Neuropteris Ovata in Lacustrine Facies Sequence below Raben Branch Member (Patoka FM.) at St. Wendel, Indiana and Related Carboniferous Reconnoissance Investigations

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Coal, Flora and Carboniferous Strata in Posey County, Indiana 1837-1937, Reconnoissance Investigations

Efforts to describe the Pennsylvanian age coal floras of Posey County were initiated simultaneously with the European's early descriptions of their Carboniferous floras. Most of the early research was written by Continental and British naturalists. F.B. Schlotheim (1804), E.T. Artis (1833), J. Lindley and W. Hutton (1831), and H.T. Witham (1833) produced some of the earlier monographs describing the coal floras. "Histoire des Vegetaux Fossiles," by A. Brongniart (1828) became perhaps the most significant of these monographs to influence the development of early Amerian coal flora classifications. Professor Leo Lesquereux published the first extensive account of North American coal floras (1878-1880) in which Brongniart's division fo the genus *Neuropteris*, "*Nevropteris*" into species was strongly disputed. Lesquereux having not seen the European type specimens erroneously identified many new species of *Neuropteris*; although this event inspired later insight into the natural groupings of pinnule forms and weaknesses of the form genera convention used for foliage classification. Authors have resolved some of the ambiguity created by Lesquereux while others have further added to it. Investigation of the Raben Branch coal flora is based on pinnule form and vennation pattern.

Traditionally investigations of the coal floras described the locations and general stratal horizons where the floras were found. Classical Nineteenth Century concepts in dynamical and historical geology, foundations of today's discipline, which evolved from the institutions of British and Continental geologists were soon imparted to North America by David Dale Owen, M.D. and gentlemen colleagues at New Harmony, Indiana. In conformity to an order of the Indiana Legislature, David Dale Owen, M.D., State Geologist conducted a geological reconnaissance of the state of Indiana in 1837, (Owen, D. 1859, p. 5-8) in which a description of Posey County included the ridge between Big Creek and the Ohio River and the "Succession" in the hills at the New Harmony "Cutoff" along the Wabash River.

D.D. Owen (1859, Second Part. p. 14) in a continuation of report presented a table illustrating the chronological succession of sedimentary or aqueous rocks including the Coal Measures. Also included in the report Coal Measures of Indiana, written by Prof. Leo Lesquereux (1859, Second part. p. 296) were references to coal floras at Big Creek, Blairsville, and Rush Creek. A translation of A. Brongniart's classification for foliage in the coal floras was included (Lesquereux, L. 1859, Second Part. p. 352).

Following his geological reconnaissance of the State of Indiana in 1837, David Dale Owen was appointed United States Geologist, and the Headquarters of the United States Geological Survey was located in New Harmony for the proceeding seventeen years (Wilson, W. 1964. p. 199).

David Owen (1843, p. 336-337) described lycopod trunks from Posey County as "fossil palm trees." Sir Charles Lyell (1849, p. 272) and D.D. Owen described "an upright Sigillarian tree" and growth floor in shale which they excavated on the ridge near Blairsville (Figure 1). D.D. Owen (1856) acting as Principal Geologist for the Commonweath of

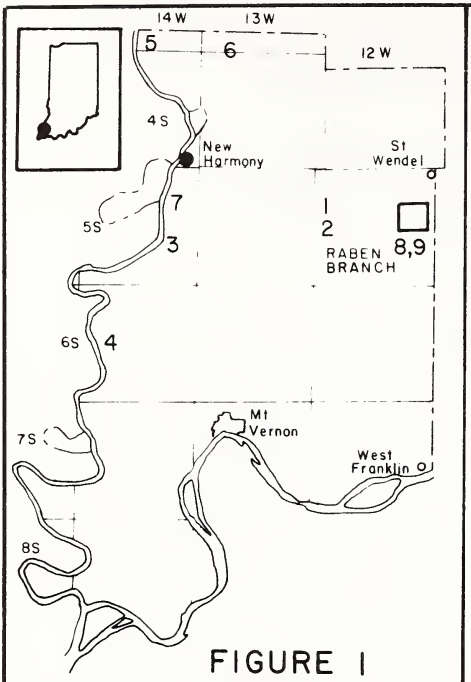

FIGURE 1

RABEN BRANCH COAL FLORA LOCATION AND STRATIGRAPHY IN POSEY CO., INDIANA

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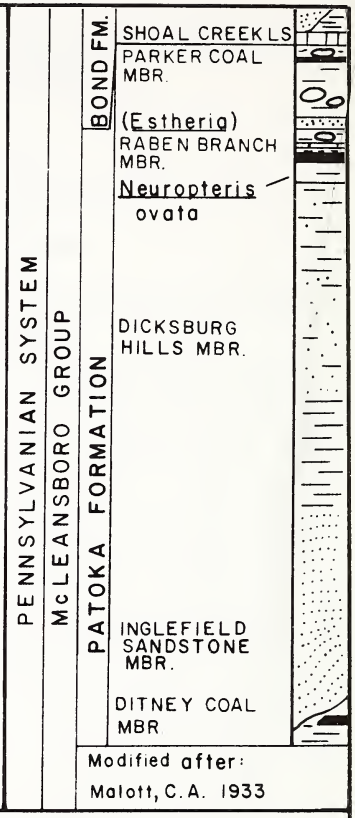


1. Fossil palm trees . D. D. Owen (1843)
2. Coal floras. C. Lyell (1849)
3. Rush Creek. L. Lesquereux (1862)
4. Big Creek . L. Lesquereux (1862)
5. Grayville Bluff. L. Lesquereux (1862)
6. Mumford Hills. L. Lesquereux (1862)
7. Cuttoff. J. Sampson collection.
8. Locality 39. W. J. Jongmans (1937) Neuropteris ovata at Raben Branch.
9. Coal balls. J. Hall (1952)

Kentucky reported on a geological survey in Kentucky made in the years 1854-1855. The Carthage Limestone (Parker Limestone Indiana equivalent) across the Ohio River (1856, p. 60). D.D. Owen (1856, p. 537) included a Paleontological Report of the Fossil Flora of Coal Measures of the Western Kentucky Coal Field by L. Lesquereux. *Neuropteris* flexuosa and *Neuropteris* tenuifolia were described from strata associated with the No. 5 coal at the Mulford mines in Union County, Kentucky.

Colonel Richard Dale Owen, M.D. State Geologist (1862) published a report of a Geological Reconnaissance of Indiana made during 1859 and 1860 by D.D. Owen. In-

cluded was a Report on the Distribution of the Geological Strata in the Coal Measures of Indiana (1862, p. 292-296) by Prof. L. Lesquereux describing coal floras at outcrops in Posey County at Rush Creek near its entry to the Wabash River two miles south of New Harmony. *Neuropteris* hirsuta and *Pecopteris* polymorphia were abundant there.

L. Lesquereux and A.H. Worthen (1866, v. 2. p. 429) refer to *Pecopteris* and *Neuropteris* from Murphysboro, Illinois that were collected by Mr. James Sampson of New Harmony.

E.T. Cox (1876, p. 251) referred to "the Merom sandstone" of former reports ranging through Indiana from Sullivan through Vanderburgh and Posey Counties.

J. Collett (1884, p. 64-65) reported on the status of coal floras collecting at Rush Creek which by then had been sufficiently extensive to cause the permanent inundation of the out-crop. The coal flora there was abundant and well preserved, although the matrix underclay when excavated from under the water deteriorated quickly as it dried. Specimens from Rush Creek were soon displayed in the cabinets of gentlemen collectors throughout the world. The extensive collections of Mr. James Sampson from the Rush Creek location are displayed at the Workingmen's Institute in New Harmony, founded in 1838 by William Maclure, as well as his collections from the New Harmony "Cutoff" and the equivalent strata exposed at Grayville, Illinois along the Wabash River.

Through the turning of the Century D.D. Owen's and R.D. Owen's successors in the Indiana Geological Survey focused on a more intense reconnaissance dividing and naming the stratal formations and describing the Indiana physiography. The newer stratigraphic divisions for the Carboniferous strata and physiographic descriptions for Posey County and adjacent areas appeared in the Patoka Quadrangle: U.S.G.S. Atlas Folio No. 105, prepared by M.L. Fuller and F.G. Clapp (1904). Their columnar section illustrated the Ditney formation, Inglefield formation, and the Wabash formation with the Parker coal at its base; in succession within the Carboniferous System.

Numerous subsurface borings for coal, brine, and other minerals in southwestern Indiana, recorded during Owen's tenure, revealed the general basin structure and the Patoka Quadrangle Atlas listed reference elevations. One of the earliest detailed structural maps in the area was drawn from an altimeter survey by R.R. Schrock and C.A. Malott (1929, p. 1302-1304) based on the West Franklin Limestone Formation. Malott (1922, p. 59-256) named the Wabash Lowland physiographic division and described the valley features.

Embellishing the descriptions of the glacial features and deposits in the Wabash Valley of Southwestern Indiana found in the previously cited works. M.M. Fidlar (1933) described the "hills of circumalluviation" in the region. This physiographic feature consists of areas of bedrock hills in the Merom sandstone overlying the West Franklin Limestone which are buried or nearly covered with Quaternary age unconsolidated loess and sands.

C.A. Malott (1933) compiled a structure map of the St. Wendels area in Vanderburgh and Posey Counties Indiana based on the *Estheria* zone and coal streak below the Parker Coal formation. These outcrops (Figure 2) were traced through the headland tributaries of Big Creek including Raben Branch, Clair Creek, and Luigs Creek where structural closures have defined several commercial oil fields.

W.J. Jongmans (1937, p. 417-422) remarked on specimens of *Neuropteris* ovata in the American Carboniferous stating this as an indicator for the Westphalian D unit of Saar-Lorraine basin and illustrated several specimens from "Location 39" one-half mile south of St. Wendel. Other genera and species including *Pecopteris* proliferatus were stated to mark the upward transition to the lower Stephanian.

C.A. Malott (1939) named the Hazelton Bridge Formation in Gibson County and surrounding area. The Hazelton Bridge Formation succeeds the Inglefield sandstone and lies below the massive portion of the Dicksburg Hills sandstone (Malott, C.A. 1947) exposed in the bedrock hills of Posey County and adjacent area in southwestern Indiana.

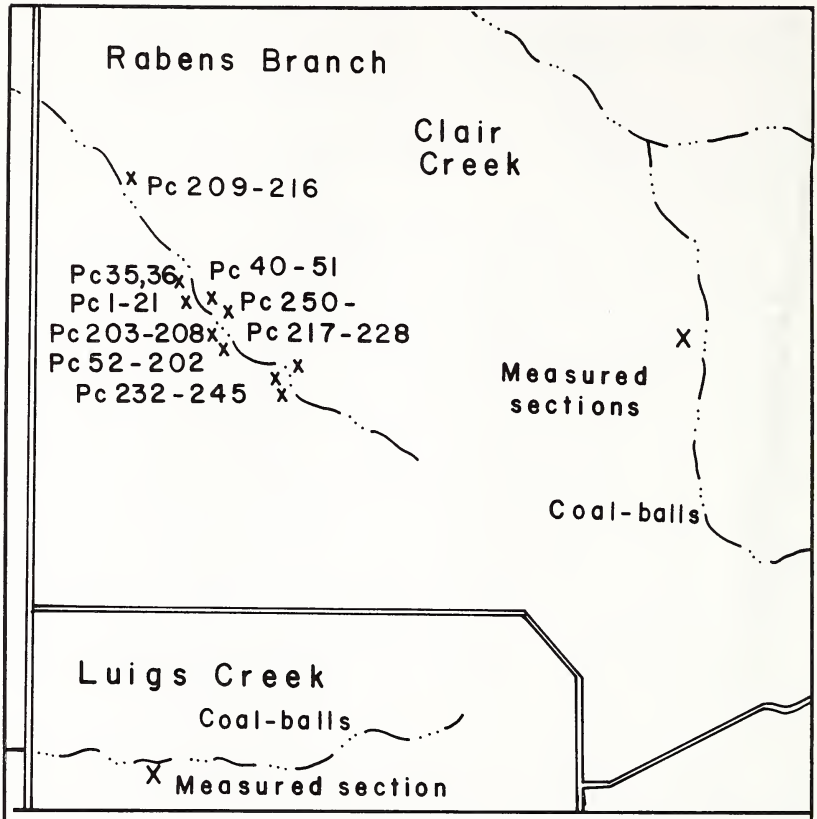
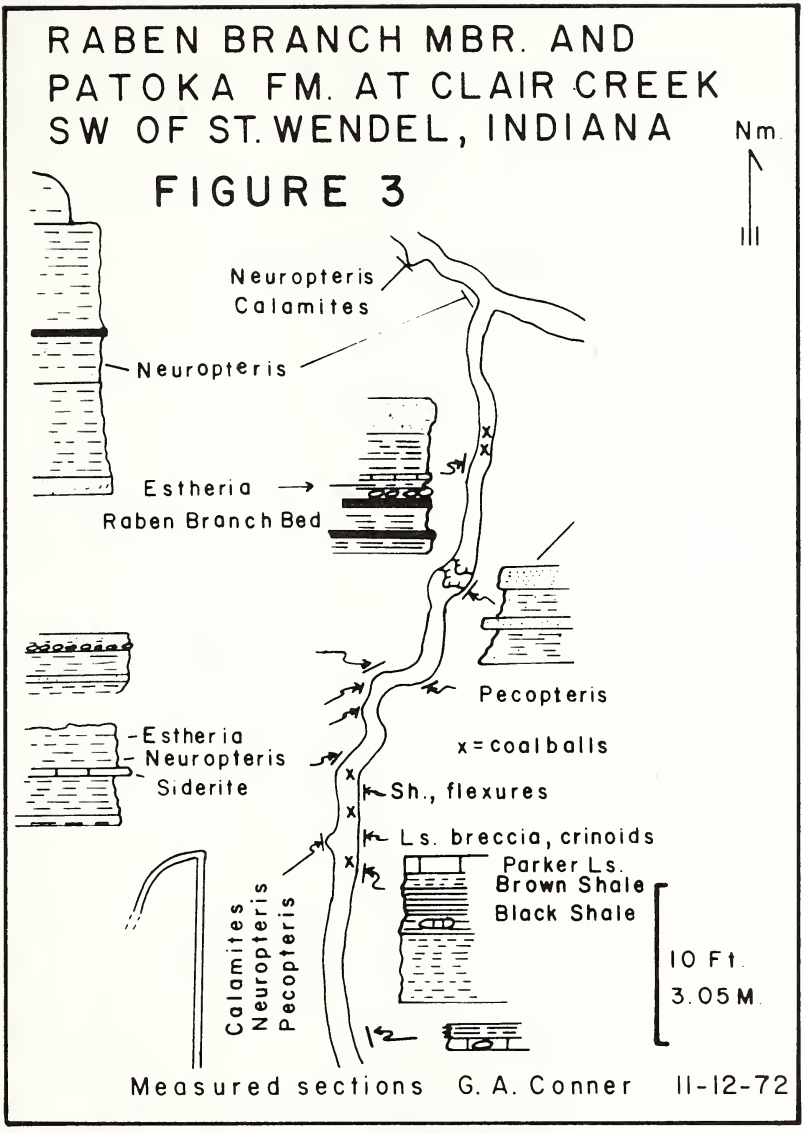


Figure 2. Raben Branch area SW of St. Wendel in Posey Co., Indiana

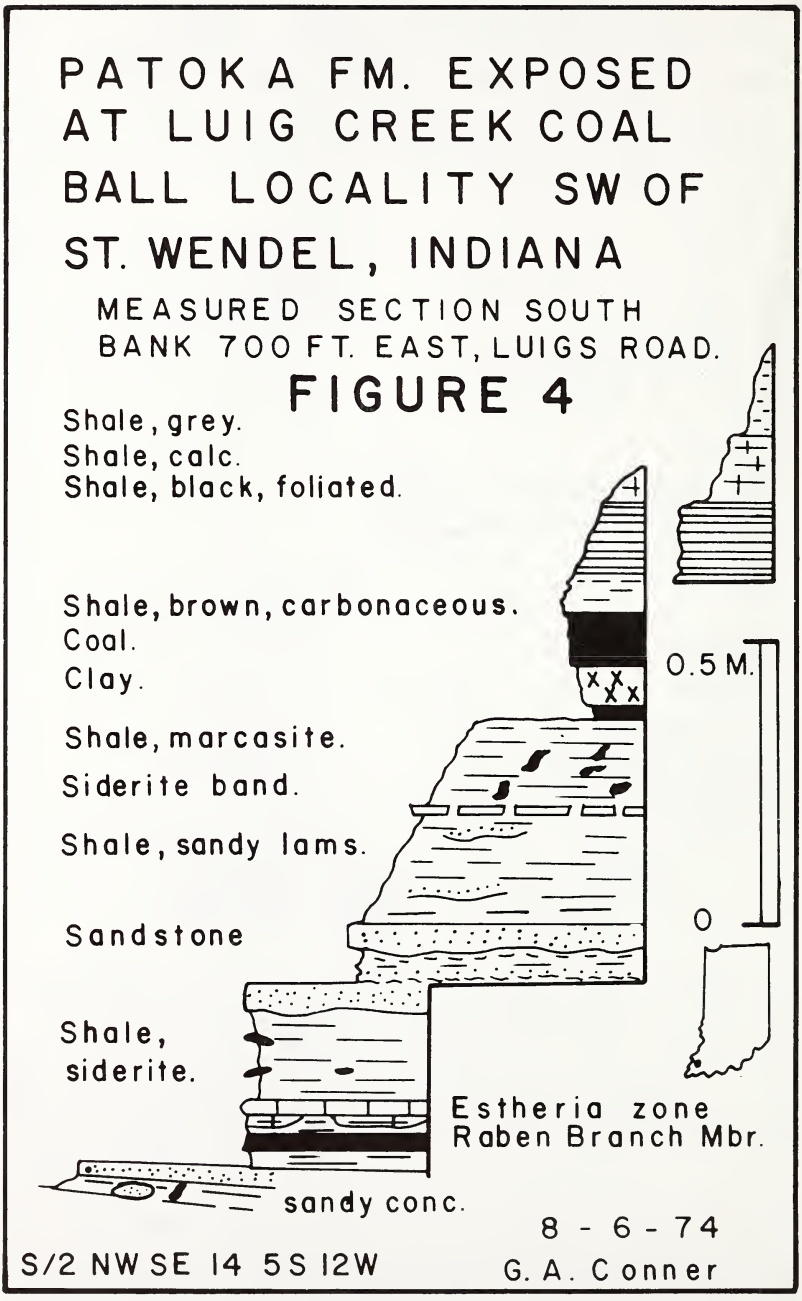
The Raben Branch bed within the Parkers Formation was named by C. Malott (1947, p. 131-132) including a thin coal streak four or six cm. thick, overlain by a ferrous carbonate band less than two cm. thick and containing *Estheria* exposed at Raben Branch the type section. Further this bed is located approximately six meters below the Parkers Coal and black shale overlain by the Parker Limestone (Carthage Limestone of Kentucky or Shoal Creek Limestone of Illinois). The stratigraphic column in (Figure 1) is essentially from Malott's unpublished contour map. J.W. Hall (1952, p. 763-768) described phloem cells in *Heterangium* americanum from a coal ball petrifaction at an exposure near St. Wendel, Indiana. This locality appears to be along the channel of Clair Creek east of Raben Branch (Figure 2).

Stratal succession of coal floras in a Constructional Deltaic and Lacustrine Sequence associated with the Raben Branch Member

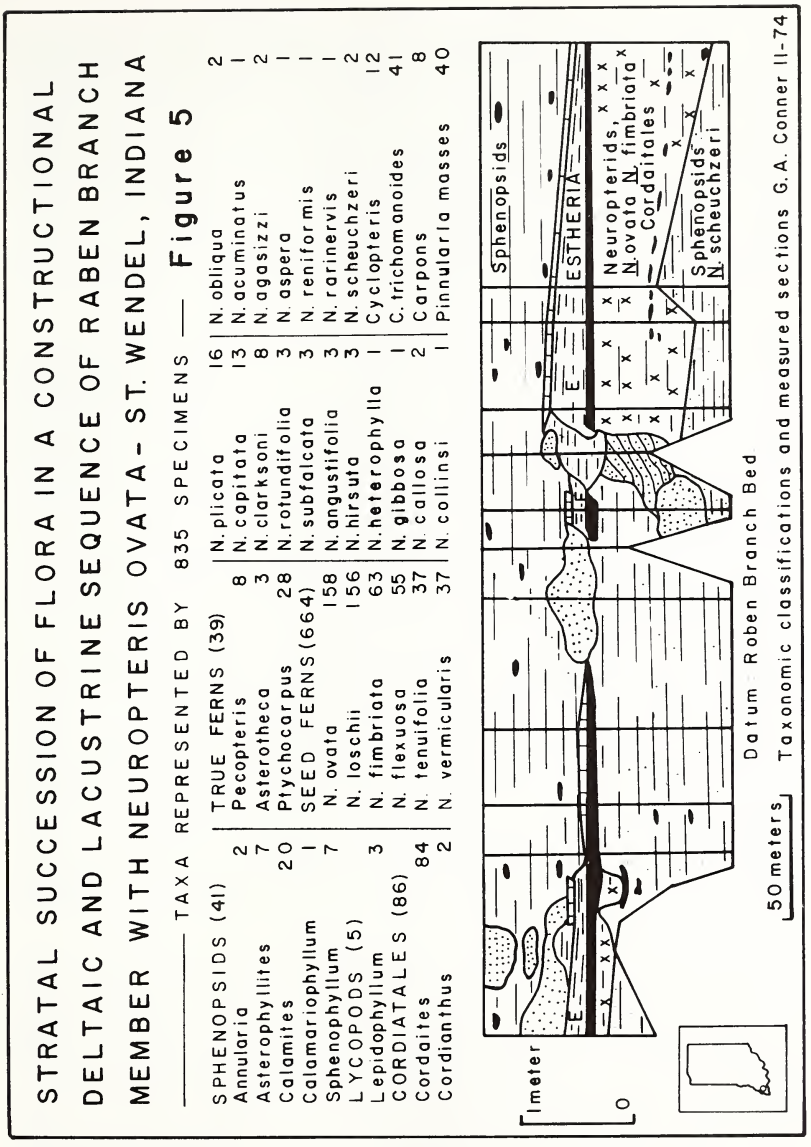
Coal flora was collected from Luig Creek (Figure 3), Clair Creek (Figure 4), and Raben Branch in 1967 recording the stratal position of genera in a seven meter interval



between the Parker Coal and the upper Dicksburg Hills sandstone. Collections from Raben Branch included five cubic meters of shale from in-situ excavations one to three meters long, one-half to one meter wide, and less than one meter in stratal depth. The entire stratigraphic interval ranges one meter above to one meter below the Raben Branch Bed. Allochthonous flora is preserved as carbon compressions lying parallel to stratification revealing no evidence of a growth floor.



A northwest facing measured profile along Raben Branch (Figure 5) extends 450 meters southeast from Luigs Road. The stratal succession of floras is illustrated in the



constructional deltaic and lacustrine facies sequence described in ascending order. Light gray shales and sandy micaceous shales of the upper Dicksburg Hills Member contain predominantly Sphenospid stems, foliage fragments, and few spore bearing structures. Genera include *Calamites* cisti, *C.* suckowi, *Calamariophyllum*, *Calamostachys*, *Paleostachys*, *Sphenophyllum*, and *Asterophyllites*. True Ferns present are *Pecopteris* and *Ptychocarpus* unitus. The Seed Fern foliage population is generally limited to the larger pinnules of *Neuropteris* scheuchzeri and that group including *N.* hirsuta and *N.*

clarksoni. These sandy shale facies are interpreted as alluvial levee and channel margin deposits. The succeeding lithologic unit is a shale composed of bluish clay in contrast to the Dicksburg Hills sandy shales. This shale is weakly laminated with shows of fissility in the lower half. A ten centimeter zone of lenticular ferruginous nodules separates the lower half from the non-laminated upper half which resembles an underclay. The entire blue clay shale where present varies from a few centimeters to a maximum of two meters in thickness. This unit is interpreted as a lacustrine facies, possibly the middle or lower end of a lake delta. Flora extends through the entire thickness of the unit including the lenticular nodule zone. The list of genera and species in Figure 5 indicate a ubiquitous Seed Fern population of neuropterid fronds with *Ptychocarpus* unitus representing the True Ferns. *Cordaites* foliage is common and finely dismembered masses of *Pinnularia* are disseminated throughout the unit. Sphenopsids and Lycopods are absent in this shale. The Raben Branch Bed overlying this shale appears as a thin bright band or smut streak of coal generally six centimeters thick. Some partings reveal Sphenopsid stem compressions, neuropterid pinnules, and *Cordaites* segments. The *Estheria* zone lies above the coal. This zone includes a gray fissle shale 1 to 30 centimeters thick weathered in recess below a two centimeter orange band of ferruginous shale frequently jointed. The gray shale and ferruginous band contain abundant specimens of *Estheria*, a freshwater conchostrican. The valves are well preserved with a high lustre. *Calamites* cisti impressions occur on the lower surface of the ferruginous band.

Laminar and cross laminar constructional channel and levee facies laterally equivalent with the lacustrine neuropterid shale, Raben Branch bed, and *Estheria* zone contain abundant Sphenopsid stems and foliage fragments. This interval includes a silty gray shale and a lighter gray cross laminated micaceous sand. Laminations are generally three millimeters thick. Foliage fragments in the shale are sparse. *Calamites* cisti and *C.* suckowi in the sand occur in horizontal and vertical orientation without association to root structures. Overlying both sandy micaceous facies and the *Estheria* zone with a conformable contact is a gray clayey and silty shale bearing frequent flexure joints. Foliage in this unit is sparse, occurring in limonitic and hematitic nodules. Specimens of *Pecopteris*, *Ptychocarpus*, *Calamites*, *Calamariophyllum*, and *Lepidodendron* were found in proximity to yellow stained nodules containing pyritic valves of *Nucula* a brackish or freshwater pelecypod. These latter nodules were black in the interior resembling argillaceous carbonate bands associated with the Parker Limestone exposed farther upstream. This shale unit is variable in thickness in the area with truncation surfaces prior to deposition of the St. Wendel sandstone.

The five cubic meters of in-situ shale collected from Raben Branch contained 835 plant fragments excluding numerous pieces too small for practical identification. These were all taken from the two meter interval described, and contained taxa with identifications based upon the following classifications: L. Lesquereux's Coal Atlas, Adolph Brongniart's l'Histoire des Vegetaux Fossiles, and Gothan and Remy's Steinkohlenpflanzen. References to grouping together of different *Neuropteris* species based on similarities is in general agreement with W. Darrah's Critical Review of Pennsylvanian floras in the eastern United States. Representation of the five major plant groups found at Raben Branch (Figure 5), includes 41 Sphenopsides, 5 Lycopods, 86 Cordaitales, 39 True Ferns, and 664 Seed Ferns including 8 Carpons.

Variation of pinnule form and vennation in Neuropteris ovata and related species at Raben Branch

Pinnule dimorphism within a second order frond rachis, and more than 18 species of the arborescent Seed Fern *Neuropteris* is observed in specimens from the blue shale below the Raben Branch Bed.

Neuropteris ovata Hoffman, *N.* loschii Brongniart, and *Neuropteris* fimbriata are the dominant specis. *N.* fimbriata occurs in a variety of pinnule forms in basal, lateral, and terminal positions on the rachis. *Cylcopteris* trichomanoides is common as a basal pinnule with fimbriate margins. Several fronds illustrate a variety of pinnatification stages of pinna along a secondary rachis. *N.* vermicularis pinnules are opposite *N.* flexuosa. *Neuropteris* subfalcata shows variations in pinnule morphology of the basal auricle. Several specimens of mixoneurid vennation and uncommon variations of terminal pinnules and cardioid basal pinnules appear on a rachis of *N.* ovata. These suggest a transition modification precursory to the final stages of Westphalian E or early Stephanian neuropterids of the Cantabrien and Saar-Lorraine Basins of Europe.

Facies association and depositional sequences

All of these specimens together in the assemblage of the blue lacustrine shale indicate an abrupt change from the underlying Dicksburg Hills Member with detached large pinnules of *N.* scheuchzeri and *N.* hirsuta in a predominately Sphenopsid stem population. Numerous exposures of the Dicksburg Hills Member and underlying Inglefield Member on the Kasson and West Franklin Quadrangles examined in detail reveal occurrences of *N.* scheuchzeri pinnules with numerous *Calamites* and *Lepidodendron* casts and compressions. The reason for this abrupt occurrence of neuropterids in the Raben Branch coal flora must be related to preservation in a somewhat unique lithology and depositional environment of rapid preservation and lower energies than persisted in the sandy facies below. Perhaps in a more upland area than was common for the preceding coal floras in the region. Recalling D.D. Owen's and Charles Lyell's observation of Lycopod forest floors in the shales of Big Creek several kilometers west and downdip from Raben Branch, these beds are probably from the cyclothemic sequence which followed the St. Wendel sandstone in the area. Foliage inventories were not described probably because foliage was weathered before burial of the growth floor. The closest evidence for a Medullosan growth floor for the neuropterids at Raben Branch lies perhaps two to three meters below the Parker Coal where *Psaronious* rootlets occur in coal-ball petrifications, but this indication is of a later floor than that associated with the blue shale. Consequently it is agreeable to infer that the medullosan growth floor above the blue lacustrine shale was destroyed or lies some distance away in the facies sequence not exposed. Remarkably, what may be the most prolific deposit of neuropterids in Indiana occurs 100 meters above the unnamed shale Member of the Shelburn Formation of Indiana investigated by R. Pheifer (1979) whose thesis included identification of more than 12,000 specimens of coal flora including only several species of neuropterids. There is a different lithological character as well as depositional sequences and thicknesses in the cyclothems of Illinois Basin below and above the base of the Conemaugh. Coal flora descriptions of these younger units are few however the frequency of neuropterids in the coal and clay below the Cuttoff sandstone below New Harmony suggests another deposit similar to Raben Branch with a similar depositional sequence. During 1974 approximately 50 specimens of *Neuropteris* ovata, *N.* hirsuta, *N.* scheuchzeri, and *N.* fimbriata were collected from below the coal at the Cuttoff. *N.* ovata showed a slightly more robust lateral pinnule form than those at Raben Branch 12 miles due east. The position of this coal above the Raben Branch Bed is by estimation 80 meters; and is 180 meters above the base of the Conemaugh Series in Indiana. The relation to the Raben Branch Bed was determined using the West Franklin and Parker limestones as reference on electrical resistivity logs and noting displacement along the New Harmony Fault. The relation of the Cuttoff sandstone described by D.D. Owen (Owen, D.D. 1859, p. 6) to the upper Conemaugh units exposed in Indiana, Illinois, and Western Kentucky has not been demonstrated with certain precision for several reasons. Further stratigraphic in-

vestigations of these upper Conemaugh strata and comparison of the Raben Branch coal flora to the upper Westphalian and lower Stephanian throughout the Euramerican province are in progress. All specimens from Raben Branch to be published in descriptions are housed in the Indiana University Paleobotany Collections in Bloomington, Indiana.

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