermost strata might be Mississippian from his study of the conodont faunas. Read and Campbell (17) placed the whole formation within the Devonian. However, Campbell later (3) decided that the uppermost strata contained a fauna of Kinderhook age. Cross and Hoskins (5) also placed the Devonian-Mississippian boundary at the uppermost strata of the New Albany Shale.

Excellent discussions on the earlier reports of *Tasmanites* (20) and *Leiosphaeridia* (6) are readily available and need not be repeated here. There are two published studies of attempts to use *Tasmanites* for correlation of rock units. The first study (13) was done on subsurface samples from the Williston Basin of southwestern Manitoba. I did the second study (1). My attempt was unsuccessful mainly because the correlation was attempted over too large an area using too many formations.

This paper is the first attempt to use *Leiosphaeridia* as a stratigraphic marker. The New Albany Shale contains both *Tasmanites* and *Leiosphaeridia* but the number of *Leiosphaeridia* specimens is far greater than the *Tasmanites* specimens. In this study I found that the most significant results were obtained by concentrating on the two most common species, *Leiosphaeridia plicata* and *L. linebacki*, and excluding all other specimens. Since the other specimens in all cases totaled less than 2% of

the entire count, I do not believe their inclusion in this paper would have altered my final conclusions.

In this study, I used only one formation in a relatively small area (Fig. 2). I was fortunate to have the outcrop localities of Lineback who has spent much time in the field studying and mapping the New Albany Shale (14, 15).

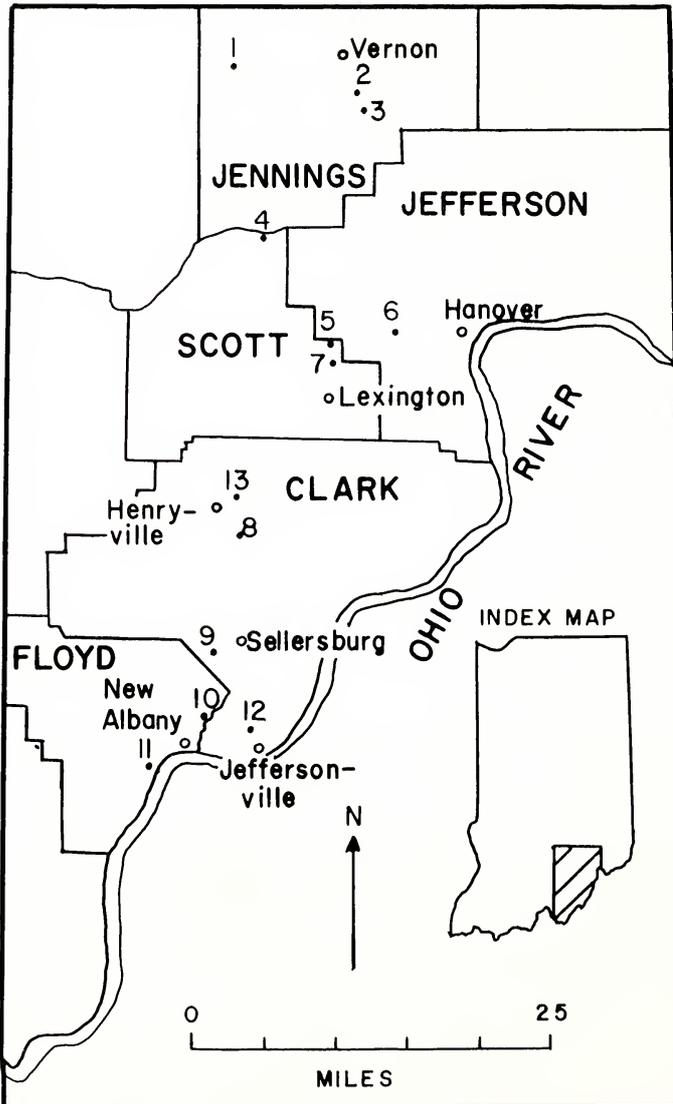


FIGURE 2. Map of southern Indiana showing collection localities.

Section Localities

Section 1 (Lineback, (14) sec. 23). Stream bank, Six-Mile Creek, T6N, R7E, sec. 11, NW $\frac{1}{4}$, Jennings Co. Morgan Trail Mbr. (top) 3 m brownish-black, fissile shale. Selmier Mbr. 2 m olive-gray to greenish-gray, blocky shale containing dolomitic septarian concretions up to 1 m in diameter.

Section 2 (Lineback (14) sec. 18). Road cut, State Highway 3, 1 mile south of Vernon, T6N, R8E, sec. 11, SE $\frac{1}{4}$, NW $\frac{1}{4}$, Jennings Co. Blocher Mbr. 2 m brownish-black, fissile shale interbedded with thin, grayish dolomitic layers.

Section 3 (Lineback (14) sec. 19). Road cut, State Highway 3, 1 $\frac{1}{2}$ miles south of Vernon, T6N, R8E, sec. 14, NE $\frac{1}{4}$, NW $\frac{1}{4}$, Jennings Co. Selmier Mbr. 2 m greenish-gray, blocky shale.

Section 4 (Lineback (14) sec. 20). Stream bank and road cut along Quick Creek, T4N, R7E, sec. 15, NE $\frac{1}{4}$, NE $\frac{1}{4}$, Scott Co. Selmier Mbr. (top) 1 m dark greenish-gray, blocky shale. Blocher Mbr. 2 m brownish-black, fissile shale.

Section 5 (Lineback (14) sec. 1). Along State Highway 56 beginning at bridge in T3N, R8E, sec. 9, SW $\frac{1}{4}$, SW $\frac{1}{4}$, thence along north line sec. 16, NW $\frac{1}{4}$, Jefferson and Scott Cos. Camp Run Mbr. 3 m brownish-black to grayish-black, fissile to blocky shale.

Section 6 (Lineback (14) sec. 11). Standard Materials Quarry, 4 miles west of Hanover, T3N, R9E, sec. 16, SW $\frac{1}{4}$, NE $\frac{1}{4}$, Jefferson Co. Morgan Trail Mbr. (top) 1 m brownish-black, fissile shale. Selmier Mbr. 1 m greenish-gray, blocky shale. Blocher Mbr. 1 m brownish-black to greenish-gray, fissile shale.

Section 7 (Lineback (14) sec. 9). Road cut State Highway 203, 1 mile northwest of Lexington, T3N, R8E, sec. 33, NW $\frac{1}{4}$, NE $\frac{1}{4}$, Scott Co. Morgan Trail Mbr. 2 m brownish-black, thinly bedded shale.

Section 8 (Lineback (14) sec. 7). Road cut State Highway 160, 3 miles southeast of Henryville, Clark Grant, lot 223, N $\frac{1}{4}$, Clark Co. Clegg Creek Mbr. 5 m brownish-black, fissile shale.

Section 9 (Lineback (14) sec. 3). Road cut State Highway 31-W, just west of Sellersburg, Clark Grant, lot 110, center southwest line, Clark Co. Clegg Creek Mbr. 6 m brownish-black to greenish-gray, fissile shale. Lineback (14) considers the lower 4 m to be the Camp Run Mbr. but the *Leiosphaeridia linebacki/L. plicata* ratio indicates the lower part is Clegg Creek (Table 1).

Section 10 (Lineback (14) sec. 13). Slate Run just west of Blackiston Mill at north edge of New Albany, Clark Grant, lot 63, Floyd Co. Camp Run Mbr. 3 $\frac{1}{2}$ m brownish-black to olive-gray, fissile shale.

Section 11 (Lineback (14) sec. 14). Falling Run, just below bridge to Silver Hills, west side of New Albany, T3S, R6E, Sec. 3, NW $\frac{1}{4}$, SE $\frac{1}{4}$, Floyd Co. New Providence Shale (top) 1 m greenish-gray, blocky shale.

Rockford Limestone $\frac{1}{4}$ m gray to brown, ferruginous limestone. Jacobs Chapel Shale $\frac{1}{10}$ m greenish-gray, glauconitic shale. Clegg Creek, Mbr. 1 m brownish-black to brownish-gray, fissile shale.

Section 12 (Lineback (14) sec. 15), Atkins Quarry, north of Jeffersonville, Clark Grant, lot 10, center southwest line, Clark Co. Morgan Trail Mbr. (top) 1 m brownish-gray, soft shale. Selmier Mbr. $\frac{1}{20}$ m greenish-gray, blocky shale. Blocher Mbr. 3 m brownish-black to brownish-gray, soft to fissile shale.

Section 13 (Lineback (14) sec. 8). Road cut, State Highway 160, $\frac{1}{2}$ mile east of Henryville, Clark Grant, lot 255, West $\frac{1}{2}$, Clark Co. Rockford Ls. (top) $\frac{8}{10}$ m light brownish-gray, fossiliferous limestone. Jacobs Chapel Bed $\frac{2}{10}$ m greenish-gray, calcareous shale. Clegg Creek Mbr. 3 m brownish-black, fissile shale.

Field and Laboratory Methods

Each outcrop was sampled vertically at 1 m intervals. The sample spacing was closer if a particular shale member was less than 1 m thick.

The samples were crushed in the laboratory with a rotary crusher. It was necessary not to crush the material too finely since the leiospheres are rather large and might be damaged. A working sample of approximately 10 g was obtained by repeatedly quartering the crushed field sample.

This laboratory sample was boiled in concentrated hydrofluoric acid (52%) for approximately 30 minutes. The residue was centrifuged and washed. Then it was placed in a 2% solution of sodium hypochlorite overnight. The residue was again centrifuged and washed, then stained in a 1% aqueous solution of methyl green. The *Tasmanites* and leiospheres usually did not take the stain. However, the amorphous, organic matter which is universally present in the shales did take the stain. The color contrast between the green-stained amorphous material and the light yellow to dark orange color of the *Tasmanites* and leiospheres made it much easier to conduct specimen counts under the microscope.

The stained material was placed in glycerine jelly and from there mounted on glass slides. A minimum of 200 grains were counted for each sample which contained fossils. The results of these counts are summarized in Table 1.

Stratigraphic Separations

Table 1 illustrates the fact that *Leiosphaeridia linebacki* and *L. plicata* are present in differing quantities in the various members of the New Albany Shale. Note that at any outcrop the *L. linebacki*/*L. plicata* ratio may vary, in some cases, over rather wide limits. However, when the specimen counts of all the exposures of a given member are averaged we arrive at a meaningful conclusion. Namely, that the Blocher, Selmier and Morgan Trail Members contain similar mean values of *L. linebacki* and *L. plicata* and it follows that the *L. linebacki*/*L. plicata* ratios fall

TABLE 1. Distribution of Leiosphaeridia species within the members of the New Albany Shale.

Member	Section	Depth (meters)	<i>Leiosphaerida linebacki</i>	Mean	<i>Leiosphaeridia plicata</i>	Mean	<i>L. linebacki/L. plicata</i>	Ratio	Range
Clegg Creek	8	Top	151		49			3.1	
		1	137		66			2.1	
		2	82		122			0.7	
	9	3	139		128			2.2	0.7-3.3
		5	101		99			1.0	
		6	96		104			1.0	
13	5	156			48		3.3		
	2	130			70		1.9		
	3	132			68		1.9		
11	2	153			47		3.3		
	5	187			13		14.4		
	1	189			11		17.2		
Camp Run	2	1	190		11		17.3		
		3	191		9		21.2		
		10	190	188	10	13		9.0-21.2	
	10	2	185			15		19.0	
		2	185			15		12.3	
		3½	180			20		9.0	
Morgan Trail	7	Top	135		65		2.1		
		1	164		36		4.6		
		6	168		32		5.3		
	12	1	185			15		12.3	
		1	190		162	20	9.5		2.1-12.3
		1	161			39		4.1	
1	Top	160			40		4.0		
	1	154			47		3.3		
	2	145			55		2.6		
Selmier	3	Top	158		44		3.6		
		1	140		78		1.8	1.8-6.7	
	4	2	153		156	48	49	3.2	
		Top	174			26		6.7	
Blocher	12	3	152		57		2.7		
		4	186		14		13.3		
	2	Top	175		160	25	41	7.0	2.1-13.3
		4	135			65		2.1	
		3	155			45		3.4	

within similar ranges. The Camp Run and Clegg Creek Members can easily be separated from each other and from the underlying members either by their difference in means or the *L. linebacki/L. plicata* ratios.

Conclusions

The significance of the differences in the means and *L. linebacki/L. plicata* ratios of some members of the New Albany Shale is that they are most likely a reflection of a portion of the changing biota of the floating algal mat which covered areas of the sea during the deposition of the New Albany Shale. Some species of *Leiosphaeridia* do have at least limited stratigraphic value within the New Albany Shale and similar studies of other black shales may prove the value of these fossils in helping stratigraphers with some of their problems in correlating various black shale exposures.

Systematic Descriptions

Group Acritarcha Evitt 1963
Subgroup Sphaeromorphitae
Downie, Evitt, and Sarjeant 1963
Genus *Leiosphaeridia*
Eisenack 1958

Leiosphaeridia plicata Felix 1965
Figure 3, Illustrations 4 and 5

Diagnosis: Spherical to subspherical. Diameter 100-(110-225)-245 μ (50 specimens measured) 96% of measured specimens are in the size range 110-225 μ . Wall thickness 3-7 μ . Surface laevigate with no pylome or pores. Wall often, but not always, folded. Lunate folds common on thinner walled specimens. Straight or slightly sinuous folds common on thicker walled specimens.

Remarks: Felix (11) found *L. plicata* in Neogene age sediments of southern Louisiana. This would indicate an extremely long time span for the species. There is a possibility that Felix (11) was working with reworked specimens. Another possibility is that the New Albany *L. plicata* are not the same species as the Louisiana *L. plicata* but resemble each other due to convergence. Speciation within the leiospheres is difficult since they have so few diagnostic characters.

Felix did note that of the hundreds of specimens he observed only one was larger than 200 μ . It was 245 μ . Felix gives a size range of 120-200 μ for the Louisiana specimens. The Indiana material extends this range slightly. However, I do not feel the great age range or slightly different size range is sufficient to believe the Indiana specimens are a different species than *L. plicata*. *Leiosphaeridia plicata* is similar in many respects to *Tasmanites plicatilis* Boneham 1967 which I have found in the Upper Devonian black shales of Michigan, Ohio, and Ontario (1). The size range and lunate-shaped wall folds are similar. However, *T.*

plicatilis has wall pores, the diagnostic feature which separates the two genera *Tasmanites* and *Leiosphaeridia*.

Leiosphaeridia linebacki sp. n.

Figure 3, Illustrations 1-3

Diagnosis: Spherical to subspherical. Diameter 35-(40-90)-95 μ (50 specimens measured) 96% of measured specimens are within the size range 40-90 μ . Wall thickness ca. 1 μ . Surface laevigate with no pylome or pores. Wall often but not always, folded. Folds straight or slightly sinuous.

Remarks: Most of the specimens of *L. linebacki* are easily distinguished from *L. plicata* by their size difference. However, there is some suggestion of an intergradational population since the largest specimens of *L. linebacki* outwardly resemble the smallest specimens of *L. plicata* if the latter have sinuous rather than lunate folds. However, there is a distinct size difference between the two species. *L. linebacki* is distinguished from *L. ralla* Felix mainly by a size difference. *L. ralla* has a diameter of 87-100 μ and a wall thickness of 1-3 μ . *L. linebacki* is distinguished from *L. tenuissima* Eisenack by the diameter, the latter has a diameter of ca. 100 μ . Eisenack (9) shows figures of *L. tenuissima* that are somewhat larger than 100 μ . Also *L. tenuissima* has lunate folds

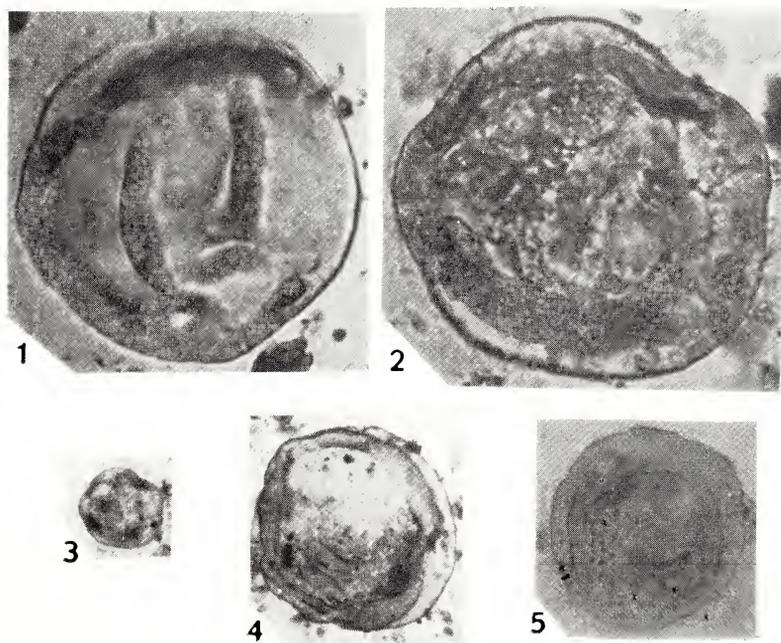


FIGURE 3. 1) *Leiosphaeridia linebacki*, holotype, $\times 900$, IU 12129G40/2; 2) *L. linebacki*, $\times 900$, IU 12129J26/0; 3) *L. linebacki*, $\times 200$, IU 12129J26/0; 4) *L. plicata*, $\times 200$, IU 12130J26/3; 5) *L. plicata*, $\times 200$, IU 12131Y29/3. (All slides are deposited with the Department of Geology, Indiana University, Bloomington. Individual figures are located on a given slide using an England Finder Slide.)

which is not the case with *L. linebacki*. The size of *L. linebacki* is similar to *Tasmanites decorus* Boneham from the Devonian black shales of Michigan, Ohio and Ontario. However, *T. decorus* has wall pores. *L. linebacki* bears a close resemblance to *Leiosphaeridia (Protoleiosphaeridium) major* (Staplin) Downie and Sarjeant 1963. *L. major* (Staplin) (18) has a more restricted size range (55-85 μ) and is relatively thick walled. These two differences lead me to believe that *L. major* and *L. linebacki* are two distinct species.

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