DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 98

FLORA OF THE OUTLYING CARBONIFEROUS BASINS OF SOUTHWESTERN MISSOURI.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1893

LIBRARY CATALOGUE SLIPS.

United States. *Department of the interior.* (*U. S. geological survey.*)
Department of the interior | — | Bulletin | of the | United States | geological survey | no. 98 | [Seal of the department] |
Washington | government printing office | 1893

Series title.

Second title: United States geological survey | J. W. Powell, director | — | Flora | of the | outlying Carboniferous basins | of | southwestern Missouri | by | David White | [Vignette]
Washington | government printing office | 1893
8°. 139 pp. 5 pl.

White (David).
United States geological survey | J. W Powell, director | — | Flora | of the | outlying Carboniferous basins | of | southwestern Missouri | by | David White | [Vignette] |
Washington | government printing office | 1893
8° 139 pp. 5 pl.
[UNITED STATES. *Department of the interior.* (*U. S. geological survey.*) Bulletin 98].

Author title.

Title for subject entry.

United States geological survey | J. W. Powell, director | — | Flora | of the | outlying Carboniferous basins | of | southwestern Missouri | by | David White | [Vignette] |
Washington | government printing office | 1893
8°. 139 pp. 5 pl.
[UNITED STATES. *Department of the interior.* (*U. S. geological survey.*) Bulletin 98].

ADVERTISEMENT.

[Bulletin No. 98.]

The publications of the United States Geological Survey are issued in accordance with the statute approved March 3, 1879, which declares that—

"The publications of the Geological Survey shall consist of the annual report of operations, geological and economic maps illustrating the resources and classification of the lands, and reports upon general and economic geology and paleontology. The annual report of operations of the Geological Survey shall accompany the annual report of the Secretary of the Interior. All special memoirs and reports of said Survey shall be issued in uniform quarto series if deemed necessary by the Director, but otherwise in ordinary octavos. Three thousand copies of each shall be published for scientific exchanges and for sale at the price of publication; and all literary and cartographic materials received in exchange shall be the property of the United States and form a part of the library of the organization; and the money resulting from the sale of such publications shall be covered into the Treasury of the United States."

On July 7, 1882, the following joint resolution, referring to all Government publications, was passed by Congress:

"That whenever any document or report shall be ordered printed by Congress, there shall be printed, in addition to the number in each case stated, the 'usual number' (734) of copies for binding and distribution among those entitled to receive them."

Except in those cases in which an extra number of any publication has been supplied to the Survey by special resolution of Congress or has been ordered by the Secretary of the Interior, this office has no copies for gratuitous distribution.

ANNUAL REPORTS.

I. First Annual Report of the United States Geological Survey, by Clarence King. 1880. 8°. 79 pp. 1 map.—A preliminary report describing plan of organization and publications.

II. Second Annual Report of the United States Geological Survey, 1880–'81, by J. W. Powell. 1882. 8°. lv, 588 pp. 62 pl. 1 map.

III. Third Annual Report of the United States Geological Survey, 1881–'82, by J. W. Powell. 1883. 8°. xviii, 564 pp. 67 pl. and maps.

IV. Fourth Annual Report of the United States Geological Survey, 1882–'83, by J. W. Powell. 1884. 8°. xxxii, 473 pp. 85 pl. and maps.

V. Fifth Annual Report of the United States Geological Survey, 1883–'84, by J. W. Powell. 1885. 8°. xxxvi, 469 pp. 58 pl. and maps.

VI. Sixth Annual Report of the United States Geological Survey, 1884–'85, by J. W. Powell. 1885. 8° xxix, 570 pp. 65 pl. and maps.

VII. Seventh Annual Report of the United States Geological Survey, 1885–'86, by J. W. Powell. 1888. 8°. xx, 656 pp. 71 pl. and maps.

VIII. Eighth Annual Report of the United States Geological Survey, 1886–'87, by J. W. Powell. 1889. 8°. 2 v. xix, 474, xii pp. 53 pl. and maps; 1 p. l., 475–1063 pp. 54–76 pl. and maps.

IX. Ninth Annual Report of the United States Geological Survey, 1887–'88, by J. W. Powell. 1889. 8°. xiii, 717 pp. 88 pl. and maps.

X. Tenth Annual Report of the United States Geological Survey, 1888–'89, by J. W. Powell. 1890. 8°. 2 v. xv, 774 pp. 98 pl. and maps; viii, 123 pp.

XI. Eleventh Annual Report of the United States Geological Survey, 1889–'90, by J. W. Powell. 1891. 8°. 2 v. xv, 757 pp. 66 pl. and maps; ix, 351 pp. 30 pl.

XII. Twelfth Annual Report of the United States Geological Survey, 1890–'91, by J. W. Powell. 1891. 8°. 2 v. xiii, 675 pp. 53 pl. and maps; xviii, 576 pp. 146 pl. and maps.

XIII. Thirteenth Annual Report of the United States Geological Survey, 1891–'92, by J. W. Powell, 1893. 8°. 3 v.

MONOGRAPHS.

I. Lake Bonneville, by Grove Karl Gilbert. 1890. 4°. xx, 438 pp. 51 pl. 1 map. Price $1.50.

II. Tertiary History of the Grand Cañon District, with atlas, by Clarence E. Dutton, Capt. U. S. A. 1882. 4°. xiv, 264 pp. 42 pl. and atlas of 24 sheets folio. Price $10.00.

III. Geology of the Comstock Lode and the Washoe District, with atlas, by George F. Becker. 1882. 4°. xv, 422 pp. 7 pl. and atlas of 21 sheets folio. Price $11.00.

IV. Comstock Mining and Miners, by Eliot Lord. 1883. 4°. xiv, 451 pp. 3 pl. Price $1.50.

V. The Copper-Bearing Rocks of Lake Superior, by Roland Duer Irving. 1883. 4°. xvi, 464 pp. 15 l. 29 pl. and maps. Price $1.85.

VI. Contributions to the Knowledge of the Older Mesozoic Flora of Virginia, by William Morris Fontaine. 1883. 4°. xi, 144 pp. 54 l. 54 pl. Price $1.05.

VII. Silver-Lead Deposits of Eureka, Nevada, by Joseph Story Curtis. 1884. 4°. xiii, 200 pp. 16 pl. Price $1.20.

VIII. Paleontology of the Eureka District, by Charles Doolittle Walcott. 1884. 4°. xiii, 298 pp. 24 l. 24 pl. Price $1.10.

IX. Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey, by Robert P. Whitfield. 1885. 4°. xx, 338 pp. 35 pl. 1 map. Price $1.15.

X. Dinocerata. A Monograph of an Extinct Order of Gigantic Mammals, by Othniel Charles Marsh. 1886. 4°. xviii, 243 pp. 56 l. 56 pl. Price $2.70.

XI. Geological History of Lake Lahontan, a Quaternary Lake of Northwestern Nevada, by Israel Cook Russell. 1885. 4°. xiv, 288 pp. 46 pl. and maps. Price $1.75.

XII. Geology and Mining Industry of Leadville, Colorado, with atlas, by Samuel Franklin Emmons. 1886. 4°. xxix, 770 pp. 45 pl. and atlas of 36 sheets folio. Price $8.40.

XIII. Geology of the Quicksilver Deposits of the Pacific Slope, with atlas, by George F. Becker. 1888. 4°. xix, 486 pp. 7 pl. and atlas of 14 sheets folio. Price $2.00.

XIV. Fossil Fishes and Fossil Plants of the Triassic Rocks of New Jersey and the Connecticut Valley, by John S. Newberry. 1888. 4°. xiv, 152 pp. 26 pl. Price $1.00.

XV. The Potomac or Younger Mesozoic Flora, by William Morris Fontaine. 1889. 4°. xiv, 377 pp. 180 pl. Text and plates bound separately. Price $2.50.

XVI. The Paleozoic Fishes of North America, by John Strong Newberry. 1889. 4°. 340 pp. 53 pl. Price $1.00.

XVII. The Flora of the Dakota Group, a posthumous work, by Leo Lesquereux. Edited by F. H. Knowlton. 1891. 4°. 400 pp. 66 pl. Price $1.10.

XVIII. Gasteropoda and Cephalopoda of the Raritan Clays and Greensand Marls of New Jersey, by Robert P Whitfield. 1891. 4°. 402 pp. 50 pl. Price $1.00.

XIX. The Penokee Iron-Bearing Series of Northern Wisconsin and Michigan, by Roland D. Irving and C. R. Van Hise. 1892. 4°.

XX. Geology of the Eureka District, Nevada, with atlas, by Arnold Hague. 1892. 4°. 419 pp. 8 pl.

In press:

XXI. The Tertiary Rhynchophorous Coleoptera of North America, by Samuel Hubbard Scudder.

XXII. A Manual of Topographic Methods, by Henry Gannett, chief topographer.

XXIII. Geology of the Green Mountains in Massachusetts, by Raphael Pumpelly, J. E. Wolff, T. Nelson Dale, and Bayard T. Putnam.

In preparation:

— Mollusca and Crustacea of the Miocene Formations of New Jersey, by R. P. Whitfield.
— Sauropoda, by O. C. Marsh.
— Stegosauria, by O. C. Marsh.
— Brontotheridæ, by O. C. Marsh.
— Report on the Denver Coal Basin, by S. F. Emmons.
— Report on Silver Cliff and Ten-Mile Mining Districts, Colorado, by S. F. Emmons.
— The Glacial Lake Agassiz, by Warren Upham.

BULLETINS.

1. On Hypersthene-Andesite and on Triclinic Pyroxene in Augitic Rocks, by Whitman Cross, with a Geological Sketch of Buffalo Peaks, Colorado, by S. F. Emmons. 1883. 8°. 42 pp. 2 pl. Price 10 cents.

2. Gold and Silver Conversion Tables, giving the coining value of troy ounces of fine metal, etc., computed by Albert Williams, jr. 1883. 8°. 8 pp. Price 5 cents.

3. On the Fossil Faunas of the Upper Devonian, along the meridian of 76° 30′, from Tompkins County, New York, to Bradford County, Pennsylvania, by Henry S. Williams. 1884. 8°. 36 pp. Price 5 cents.

4. On Mesozoic Fossils, by Charles A. White. 1884. 8°. 36 pp. 9 pl. Price 5 cents.

5. A Dictionary of Altitudes in the United States, compiled by Henry Gannett. 1884. 8°. 325 pp. Price 20 cents.

6. Elevations in the Dominion of Canada, by J. W. Spencer. 1884. 8°. 43 pp. Price 5 cents.

7. Mapoteca Geologica Americana. A Catalogue of Geological Maps of America (North and South). 1752–1881, in geographic and chronologic order, by Jules Marcou and John Belknap Marcou. 1884. 8°. 184 pp. Price 10 cents.

8. On Secondary Enlargements of Mineral Fragments in Certain Rocks, by R. D. Irving and C. R. Van Hise. 1884. 8°. 56 pp. 6 pl. Price 10 cents.

9. A report of work done in the Washington Laboratory during the fiscal year 1883–'84. F. W. Clarke, chief chemist. T. M. Chatard, assistant chemist. 1884. 8°. 40 pp. Price 5 cents.

10. On the Cambrian Faunas of North America. Preliminary studies, by Charles Doolittle Walcott. 1884. 8°. 74 pp. 10 pl. Price 5 cents.

11. On the Quaternary and Recent Mollusca of the Great Basin; with Descriptions of New Forms, by R. Ellsworth Call. Introduced by a sketch of the Quaternary Lakes of the Great Basin, by G. K. Gilbert. 1884. 8°. 66 pp. 6 pl. Price 5 cents.

12. A Crystallographic Study of the Thinolite of Lake Lahontan, by Edward S. Dana. 1884. 8°. 34 pp. 3 pl. Price 5 cents.

13. Boundaries of the United States and of the several States and Territories, with a Historical Sketch of the Territorial Changes, by Henry Gannett. 1885. 8°. 135 pp. Price 10 cents.

14. The Electrical and Magnetic Properties of the Iron-Carburets, by Carl Barus and Vincent Strouhal. 1885. 8°. 238 pp. Price 15 cents.

15. On the Mesozoic and Cenozoic Paleontology of California, by Charles A. White. 1885. 8°. 33 pp. Price 5 cents.

16. On the Higher Devonian Faunas of Ontario County, New York, by John M. Clarke. 1885. 8°. 86 pp. 3 pl. Price 5 cents.

17. On the Development of Crystallization in the Igneous Rocks of Washoe, Nevada, with notes on the Geology of the District, by Arnold Hague and Joseph P. Iddings. 1885. 8°. 44 pp. Price 5 cents.

18. On Marine Eocene, Fresh-water Miocene, and other Fossil Mollusca of Western North America, by Charles A White. 1885. 8°. 26 pp. 3 pl. Price 5 cents.

19. Notes on the Stratigraphy of California, by George F. Becker. 1885. 8°. 28 pp. Price 5 cents.

20. Contributions to the Mineralogy of the Rocky Mountains, by Whitman Cross and W. F. Hillebrand. 1885. 8°. 114 pp. 1 pl. Price 10 cents.

21. The Lignites of the Great Sioux Reservation. A Report on the Region between the Grand and Moreau Rivers, Dakota, by Bailey Willis. 1885. 8°. 16 pp. 5 pl. Price 5 cents.

22. On New Cretaceous Fossils from California, by Charles A. White. 1885. 8°. 25 pp. 5 pl. Price 5 cents.

23. Observations on the Junction between the Eastern Sandstone and the Keweenaw Series on Keweenaw Point, Lake Superior, by R. D. Irving and T. C. Chamberlin. 1885. 8°. 124 pp. 17 pl. Price 15 cents.

24. List of Marine Mollusca, comprising the Quaternary Fossils and recent forms from American Localities between Cape Hatteras and Cape Roque, including the Bermudas, by William Healy Dall. 1885. 8°. 336 pp. Price 25 cents.

25. The Present Technical Condition of the Steel Industry of the United States, by Phineas Barnes. 1885. 8°. 85 pp. Price 10 cents.

26. Copper Smelting, by Henry M. Howe. 1885. 8°. 107 pp. Price 10 cents.

27. Report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1884–'85. 1886. 8°. 80 pp. Price 10 cents.

28. The Gabbros and Associated Hornblende Rocks occurring in the neighborhood of Baltimore, Maryland, by George Huntington Williams. 1886. 8°. 78 pp. 4 pl. Price 10 cents.

29. On the Fresh-water Invertebrates of the North American Jurassic, by Charles A. White. 1886. 8°. 41 pp. 4 pl. Price 5 cents.

30. Second Contribution to the Studies on the Cambrian Faunas of North America, by Charles Doolittle Walcott. 1886. 8°. 369 pp. 33 pl. Price 25 cents.

31. Systematic Review of our Present Knowledge of Fossil Insects, including Myriapods and Arachnids, by Samuel Hubbard Scudder. 1886. 8°. 128 pp. Price 15 cents.

32. Lists and Analyses of the Mineral Springs of the United States; a Preliminary Study, by Albert C. Peale. 1886. 8°. 235 pp. Price 20 cents.

33. Notes on the Geology of Northern California, by J. S. Diller. 1886. 8°. 23 pp. Price 5 cents.

34. On the relation of the Laramie Molluscan Fauna to that of the succeeding Fresh-water Eocene and other groups, by Charles A. White. 1886. 8°. 54 pp. 5 pl. Price 10 cents.

35. Physical Properties of the Iron-Carburets, by Carl Barus and Vincent Strouhal. 1886. 8°. 62 pp. Price 10 cents.

36. Subsidence of Fine Solid Particles in Liquids, by Carl Barus. 1886. 8°. 58 pp. Price 10 cents.

37. Types of the Laramie Flora, by Lester F. Ward. 1887. 8°. 354 pp. 57 pl. Price 25 cents.

38. Peridotite of Elliott County, Kentucky, by J. S. Diller. 1887. 8°. 31 pp. 1 pl. Price 5 cents.

39. The Upper Beaches and Deltas of the Glacial Lake Agassiz, by Warren Upham. 1887. 8°. 84 pp. 1 pl. Price 10 cents.

40. Changes in River Courses in Washington Territory due to Glaciation, by Bailey Willis. 1887. 8°. 10 pp. 4 pl. Price 5 cents.

41. On the Fossil Faunas of the Upper Devonian—the Genesee Section, New York, by Henry S. Williams. 1887. 8°. 121 pp. 4 pl. Price 15 cents.

42. Report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1885–'86. F. W. Clarke, chief chemist. 1887. 8°. 152 pp. 1 pl. Price 15 cents.

43. Tertiary and Cretaceous Strata of the Tuscaloosa, Tombigbee, and Alabama Rivers, by Eugene A. Smith and Lawrence C. Johnson. 1887. 8°. 189 pp. 21 pl. Price 15 cents.

44. Bibliography of North American Geology for 1886, by Nelson H. Darton. 1887. 8°. 35 pp. Price 5 cents.

45. The Present Condition of Knowledge of the Geology of Texas, by Robert T. Hill. 1887. 8°. 94 pp. Price 10 cents.

46. Nature and Origin of Deposits of Phosphate of Lime, by R. A. F. Penrose, jr., with an Introduction by N. S. Shaler. 1888. 8°. 143 pp. Price 15 cents

47. Analyses of Waters of the Yellowstone National Park, with an Account of the Methods of Analysis employed, by Frank Austin Gooch and James Edward Whitfield. 1888. 8°. 84 pp. Price 10 cents.

48. On the Form and Position of the Sea Level, by Robert Simpson Woodward. 1888. 8°. 88 pp. Price 10 cents.

49. Latitudes and Longitudes of Certain Points in Missouri, Kansas, and New Mexico, by Robert Simpson Woodward. 1889. 8°. 133 pp. Price 15 cents.

50. Formulas and Tables to facilitate the Construction and Use of Maps, by Robert Simpson Woodward. 1889. 8°. 124 pp. Price 15 cents.

51. On Invertebrate Fossils from the Pacific Coast, by Charles Abiathar White. 1889. 8°. 102 pp. 14 pl. Price 15 cents.

52. Subaërial Decay of Rocks and Origin of the Red Color of Certain Formations, by Israel Cook Russell. 1889. 8°. 65 pp. 5 pl. Price 10 cents.

53. The Geology of Nantucket, by Nathaniel Southgate Shaler. 1889. 8°. 55 pp. 10 pl. Price 10 cents.

54. On the Thermo-Electric Measurement of High Temperatures, by Carl Barus. 1889. 8°. 313 pp. incl. 1 pl. 11 pl. Price 25 cents.

55. Report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1886–'87. Frank Wigglesworth Clarke, chief chemist. 1889. 8°. 96 pp. Price 10 cents.

56. Fossil Wood and Lignite of the Potomac Formation, by Frank Hall Knowlton. 1889. 8°. 72 pp. 7 pl. Price 10 cents.

57. A Geological Reconnaissance in Southwestern Kansas, by Robert Hay. 1890. 8°. 49 pp. 2 pl. Price 5 cents.

58. The Glacial Boundary in Western Pennsylvania, Ohio, Kentucky, Indiana, and Illinois, by George Frederick Wright, with an introduction by Thomas Chrowder Chamberlin. 1890. 8°. 112 pp. incl. 1 pl. 8 pl. Price 15 cents.

59. The Gabbros and Associated Rocks in Delaware, by Frederick D. Chester. 1890. 8°. 45 pp. 1 pl. Price 10 cents.

60. Report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1887–'88. F. W. Clarke, chief chemist. 1890. 8°. 174 pp. Price 15 cents.

61. Contributions to the Mineralogy of the Pacific Coast, by William Harlow Melville and Waldemar Lindgren. 1890. 8°. 40 pp. 3 pl. Price 5 cents.

62. The Greenstone Schist Areas of the Menominee and Marquette Regions of Michigan; a contribution to the subject of dynamic metamorphism in eruptive rocks, by George Huntington Williams; with an introduction by Roland Duer Irving. 1890. 8°. 241 pp. 16 pl. Price 30 cents.

63. A Bibliography of Paleozoic Crustacea from 1698 to 1889, including a list of North American species and a systematic arrangement of genera, by Anthony W. Vogdes. 1890. 8°. 177 pp. Price 15 cents.

64. A report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1888–'89. F. W. Clarke, chief chemist. 1890. 8°. 60 pp. Price 10 cents.

65. Stratigraphy of the Bituminous Coal Field of Pennsylvania, Ohio, and West Virginia, by Israel C. White. 1891. 8°. 212 pp. 11 pl. Price 20 cents.

66. On a Group of Volcanic Rocks from the Tewan Mountains, New Mexico, and on the occurrence of Primary Quartz in certain Basalts, by Joseph Paxson Iddings. 1890. 8°. 34 pp. Price 5 cents.

67. The Relations of the Traps of the Newark System in the New Jersey Region, by Nelson Horatio Darton. 1890. 8°. 82 pp. Price 10 cents.

68. Earthquakes in California in 1889, by James Edward Keeler. 1890. 8°. 25 pp. Price 5 cents.

69. A Classed and Annotated Bibliography of Fossil Insects, by Samuel Hubbard Scudder. 1890. 8°. 101 pp. Price 15 cents.

70. Report on Astronomical Work of 1889 and 1890, by Robert Simpson Woodward. 1890. 8°. 79 pp. Price 10 cents.

71. Index to the Known Fossil Insects of the World, including Myriapods and Arachnids, by Samuel Hubbard Scudder. 1891. 8°. 744 pp. Price 50 cents.

72. Altitudes between Lake Superior and the Rocky Mountains, by Warren Upham. 1891. 8°. 229 pp. Price 20 cents.

73. The Viscosity of Solids, by Carl Barus. 1891. 8°. xii, 139 pp. 6 pl. Price 15 cents.

74. The Minerals of North Carolina, by Frederick Augustus Genth. 1891. 8°. 119 pp. Price 15 cents.

75. Record of North American Geology for 1887 to 1889, inclusive, by Nelson Horatio Darton. 1891. 8°. 173 pp. Price 15 cents.

76. A Dictionary of Altitudes in the United States (second edition), compiled by Henry Gannett, chief topographer. 1891. 8°. 393 pp. Price 25 cents.

77. The Texan Permian and its Mesozoic Types of Fossils, by Charles A. White. 1891. 8°. 51 pp. 4 pl. Price 10 cents.

78. A report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1889–'90. F. W. Clarke, chief chemist. 1891. 8°. 131 pp. Price 15 cents.

79. A Late Volcanic Eruption in Northern California and its Peculiar Lava, by J. S. Diller. 1891. 8°. 33 pp. 17 pl. Price 10 cents.

80. Correlation papers—Devonian and Carboniferous, by Henry Shaler Williams. 1891. 8°. 279 pp. Price 20 cents.

81. Correlation papers—Cambrian, by Charles Doolittle Walcott. 1891. 8°. 447 pp. 3 pl. Price 25 cents.

82. Correlation papers—Cretaceous, by Charles A. White. 1891. 8°. 273 pp. 3 pl. Price 20 cents.

83. Correlation papers—Eocene, by William Bullock Clark. 1891. 8°. 173 pp. 2 pl. Price 15 cents.

84. Correlation papers—Neocene, by W. H. Dall and G. D. Harris. 1892. 8°. 349 pp. 3 pl. Price 25 cents.

85. Correlation papers—The Newark System, by Israel Cook Russell. 1892. 8°. 344 pp. 13 pl. Price 25 cents.

86. Correlation papers—Archean and Algonkian, by C. R. Van Hise. 1892. 8°. 549 pp. 12 pl. Price 25 cents.

90. A report of work done in the Division of Chemistry and Physics, mainly during the fiscal year 1890–'91. F. W. Clarke, chief chemist. 1892. 8°. 77 pp. Price 10 cents.

91. Record of North American Geology for 1890, by Nelson Horatio Darton. 1891. 8°. 88 pp. Price 10 cents.

92. The Compressibility of Liquids, by Carl Barus. 1892. 8°. 96 pp. 29 pl. Price 10 cents.

93. Some insects of special interest from Florissant, Colorado, and other points in the Tertiaries of Colorado and Utah, by Samuel Hubbard Scudder. 1892. 8°. 35 pp. 3 pl. Price 5 cents.

94. The Mechanism of Solid Viscosity, by Carl Barus. 1892. 8°. 138 pp. Price 15 cents.

95. Earthquakes in California in 1890 and 1891, by Edward Singleton Holden. 1892. 8°. 31 pp. Price 5 cents.

96. The Volume Thermodynamics of Liquids, by Carl Barus. 1892. 8°. 100 pp. Price 10 cents.

97. The Mesozoic Echinodermata of the United States, by W. B. Clark. 1893. 8°. 209 pp. 50 pl. Price 20 cents.

98. Flora of the Outlying Carboniferous Basins of Southwestern Missouri, by David White. 1893. 8°. 139 pp. 5 pl. Price 15 cents.

99. Record of North American Geology for 1891, by Nelson Horatio Darton. 1892. 8°. 73 pp. Price 15 cents.

101. Insect Fauna of the Rhode Island Coal Field, by Samuel Hubbard Scudder. 1893. 8°. 27 pp. 2 pl. Price 5 cents.

In press:

100. Bibliography and Index of the publications of the U. S. Geological Survey, 1879–1892, by P. C. Warman.

102. A Catalogue and Bibliography of North American Mesozoic Invertebrata, by C. B. Boyle.

103. High Temperature Work in Igneous Fusion and Ebullition, chiefly in relation to pressure, by Carl Barus.

104. Glaciation of the Yellowstone Valley north of the Park, by W. H. Weed.

105. The Laramie and the overlying Livingstone Formation in Montana, by W. H. Weed, with Report on Flora, by F. H. Knowlton.

106. The Colorado Formation and its Invertebrate Fauna, by T. W. Stanton.

107. The Trap Dikes of Lake Champlain Valley and the Eastern Adirondacks, by J. F. Kemp.

108. A Geological Reconnoissance in Central Washington, by Israel C. Russell.

109. The Eruptive and Sedimentary Rocks on Pigeon Point, Minnesota, and their contact phenomena, by W. S. Bayley.

110. The Paleozoic Section in the vicinity of Three Forks, Montana, by A. C. Peale.

In preparation:

— Correlation papers—Pleistocene, by T. C. Chamberlin.

— The Moraines of the Missouri Coteau, and their attendant deposits, by James Edward Todd.

— On the Structure of the Ridge between the Taconic and the Green Mountain Ranges in Vermont; and On the Structure of Monument Mountain in Great Barrington, Mass., by T. Nelson Dale.

— A Bibliography of Paleobotany, by David White.

STATISTICAL PAPERS.

Mineral Resources of the United States, 1882, by Albert Williams, jr. 1883. 8°. xvii, 813 pp. Price 50 cents.

Mineral Resources of the United States, 1883 and 1884, by Albert Williams, jr. 1885. 8°. xiv, 1016 pp. Price 60 cents.

Mineral Resources of the United States, 1885. Division of Mining Statistics and Technology. 1886. 8°. vii, 576 pp. Price 40 cents.

Mineral Resources of the United States, 1886, by David T. Day. 1887. 8°. viii, 813 pp. Price 50 cents.

Mineral Resources of the United States, 1887, by David T. Day. 1888. 8°. vii, 832 pp. Price 50 cents.
Mineral Resources of the United States, 1888, by David T. Day. 1890. 8°. vii, 652 pp. Price 50 cents.
Mineral Resources of the United States, 1889 and 1890, by David T. Day. 1892. 8°. viii, 671 pp. Price 50 cents.
Mineral Resources of the United States, 1891, by David T. Day. 1893. 8°. vii, 630 pp. Price 50 cents.

In preparation:

Mineral Resources of the United States, 1892.

The money received from the sale of these publications is deposited in the Treasury, and the Secretary of the Treasury declines to receive bank checks, drafts, or postage stamps; all remittances, therefore, must be by POSTAL NOTE or MONEY ORDER, made payable to the Librarian of the U. S. Geological Survey, or in CURRENCY, for the exact amount. Correspondence relating to the publications of the Survey should be addressed

TO THE DIRECTOR OF THE
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

WASHINGTON, D. C., *April, 1893.*

DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 98

WASHINGTON
GOVERNMENT PRINTING OFFICE
1893

UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

FLORA

OF THE

OUTLYING CARBONIFEROUS BASINS

OF

SOUTHWESTERN MISSOURI

BY

DAVID WHITE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1893

CONTENTS.

ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
U. S. GEOLOGICAL SURVEY,
Washington, D. C., December 1, 1891.

SIR: I have the honor to transmit herewith the manuscript and drawings for a paper by Mr. David White, assistant paleontologist, on the Flora of the Outlying Carboniferous Basins of Southwestern Missouri, and to request its publication as a bulletin of the U. S. Geological Survey.

Very respectfully yours,

LESTER F. WARD,
Geologist.

Hon. J. W. POWELL,
Director U. S. Geological Survey.

OUTLINE OF THIS PAPER.

The flora treated in this bulletin comes from the most recent fossiliferous rock within the limits of the lead and zinc region of southwestern Missouri that is known to have been laid down before the ores were formed. It therefore furnishes a date for the earliest limit of a period during some portion of which the rich ores of that region were deposited.

It is noteworthy as the first flora to be described from any other horizon of the Carboniferous of the state than that at Clinton near the base of the Lower Coal-measures. It is also the first flora sufficient for correlation that has been made known from above the Clinton stage throughout the entire trans-Mississippi Carboniferous.

The assemblage of types, which may be regarded as constituting, in some respects, an upland flora by reason of its probable altitude of one or two hundred feet or more above the contemporaneous Coal-measure marshes, is characterized by a predominance of Neuropterids, the presence of numerous Cordaites leaves, the entire absence of any remains of the Lycopodineæ except the leaves of one species, and the scarcity of Calamarian fragments.

All the species are described, several old or uncertain forms, as well as the new ferns, being illustrated. Generic and ordinal characterizations are omitted except in cases where recent discoveries as to the nature or relation of the groups make it seem desirable.

An examination of the distribution of the species and of the facies and affinities of the flora leads to the conclusion that the plant-bearing outliers belong to the Lower Coal-measures, with an indicated stage near, probably above, the middle of that series.

FLORA OF THE OUTLYING CARBONIFEROUS COAL BASINS OF SOUTHWESTERN MISSOURI.

By David White.

INTRODUCTION.

GEOLOGICAL.

The flora described in this report is worthy of consideration in three respects: (1) It furnishes locally a datum subsequent to which the deposition of the lead and zinc ores of this region must have occurred, the plants having been laid down in these basins in the Lower Carboniferous rock prior to the ore formation. (2) The collection constitutes essentially the first flora that has been studied and described from any horizon above the lower part of the Lower Coal-measures in the Carboniferous terranes of the trans-Mississippi regions. It is therefore of much interest and of considerable importance, although the fossils do not from the nature of their occurrence constitute the flora of a single ascertained horizon in a section of the Coal-measures. (3) The position and stratigraphic relations of the outliers with which we are concerned are such as to indicate an altitude of perhaps 100 to 200 feet above the contemporaneous marshes flanking the "Ozark Uplift" at some distance westward, which now constitute the coal fields of northern Missouri and eastern Kansas. We are therefore justified, from the biological point of view, in regarding this assemblage of species, which must have grown on dry land or near a small upland stream or pond, as practically constituting an upland flora, as contrasted with that of the semi-inundated region westward.

LOCALITIES.

The material examined comprises the contents of fourteen boxes, collected in the fall of 1889 by Dr. W. P. Jenney, of the U. S. Geological Survey, while engaged in the study of the zinc and lead deposits of the southwestern Missouri region. The localities where the fossils were obtained are, in the order of their richness in species, as follows:

I. By far the greater number of species were obtained from near Belleville, Jasper county, Missouri, at McClelland's shaft, Sec. 31, T. 28 W., R. 33 N. These are contained in light ash-colored somewhat

arenaceous shales with minute particles of mica. In portions they are more massive and are sandy and rather darker.

II. Several species, belonging mostly to *Neuropteris*, were found in similar shales at the Hannam shaft, 1 mile northeast of Carterville, Jasper county. These shales are rather finer and more compact, weathering a light brownish tea color.

III. From a shaft 1 mile north of Aurora, Lawrence county, a small bundle of specimens was collected in May, 1891. The shales containing the fossils are lighter than those described above, with less sand. The plants are poorly preserved, though numerous, the thicker tissues and leaves of *Cordaites* being somewhat infiltrated with pyrites.

IV. A few fragments were collected from the north end of the Bay State lease near Joplin, Jasper county. They consist of a dark coarse sandstone, somewhat laminated, filled with small fragments of vegetable matter, chiefly stems, either charred or replaced wholly or in part by marcasite.

V. A number of specimens of black coaly shale from the Bristow land, Sec. 15, T. 28, R. 33, 4 miles north of Joplin, Jasper county, contain lamellæ composed almost exclusively of fragments of *Cordaites* leaves and stems. The latter are either too small or too ill-preserved for satisfactory identification.

MODE OF OCCURRENCE.

The small basins from which the plants in hand were collected were all eroded in a limestone considered on the evidence of its fossils to be "of Warsaw–St. Louis age." At other points of the Ozark Uplift, such outlying basins are found in the Burlington and Chouteau limestones of the Lower Carboniferous, and even in the upper limestones of the Magnesian series of Swallow, of Lower Silurian (Ordovician) age. Whether these outliers in the zinc region are of the same date as those found in Lincoln, Warren, Montgomery, Calloway, Cole, and other counties, which have generally been regarded as contemporaneous with the lowest of the true Coal-measures in western Missouri, remains undecided, no plants having, so far as I can learn, yet been collected or studied from any of the latter[1] deposits.

The geology of this region, which will form the especial subject of Dr. Jenney's report, has been discussed in many state and individual publications, particularly in Messrs. Adolf Schmidt and Alexander Leonhard's valuable report included in the volume issued by the state survey for 1873–1874.[2]

For the purpose of indicating, in the present paper, the relation of the plant-bearing shales to the adjacent terranes, a description of the basin at McClelland's shaft will suffice. Moreover this outlier furnished

[1] It is not assumed that the outliers scattered from northern Arkansas to Wisconsin and Michigan are all of the same age.

[2] Jefferson City, 1874. See pp. 381–734, with 28 plates.

the greater portion of the data on which the chronological conclusions are based.

At McClelland's shaft the basin affects the surface topography as a slight "sink." The depression occurs in a peculiar series of the Lower Carboniferous, consisting of loose layers of chert brecciated in situ and alternate limestone strata, more or less dissolved and removed, whose fossils, determined by Prof. H. S. Williams, are characteristic of the Warsaw and Chester groups. The bottom of the depression is covered by loose chert. The walls, composed of the same formation, are also somewhat broken. On this loose floor rests the lenticular body of shales, about ten feet in thickness, very convex below and slightly convex above. The basin at this level is about thirty feet in diameter. A tunnel was extended from the shaft in the center following the plant-bearing layers, to the wall of the sink on one side, a distance of fifteen feet. From the top of the shales to the surface, about thirty feet, the depression is filled with loose chert, gravel, and recent material washed in.

The accompanying section, drawn semidiagrammatically, is prepared from sketches kindly furnished by Dr. Jenney, to whose notes I am indebted for the brief description of the formation in advance of his own publication.

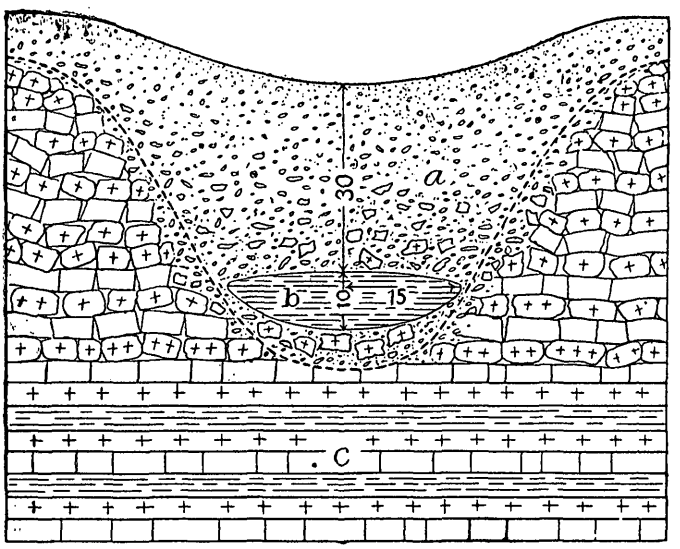


FIG. 1.—Semidiagrammatic section of outlier at McClelland's shaft; Sec. 31, T. 28, R. 33.
a, loose chert, gravel, and wash.
b, plant-bearing shales.
c, alternate strata of chert and limestone, more or less broken, the interstices filled with ore. (The broken character is not well represented in the diagram.)

The more important events relating to the formation of the fossiliferous shales are: (1) The flexure of the strata and fracture of the chert attending the latter part of the Ozark uplift, which elevated this re-

gion, near the close of the Lower Carboniferous, to a considerable height above the Carboniferous sea lying to the westward. (2) The solution and removal of the fissured alternating limestones by surface water charged with carbon-dioxide, continuing for a long period and producing innumerable passages, crevices, and chambers, often permitting the interlarded chert layers to crush for want of support. This undermining has occasionally been so extensive as to result in a collapse of all the overlying rock, producing a sink or pothole, such as that described, that is apparent in the surface topography, and which indicates to the prospector the existence in the subjacent rocks of chambers, pockets, etc., containing the ores. (4) Such a sink existed, or came into existence, in the early Carboniferous, constituting a small pond which was filled with sediments burying portions of the plants that grew in the shallows or near the borders. (5) After filling to the point of erosion by drainage, no more sediments were perhaps deposited until the Pleistocene, when the outlet, which was probably a tributary to the Carboniferous river described by Winslow [1] and others, may have been obstructed and the process of washing in gravels and detritus renewed. (6) At some time during the interval between the deposition of the shales and that of the superimposed gravels and detritus, rich deposits of zinc blende and galena were formed in the passages, fissures, caverns, and interstices of the limestone and chert, frequently filling the chambers and constituting large masses and pockets. At the same time dolomite, with minute quantities of chalcopyrite, greenockite, and marcasite were formed. Quartz and calcite rarely occur as gangues. Many other minerals have subsequently been formed by alteration. The dense mass of clay shales was penetrated for a foot or more by the solutions carrying lead and zinc and contains near its borders numerous perfect crystals of galena and blende, often distorting and replacing portions of the plant remains, and showing that the deposition of the ores was later than the preservation of the plants. The shales are nearly horizontal, and but slightly disturbed, the disturbance being apparently due to the irregular settling of the mass consequent to the subterranean erosion of the underlying terranes.

The vegetable remains are generally well preserved, the thinner laminæ being brown or dark, and distinct, while the stems and denser portions are carbonized. But in the coarser matrix the preservation is hardly so good, especially for the study of the nervation. As a rule the plant fragments lie nearly normal to the bedding. The surface of the rock specimens from certain horizons in the finer sediments is nearly covered by plant remains presenting on the same stone associated species of great diversity in form and relationship.

[1] Bull. Geol. Surv. Mo., No. 1, pp. 14–20, 1890.

PALEONTOLOGICAL.

In describing the following species I have sought to make the diagnoses as full as was expedient from all the material at my disposal in order to secure as complete a differentiation and characterization as possible of each species, and to render its identification by other workers in other localities more exact and less difficult.

The greater service to geology will, I trust, be accomplished in the more accurate differentiation of the species and forms. If we admit as a fact that the modifications in many species enduring through a long period are such in the course of time, or amid changing circumstances, that certain phases or forms in a fossil state are peculiar to certain horizons, especially within limited regions, it follows that the greater efficiency in correlation will be attained, and consequently the greater aid given by paleontology to geology, by thoroughly diagnosing each variety or form of a species which is sufficiently distinct from all others to be clearly distinguishable in any region or series of localities when thus fully characterized. In the ideal point of view any impression that possesses a character which marks it as different from all other impressions and as peculiar to a horizon or series merits a characterization sufficient for its complete distinction; for its value in identifying that horizon within certain limits is equally important whether it be a good species to the eye of the systematic biologist, or only the track of an otherwise unknown organism. However, in practice the material at hand is so far from the ideal either in quantity or in the degree of perfection, that it is seldom that differentiation has gone with distinct characterization beyond what are regarded as distinct species.

In several cases, on account of the paucity of material belonging to a certain species in the collection, or for lack of specimens for comparison, I have doubtfully referred a form to an established species for the present, though the identification is far from satisfactory. In other cases I have united old species whose forms either represent different portions of the same plant or do not appear capable of distinction when represented by a good suite of specimens from any locality.

The systematic arrangement of the groups represented in this flora is temporary. The relations of many of them are now the subjects of radical disagreements among paleontologists, while the knowledge constantly accruing from the study of internal structure and fructification compels a frequent readjustment of the lines of classification.

It is hoped that my coworkers, whether in the laboratory or the field, will herein find assistance in identifiying our species, a task which is often difficult when the student has no other aid than the descriptions and figures in our American literature on the Carboniferous plants. The method followed is that employed by the distinguished paleobotanist, Mr. René Zeiller, in his classical work on the coal flora of the Valenciennes basin, and to that work I am much indebted for aid and information.

In taking up the systematic study of our Carboniferous flora where it was left by its chief architect and devotee, Prof. Lesquereux, it has become apparent that a certain amount of revision to suit the progress of the science, and of recharacterization accompanied by reexamination of collections, is necessary; but such faults as are found in the existing condition of American Paleozoic paleobotany are easily explained when we remember his failing powers of memory and vision during his last years, and the great physical disadvantages under which his labor was performed and which win for his life work the highest admiration and distinction, especially from those who through scientific or friendly intercourse learned the beauty and simplicity of his personal character.

Grateful acknowledgments are due to Mr. R. D. Lacoe, of Pittston, Pennsylvania, and Dr. J. H. Britts, of Clinton, Missouri, for kind courtesies in transmitting authentic specimens from Lesquereux's hand for comparison; and particularly to Mr. Lacoe for valuable counsel and information given during the preparation of this manuscript.

DESCRIPTION OF THE SPECIES.

I. VASCULAR CRYPTOGAMS.

EQUISETINEÆ.

CALAMARIÆ.[1]

CALAMITES Suckow. 1784.

CALAMITES (EUCALAMITES) RAMOSUS Artis.

1825. *Calamites ramosus* Artis, Antedil. Phytol., Pl. II. 1828: Brongniart, Hist. Vég. foss., p. 127; Pl. XVII, Fig. 5 (non 6). 1835: Gutbier, Abdrücke, p. 18; Pl. II, Fig. 6. 1848: Sauveur, Vég. foss. Belg., Pl. IX, Fig. 2; Pl. X, Figs. 1, 2. 1858: Lesquereux, Geol. Penn., II, p. 850. 1866: Lesquereux, Geol. Surv. Ill., II, Pal., p. 445. 1877: Grand'Eury, Fl. Carb. Loire, p. 20; Pl. II, Fig. 4. 1879: Lesquereux, Coal Flora, I, atlas, Pl. I, fig. 2; text (1880), p. 22. 1882: Renault, Cours bot. foss., II, p. 163; Pl. XXIV, Figs. 8, 9. 1884: Lesquereux, Coal Flora, III, p. 702; Pl. XCII, Figs. 1-4. 1886: Zeiller, Fl. foss. Valenciennes, atlas, Pl. LV., Fig. 3; Pl. LVI, Fig. 3; text (1888) p. 345. 1887: Stur, Carb. Fl. Schatzlarer Sch., II, p. 96; Pl. XII, Figs. 1-6; Pl. XIIb; Pl. XIII, Figs. 1-9; Pl. XIV, Figs. 3-5; text figs. 1, 2, 28, 29, 31, 32.

1877. *Calamites nodosus* Schl., Lebour, Illustr., Pl. II, Pl. III.

1884. *Calamites* (*Eucalamites*) *ramosus*, Weiss, Steink.-Cal., II, p. 98, Pl. II, Fig. 3; Pl. V, Figs. 1, 2; Pl. VI; Pl. VII, Figs. 1, 2; Pl. VIII, Figs. 1, 2, 4; Pl. IX, Fig. 1; Pl. X, Fig. 1; Pl. XX, Figs. 1, 2. 1886: Kidston, Foss. Pl. Lanarksh., p. 51.

1887. *Eucalamites* (*Calamites*) *ramosus*, Kidston, Foss. Fl. Radstock Series, p. 341. 1889: Kidston, Foss. Pl. Ravenhead Coll., p. 400.

1888. *Eucalamites ramosus*, Schenk, Die foss. Pflanzen., p. 125.

FOLIAGE.

1828. *Annularia radiata* Brongn., (pars?), Prodrome, p. 156.

1848. *Annularia radiata*, Sauveur, Vég. foss. terr. houill. Belg., Pl. LXVII, Fig. 2. 1855: Geinitz, Verst. Steink. Sachsens, p. 11, Pl. XVIII, Figs. 6, 7. 1869: v. Roehl, Foss. Fl. Steink. Westphalens, p. 28, Pl. IV, Fig. 3. 1874: O. Feistmantel, Verst. böhm. Ablag., I, p. 130, Pl. XVII, Figs. 2, 3, 4. 1878: Zeiller, Vég. foss. terr. houill., atlas, Pl. CLX, Fig. 1, text (1879), p. 24. 1886: Zeiller, Fl. foss. Valenciennes, atlas, Pl. LIX, Fig. 8, Pl. LXI, Figs. 1, 2, text (1888), p. 394.

1877.(?) *Calamites nodosus* Schloth., Lebour, Illustr., Pl. III.

1881. *Annularia ramosa* Weiss, N. Jahrb. f. Min., II, (Brief.) p. 273. 1884: Weiss, Steink.-Cal., II, p. 98; Pl. V, Figs. 1, 2; Pl. VI, Figs. 1-7; Pl. X, Fig. 1; Pl. XX, Figs. 1, 2.

1887. *Annularia ramosa* Stur, Carb.-Fl. Schatzlarer Sch., II, p. 106; Pl. XIIb, Figs. 2, 3, 4, 6; Pl. XIII, Figs. 1, 3-9; Pl. XIV, Figs. 3-5.

1886. *Calamites* (*Eucalamites*) *ramosus*, Kidston, Foss. Pl. Lanarksh. p. 51, Pl. III, Fig. 1.

[1] As the order *Equisetaceæ* is defined and generally understood among botanists, the great family *Calamariæ* can not be included therein. I have preferred therefore to adopt the classification coordinating the two families within the order *Equisetineæ*, which has been so defined as to contain the highly organized Carboniferous representatives, of which the living *Equiseta* are but feeble and degenerate descendants.

FRUCTIFICATION.

1884. *Calamites* (*Eucalamites*) *ramosus*, Weiss, Steink.-Cal., II, p. 98; Pl. v, Fig. 2; Pl. VI, Figs. 2, 3, 4, 6, 7; Pl. XX, Figs. 1, 2.
1884. *Calamostachys ramosa* Weiss, Steink.-Cal., II, p. 180 (266), Pl. XX, Figs. 1, 2.
1887. *Calamites ramosus* Stur, Carb.-Fl. Schatzlarer Sch., II, p. 96; Pl. XII, Figs. 5 (?), 6 (?); Pl. XIIb, Figs. 2, 3, 4, 6.

Stems cylindrical, branching, the lower portions and rhizomes bearing roots; internodes slender, generally much longer than broad; ribs straight, low, $1\frac{1}{2}$–3 or even 4 mm broad, rounded or obtusely pointed at the extremities, minutely striated longitudinally, often marked transversely so as to form rectangular meshes, furrows shallow, $\frac{1}{4}$–$\frac{1}{2}$ mm broad and bounded on the internal casts by two fine indented lines between which the surface is slightly raised, tubercles often indistinct, at the tops of the ribs, oval, rather longer than broad, often absent from the lower ends of the ribs or represented only by indistinct rounded protuberances; branches and upper part of the stems slender and less distinctly costate; branching several times repeated, the branches or their cicatrices usually placed diametrically opposite, two at each node, or sometimes three or rarely one; rameal cicatrices placed on the middle of the articulation, large, circular, or oval, a little broader than long, more or less depressed, with a zone of converging furrows, corresponding to the ribs of the stem, within its borders; final branches and branchlets foliate, in annulated verticils of radiating, uninerved leaves, the latter being lanceolate, narrowed to each end, 5–20mm long, and $\frac{1}{2}$–2 mm wide, the smaller ones nearer the tips of the branches; this foliage is commonly known as *Annularia radiata* (Brongn.) Sternb.

This species, now one of the best known of its genus, is a good example of the progress made in synthetic work among fossil plants during the last decade. The careful studies by the late Dr. Weiss of the rich material contained in the collections of the Prussian Geological Survey and many other German institutions, the critical examinations by Director Stur of the exhaustive collections from the coal-fields of Bohemia and Moravian Silesia, with comparisons with numerous other collections to which he had access, the constructive work of Grand 'Eury among the plants from the basin of the Loire, and especially the painstaking and brilliant work of Zeiller and Renault among the collections from the regions of Autun, Valenciennes, and Commentry, have yielded a great amount of data for the revision of the flora of the Coal-measures and the future reconstruction of the system of Paleozoic plants on the basis of a knowledge of the essential characters in the entire plant, including its fruiting and its internal structure. Few as are the types whose life history is yet even relatively well known, the increments contributed to our understanding of many widely different types make the last fifteen years an important period in the history of paleobotanical progress. The study of the *Calamariæ* has been characterized by special activity and enthusiasm regarding both the superficial characters of the various organs and their microscopic structure. The results of all, so far, though establishing not many specific correlations of stems, foliage, and fruitings, go to prove,

at the same time, the unity of many of the types in the calamarian family, and the real diversity of the types formerly included in the genus *Calamites* itself. Sufficient has been learned of the organs belonging to various forms of *Calamites* to show that it contains types which will probably necessitate its division into several distinct genera.

In the meantime, for convenience and a better definition of its characters, Weiss has proposed a provisional classification of the stems belonging to this genus, which may itself be considered as provisional, into four groups based on the alternation or continuity of the furrows at the nodes, the periodicity of the branch cicatrices, and the relative length of the internodes.[1]

According to this system, *Calamites ramosus* belongs to the group *Eucalamites*, branching as a rule from every joint, and most nearly resembling our branching *Equiseta*.

With the exception of the rhizomes and basal tips of the stems, our acquaintance with the superficial characters of this plant is relatively complete. Considering it, therefore, as a type of the true *Calamites*, its general characters will be given somewhat in detail, avoiding as far as may be the repetition of those given in the above description.

Rhizomes and roots.—Rhizomes undoubtedly belonging to this species have not yet been found attached to stems, though the latter are supposed to have originated from the articulations of a rootstock, as in other species of the genus.

---

[1] The grouping proposed by Weiss for the calamitean stems, independent of the other parts of the plants, is as follows:

I. *Furrows alternating at the joints.*

1. *Calamitina* (emend.) Weiss.—Branch scars occurring periodically, the scar-bearing nodes being separated by a certain number of joints without scars. In most cases there is a regular increase or decrease in the length of the internodes or joints occurring between the scar-bearing nodes; e. g. *C. varians* Sternb., *C. verticillatus* L. & H., and *C. approximatus* Brongn.

2. *Eucalamites* Weiss.—Branch scars at every joint; the internodes all of the same length or varying irregularly in length; e. g. *Calamites ramosus* Artis, and *C. cruciatus* Sternb.

3. *Stylocalamites* Weiss.—Branch scars occurring without definite order, of subordinate importance, often entirely wanting on long stretches of the stem; the internodes of equal length or varying irregularly in length; e. g. *C. Suckowii* Brongn., *C. arborescens* Sternb.

II. *Furrows not alternating at the joints.*

4. *Archæocalamites* Stur. [*Bornia* Sternb. (pars), *Asterocalamites* Schimp.]—Branch scars occurring irregularly; the internodes of unequal length.

Weiss, Beiträge zur fossilen Flora, III. Steinkohlen-Calamarien, II. Abhandl. z. geol. Specialkarte v. Preussen u. d. Thüringischen Staaten, Vol. V, Heft. 2, Berlin, 1884, pp. 1-204 (87-290), 8°. Atlas, Pl. I-XXVIII, 4°. (See pp. 55, 56, 59, 96, 119, 141).

It is at once apparent that this division of the genus, though largely artificial and purely provisional, is simple and most convenient as an aid in classifying the stems until the true relations of the various species shall be determined. It has, accordingly, been followed by several authors, among whom Kidston (Foss. Pl. Ravenhead Coll., 1889) elevates the groups to generic rank.

While most recent authors agree in discarding Sternberg's name, *Bornia*, as confusing to the nomenclature on account of its synonymic relations to *Calamites* and its original inclusion of species of *Asterophyllites* and *Annularia*, it seems only allowable, if that prevalent ruling is to continue, that the earliest special well-defined name should be accepted. Among the later names Schimper's genus *Asterocalamites* (Terr. trans. d. Vosges, 1862, p. 321) has priority, and is preferred by Kidston and Zeiller to the name *Archæocalamites*, chosen by Stur (Culm Flora, 1, 1875, p. 2), after a careful review of the genus, and adopted by Weiss largely on account of its appropriate etymology. Its fruit, described by Stur, has also been shown by Kidston (Ann. Mag. Nat. Hist., May, 1883, p. 297) to be identical with Patterson's *Pothocites Grantoni*.

Stur, in his large work on the *Calamariæ*[1] figures a large fragment 23^{cm} long and about 4^{cm} broad, with five nodes, which he considers a rhizome of this species. It was found oblique to the bedding, with roots passing from the nodes horizontally and conformably to the bedding. A tapering conical base of a stem is still attached to one of the nodes, but it is too poorly preserved to show much except that it is ribbed, and that the segments grow shorter towards the base. Another very large conical base of a stem, springing from a rhizome, is also illustrated[2] under the same name. As in *Calamites ramifer* Stur, the coaly substance is thicker on the rhizome than on the stem. This base is described as 1^{cm} broad at the tip, enlarging to a diameter of 15^{cm} at the height of 18^{cm}, the lowest internodes measuring hardly 3^{mm}. The tubercles at the upper ends of the ribs ("root scars" as interpreted by the author) are seen distinctly at every node, while those on the lower ends of the ribs ("leaf scars") are seen only rarely on the coaly substance. No branch scars appear. No roots are seen on these two stem bases. Weiss notes the occurrence of rhizomes at the same places with *Calamites ramosus*, which may perhaps belong to that species, but which, on account of the smooth or very slightly ribbed surface, bear an aspect so different from the stems that only organic union would permit them to be considered as specifically identical. Neither Weiss nor Zeiller have been able to identify stems of this species with the lower ends contracted in the form of a reversed cone and with a corresponding foreshortening of the internodes, like that figured by Stur or those belonging to *Calamites* (*Stylocalamites*) *Suckowii*.

To Prof. Leo Lesquereux is perhaps due the credit for first describing, from specimens obtained in the vicinity of Lawrence, Kansas, the rounded, conical, or subtruncate bases of these stems, with their attached roots.[3] The rootlets on these bases are described as simple, 1½^{mm} in thickness at the point of attachment, and tapering filiform from about 1^{mm} in diameter. He says:

> They penetrate the stone, passing outward and downward in a curve, from their point of attachment in regular rows a little above the tubercles or leaf scars, more rarely upon the articulations, the point of insertion being marked by a deep round perforation about half as large as the convex tubercles to which they are parallel. They are, however, irregular in horizontal distances, the space between them varying from 2^{mm} to 4^{mm}. The whole length of the radicles can not be seen. By a vertical breaking of the block embedding the stems of these *Calamites*, the rootlets are exposed from 1^{cm} to 3^{cm} from their origin to the points where they penetrate the stone. The scars of the rootlets, as well as the tubercles of the leaves and the articulations, are distinctly seen down to the rounded or subtruncate part of the inverted cones which constitute the base of the stems. The lowest articulations, less than 6^{mm} apart, are gradually more distant up to the eighth one, where, at 7^{cm} from the base, the space between them is 15^{mm}. There is no trace of any rhizoma with these speci-

[1] Die Calamarien der Carbon-Flora der Schatzlarer Schichten. Abhandlungen d. k.-k. geol. Reichsanstalt, vol. XI, 2. Abth., Wien, 1887, p. 4.

[2] Op. cit., p. 8.

[3] Coal Flora, vol. III, p. 702; Pl. XCII, Figs. 1-4.

mens, which are all isolated. But another specimen from the same locality has three stems, two of which appear to originate from an inclined stock resembling a fragment of *Calamites*, as if they were attached to it like branches, while another gradually narrowed to a point or to a sharply obconical base, bears rootlets and merely touches the stock by its point, in the same way as are represented by the young shoots derived from a horizontal branch in Grand'Eury's Fl. Carb., Pl. I, Fig. 2. In all the specimens observed without connection to a parent stock, the basilar point of the stem is a small blunt mamilla, smooth or without any trace of fracture or point of attachment, and the radicles are diverging all around the conical base.

Lesquereux's description was based on specimens $1\frac{1}{2}$–4^{cm} in diameter. The figures[1] show the tubercles to be low down on the costæ of the root-bearing portion, sometimes near the middle of the shorter internodes and covering a considerable portion of the costæ. The specimens figured are in the cabinet of Mr. R. D. Lacoe, of Pittston, Pennsylvania. Two specimens identified and labelled by Prof. Lesquereux as *Calamites ramosus* are at present in the fossil plant collection of the U. S. National Museum. Both purport to come from Ottawa, Illinois. The rock is a coarse and rather soft sandstone, somewhat stained by iron. Both fragments agree fairly well with Lesquereux's figures. The larger specimen, an impression about 10^{cm} long and 6^{cm} wide, shows neither the full width of the stem nor the extreme lower part of it. It presents five nodes, the lowest segment being about $1\frac{1}{4}^{cm}$ in length, the highest about 3^{cm}. The tubercles are large, circular, and near the tops of the ribs. The rows of pits, apparently on the nodes, marking the origin of the rootlets, seem as represented in the Coal Flora, Figs. 1, 2, the number of pits nearly equaling the number of ribs of the segment. A fracture of the rock shows the filamentous appendages illustrated in Fig. 2. The tubercles are larger at the lower nodes. The second specimen is a cast, about 10^{cm} long, of the contracting base of the stem, but does not include the tip. It remains partly embedded in the rock and is somewhat flattened, but nearly three-fourths of its circumference is exposed, indicating a diameter of about 5^{cm} at the top and $2\frac{1}{2}^{cm}$ at the bottom of the fragment. Five articulations are seen, the highest $2\frac{1}{2}^{cm}$ in length, the lowest 8^{mm}. It resembles Fig. 3 of the Coal Flora. A portion of the cast not compressed shows the low ribs finely striated, the distance being the same as in undoubted stems of this species. It also shows the two vascular bundles marking by their creases the borders of the furrows. The ribs are mostly flat in the upper part of the fragment, but become round and prominent in the lower portion. The upper tubercles are large, well developed, and often protruded. This protrusion has in places been very great, as is distinctly shown by their having been broken off, sometimes at a distance of 2^{mm} from the rib, the stout stump lying twisted obliquely aside, so that in a few cases they overlap halfway across the next rib. Smaller scars, usually indistinct, can be sometimes seen at the bottoms of the larger costæ. No appendages corresponding to the pits seen in the impression in hand, or in

[1] Op. cit., Pl. XCII, Figs. 1-4.

those figured in the Coal Flora, are clearly demonstrable on the cast, nor do the elongated tubercles of the cast described above seem to correspond in position with the pits of the impression. In the impression the specific characters are indistinct, the ribs are broader, and the tubercles larger. The pits which were interpreted by Lesquereux to represent the origin of the roots are distinctly seen, in many cases, to be placed at the base of the ribs. Owing to the close interlacing of the ribs at the nodes in the lower segments, these pits are practically on the nodes themselves. They perhaps represent the tubercles at the lower end of the ribs. The pits are circular, and pass down into the rock, and in many cases a portion, at least, of the vascular fibres running along the furrows of the interior internode may clearly be seen to curve and pass down into the larger of the pits. It may be added that the same feature is observable on a tip from the same place identified by Lesquereux as *C. Suckowii*. The internal cast of this base of *C. Suckowii* has internodes more or less concave. The lower ends of the ribs, jutting out very prominently and generally broken, strongly indicate, in the appearance of the fracture, a former protuberance, coinciding with the pits in the impression of the same specimen, these pits remaining hollow to a depth of 6^{mm} or 7^{mm}. The specimens identified by Lesquereux correspond in the much rounded dome-shaped apex, the proportionate length of the internodes, and the disposition of the tubercles with the figures of *C. Suckowii* on Stur's Pl. v, Figs. 5, 6; Pl. XVI, Fig. 1. But one of the distinctive characters of *C. ramosus*, according to that author, lies in their tips being more acute. While the identity of the Museum specimens with *C. ramosus* is very probable, the fragments in the Museum are insufficient to warrant the conclusion that they belong indisputably to that species. Although they agree largely with the base figured, but not described in detail, by Stur (op. cit., p. 8) neither they nor Stur's Fig. 7 correspond in form to the base attached to the specimen figured by the latter as the rhizome of this species. And while the specimens figured by Lesquereux seem to have the characters of *C. ramosus*, we can not consider either the stem bases nor the rhizomes of this species as definitely correlated until they are demonstrated by better material or actual union.

Roots originating at the articulation of the lower portion of the main stems have been described and figured by several authors. These are simple, in fascicles, or sometimes in verticils. Frequently they appear in fascicles or semi-verticils about the lower side of the articulations of the main branches with the stem. They are cylindrical, 4–7^{mm} thick, and about 10–17^{mm} long, or perhaps longer, tapering to a point. These roots have their surfaces shagreened and are traversed by an axial vascular bundle.

Stems and branches.—This species of *Calamites* is very ramose, the branches dividing in the same manner as the stems. The internodes of the latter are usually 5–25^{cm} long, the low ribs 1½–3 or 4^{mm} broad, finely

striated, and the furrows $\frac{1}{4}$–$\frac{1}{2}^{mm}$ wide, marked in the cast at each edge by the furrow of a vascular bundle, the intervening portion being raised. The segments are generally swollen toward the joints. The branch scars, usually two, opposite, at each node, though sometimes three, one, or even none, are 1–$3\frac{3}{4}^{cm}$ in diameter. The larger branches, rather oblique to the stem, reach a diameter of $3\frac{1}{2}^{cm}$ and have internodes as long as 20^{cm}. The ribs on the branches are narrower than on the stem, $\frac{1}{2}$–$1\frac{1}{2}^{mm}$ broad, the furrows becoming less distinct. The general diametrically opposite habit of branching gives the secondary ramification a distichous aspect, although the larger branches frequently give rise to three subordinate branches from a node. The internodes in the smaller branches become shorter, and the ramification more nearly distichous.

Foliage.—The discovery of the dependence of certain forms of *Annularia radiata*, as foliage, on *Calamites ramosus*, was made independently, and at about the same time, by both Weiss and Stur. The larger foliate branches are mostly distichous in pairs $\frac{1}{2}$–3^{mm} in width, with nodes 15–30^{mm} long, finely striate, the smaller branches being $\frac{1}{2}$–1^{mm} wide, the verticils overlapping. The verticils contain 8–20 uninerved acute leaves, often linear, spread out flat and joined at the base in a very narrow ring. The length of the leaves varies greatly, those in the larger foliar twigs, whose verticils often only touch, measuring 15^{mm} in length, and reaching a width at the widest part of 2^{mm}, becoming contracted toward the base. Those in the smaller verticils are shorter, 7–15^{mm} in length, narrower, $\frac{1}{2}$–2^{mm}, and more acute, the number of leaves to the verticil also diminishing. Those on the smallest branches are proportionately broader at the base and somewhat resemble *Annularia microphylla*. The observed foliage of *Calamites ramosus* includes nearly all the forms that have been described as *Annularia radiata* (Brongn.) Stb., and Zeiller and Kidston refer this entire species to the *Calamites* in question. So far, however, the long awl-shaped leaves figured by Brongniart in his original description,[1] and later by Geinitz,[2] which are rare, have not been seen attached, I believe,[3] to this species of *Calamites*. The true *Annularia radiata* of Brongniart has its verticils from $3\frac{1}{2}$–5^{cm} in diameter, the leaves being also much narrower in proportion to their length, while those verticils attached to the *Calamites* measure about $2\frac{1}{2}^{cm}$ across. Observing this difference, Weiss and Stur independently restricted *Annularia radiata* to Brongniart's typical form, each proposing for the Calamitean foliage the name *Annularia ramosa*. The description and figures of Stur's *Annularia ramosa* having been prepared in 1880, while Weiss's announcement of the discovery, in which he proposes the name *A. ramosa* Weiss, appeared in 1881, Stur sues for priority, though his publication did not appear till later. However, strict observance of the rules of nomenclature demands priority for *Annularia*

[1] Classif. et dist. vég. foss., 1822, Pl. II, Figs. 7a, b.

[2] Verst. Steink. Sachsens, Pl. XVIII, Figs. 6, 7.

[3] In arranging the synonymy I have cited only those figures which may be referred to as the leaves of *Annularia ramosa*.

ramosa Weiss, the *A. ramosa* Stur being identical with it, and its synonym. The specimens referred by Geinitz[1] and Lesquereux[2] to *Asterophyllites foliosus* and by Lebour[3] to *Calamites nodosus* are possibly *Annularia ramosa* Weiss.[4]

Fructification.—The brilliant discoveries of Weiss and Stur which almost simultaneously established the absolute connection between stem, branches, and foliage of *Calamites ramosus* were further singularly coincident in revealing the fruiting spikes attached to the branches. These strobili are mostly small, slender, and elongated, fixed at the end of the leaf-bearing twigs, or arranged in irregular panicles. The axis is slender, the segments being about 3^{mm} long, the joints surrounded by verticils of very slender, short, acute, sterile bracts, curved outward at nearly a right angle at the base, and turning upward. In the older portions of the spike they arch farther backward, but near the end they curve upward, closing together like a bud at the apex. The sporangiophores spring from the middle of the internodes according to the *Bruckmannia* type. The sporangia are distinct when present, but their internal structure is not yet known. More often they are fallen away. The spikes are usually borne on multinodial leafy twigs, the minute leaves of the latter measuring about $\frac{1}{2}^{cm}$ in length and $\frac{1}{2}^{mm}$ in width. For the strobili of *Calamites ramosus* Weiss proposed the name *Calamostachys ramosa.*

Habit and relations.—The roots springing from the lower articulations of the main stem (not the conical base) and especially at the origin of the primary branches, are construed by some authors as indicating a subaqueous or subterranean habit of growth. The distichous ramification of some of the larger branches and the *Annularia* branchlets, in one plane, are said to argue a floating condition for them, while the others, branching irregularly, including the irregular forms of *Annularia* with the minute leaves, may represent an aerial growth. Stur inclines to the belief that the species is heteromorphous, and that certain *Volkmannia* spikes, found intimately associated, also belong to this species; but as only the one described has been found physically united, the relation of the *Volkmannia* remains in doubt.

Calamites ramosus is most nearly related to *C. ramifer* and *C. Suckowii*, Weiss having referred Stur's *C. ramifer*[5] to *C. ramosus.* Stur in his Calamariæ, p. 116, describes the former as the ancestor of *C. ramosus*, which he regards as representing a later condition of the same type. He describes the rhizome of the latter as similar to the stems, while that of *C. ramifer* requires a careful examination to prove it a *Calamites.*

[1] Verst. Steink. Sachsens, Pl. XVI, Fig. 2.

[2] Coal Flora, I, p. 39.

[3] Illustrations, Pl. III.

[4] The annularian leaves are well represented in Weiss's Monograph of the *Calamariæ*, Part 2, and Stur's *Calamariæ* of the Schatzlar strata, Pl. XIV, and XIII, Figs. 1–9 of the latter having been made from the same specimen.

[5] Culm-Flora, II, 1877, p. 82 (188), Pl. III, Figs. 3, 3b, 4; Pl. IV, Figs. 2, 3, 4.

The stems of *C. ramifer* have a thick coaly substance, while those of the other species have a very thin, almost membranaceous layer. The Lower Carboniferous form has few branches, often naked for 2–4 consecutive joints, whereas the Carboniferous form branches at every, or nearly every joint, the ornamentation being at the same time slightly more distinct. The furrows of the stems of *C. ramosus* are sometimes alternate, sometimes irregular at the nodes, and quite frequently they pass directly across the node, continuing along the next interval. The last arrangement is much more common in *C. ramifer*, and would seem to suggest a transition from the *Bornia* type. The stems of *C. ramosus* differ from those of *C. Suckowii*, as pointed out by Zeiller, by the proportionately longer internodes of the former, the branches not shortened near the insertion of the stem, the ribs often broader, less distinctly marked, the tubercles at the upper ends more oval, and the striations of the internal cast less crowded, resembling more those of *C. undulatus*. The close relation of *C. ramosus* and *C. Suckowii* in their ramification, shows the artificial character of Weiss's classification and argues against the promotion of the groups *Eucalamites* and *Stylocalamites* to independent generic rank.

Locality.—Represented by several fragments of stems and detached foliage from McClelland's Shaft, near Belleville, and from Aurora, Lawrence county.

ANNULARIA Sternberg. 1823.

ANNULARIA STELLATA (Schloth.) Wood.

1699. *Apparinæ densius foliatæ* Luidius, Lithophyl. Brit., p. 12; Pl. v, Fig. 201. 1723: Scheuchzer, Herb. diluv., p. 19; Pl. III, Fig. 3.

1771. *Galium album latifolium* Rupp., Walch, Naturgesch. Verst., III. Th. p. 117; pl. ω, Fig. 2.

1723. *Galium album vulgare* Tourn., Scheuchzer, Herb. diluv., p. 63; Pl. XIII, Fig. 3.

1804. ——, Schlotheim, Flora Vorw., Pl. I, Fig. 4.

1804. *Equisetum?* Parkinson, Organic Remains, p. 428; Pl. v, Fig. 11.

1809. *? Phytolithus stellatus* Martin, Petrificata Derb., Pl. XX, Fig. 4.

1820. *Casuarinites stellatus* Schlotheim, Petrifactenkunde, p. 397. 1832: Schlotheim, Merkwürdige Verst., p. 5; Pl. I, Fig. 4.

1823. *Annularia spinulosa* Sternberg, Versuch, I, fasc. 2, pp. 28, 32; Pl. XIX, Fig. 4; Tent., p. xxxi.

1826. *Bornia stellata*, Sternberg, Versuch, Tent., p. xxviii.

1826. *Annularia fertilis* Sternberg, Versuch, I, fasc. 4, p. 43; Pl. LI, Fig. 2; Tent., p. xxxi. 1837: Bronn, Lethæa geogn., p. 44; Pl. VIII, Fig. 8. 1859: Eichwald, Lethæa rossica, p. 187; Pl. XIV, Fig. 9.

1828. *Annularia longifolia* Brongniart, Prodrome, p. 156. 1845: Germar, Verst. Wettin u. Löbejün, p. 25; Pl. IX, Figs. 1–3. 1849: Brongniart, Tableau, p. 53 (102). 1852: V. Ettingshausen, Steink.-Fl. Stradonitz, p. 8; Pl. I, Fig. 4. 1855: Geinitz, Verst. Steink. Sachsens, p. 10; Pl. XIX, Figs. 3–5. 1866: Lesquereux, Geol. Surv. Ill., II, Pal., p. 444. 1869: Schimper, Traité, I, p. 348 (pars); Pl. XXII, Fig. 5; Pl. XXVI, Figs. 2, 3, 4. 1869: v. Roehl, Foss. Fl. Steink. Westphal., p. 28; Pl. IV, Fig. 6. 1874: O. Feistmantel, Verst. böhm. Ablag, I, p. 127; Pl. XV, Fig. 3; Pl. XVI, Fig. 1. 1876: Ferd. Roemer,

Lethaea geognost., I, atlas, Pl. L, Fig. 8; text (1880) p. 150. 1876: Heer, Fl. foss. Helv., p. 51; Pl. XIX, Figs. 4, 5. 1879: Lesquereux, Coal Flora, atlas, Pl. II, Figs. 1, 2, 2a; text (1880), I, p. 45. 1881: Lesquereux, Rept. Geol. Surv. Ind., 1879-'80, p. 153; Pl. XI, Fig. 1. 1882: Renault, Cours bot. foss., II, p. 126; Pl. XX, Fig. 1. 1883: Lesquereux, 13th Rept. Geol. Surv. Ind., pt. 2, p. 44; Pl. VII, Figs. 1, 2. 1883: Schenk in Richthofen's China, IV, p. 232; Pl. XXXIX. 1884: Lacoe in Lesquereux, Coal Flora, III, p. 706. 1889: Lesley, Dict. foss. Penn., I, p. 26 (fig.).

1834. *Asterophyllites equisetiformis* (Schloth.) Brongn., Lindley and Hutton, Foss. Fl., II, Pl. 124.

1835. *Equisetum stellifolium* Harlan, Trans. Geol. Soc. Penn., I, p. 260; Pl. XIV, Fig. 4.

1836. *Asterophyllites?* Morton, Am Jour. Sci. XXIX, p. 151; Pl. IX, Fig. 30.

1840. *Asterophyllites*, Jackson, Rept. Geol. Surv. R. I., 1839, p. 288; Pl. VI.

1841. *Annularia*, Hitchcock, Final Rept. Geol. Mass., II, p. 754, Fig. 226; Pl. XXII, Fig. 3; Pl. XXIII.

1860. *Annularia stellata* (Schloth.) H. C. Wood, Proc. Acad. Nat. Sci., Philada., XII, p. 236. 1878: Zeiller, Vég. foss. terr. houill., atlas, Pl. CLX, Figs. 2, 3; text (1879) p. 26. 1886: Zeiller, Fl. foss. Valenciennes, atlas, Pl. LXI, Figs. 4–6; text (1888), p. 398. 1887: Kidston, Radstock Series, p. 343. 1887: Stur, Carb.-Fl. Schatzlarer Sch., II, p. 55; Pl. XIIIb, Fig. 3. 1890: Renault and Zeiller, Fl. foss. Commentry, Pt. 2, p. 398; Pl. XLV, Figs. 1–7; Pl. XLVI, Figs. 1–6.

1868. *Asterophyllites longifolius* (Sternb.) Brongn., Binney, Obs. Struct. foss. pl. Carb., I, p. 28; Pl. VI, Fig. 3.

1883. (?) *Annularia mucronata* Schenk in Richthofen, China, IV, p. 226; Pl. XXX, Fig. 10.

1887. *Annularia Geinitzii* Stur., Carb.-Fl. Schatzlarer Sch., II, p. 215; Pl. XVIb, Figs. 1, 2, 3.

1887. *Annularia westphalica* Stur, op. cit., p. 213; Pl. XIIIb, Fig. 2.

1887. *Asterophyllites westphalicus* Stur., op. cit., p. 216; Pl. IVb, Fig. 4.

FRUCTIFICATION.

1826. *Bruckmannia tuberculata* (pars?) Sternberg, Versuch. I, fasc. 4, Tent., p. xxix; Pl. XLV, Fig. 2. 1882: Renault, Cours bot. foss., II, p. 129; Pl. XXI, Figs. 1–6bis.

1828. *Asterophyllites tuberculata* (Sternb.) Brongniart, Prodrome, p. 159.

1876. *Annularia longifolia* Brongn., Ferd. Roemer, Lethaea geognost., I, atlas, Pl. L, Fig. 9; text (1880), p. 150. 1877: Grand'Eury, Fl. Carb. Loire, p. 44; Pl. VI, Fig. 4. 1879: Heer, Urwelt d. Schweiz, p. 16; Fig. 22. 1879: Lesquereux, Coal Flora, I, Pl. III, Fig. 10 (not 11 and 12). 1882: Renault, Cours bot. foss., II, p. 126; Pl. XXI, Figs. 1–7. 1883: Schenk in Richthofen, China, IV, p. 232; Pl. XXXIV, Figs. 4–7; Pl. XXXV, Fig. 7; Pl. XXXVI, Figs. 1–4; Pl. XXXIX; Pl. XLI, Fig. 6.

1876. *Stachannularia tuberculata* (Sternb.) Weiss, Steink., Cal., I, p. 17; Pl. I, Figs. 2–4; Pl. II, Figs. 1–3; Pl. III, Figs. 3–10, 12.

1884. *Calamostachys tuberculata* (Sternb.) Weiss (nec Lx.), Steink.-Cal., II, p. 178.

1886. *Annularia stellata*, Zeiller, Fl. foss. Valenciennes, atlas; Pl. LXI, Figs. 3, 3a; text (1888), p. 398. 1890: Renault and Zeiller, Fl. foss. Commentry, II, p. 398; Pl. XLV, Figs 1, 3; Pl. XLVI, Figs. 4–6.

Stems finely striate, branching distichously opposite at the articulations, all the ramifications lying in the same plane; leaves in whorls of sixteen to thirty-two at the nodes of the branches, narrowly lanceolate-spatulate, broadest at the middle, or a little above the middle, cuneate towards the base, lanceolate, rather abruptly contracted to an acute point or somewhat obtuse above, 1–5^{cm} long, 1–3^{mm} wide, flat or slightly arched, with borders usually reflexed, the entire whorl lying nearly in the same plane as the branches; medial nerve broad and distinct.

Fructifications in long cylindrical spikes, arranged in verticils at the nodes of the principal branches or stems, characterized by whorls of sterile bracts at the joints of the axis, with alternating whorls of sporangiophores situated on the ribs in the internodes, representing a type familiar under the name *Bruckmannia tuberculata* Sternberg.

This species, one of the commonest of the *Annulariæ*, was among the first to be described and finally reconstructed, though the caducous nature of the branches and spikes delayed the definite correlation of the organs until recent years. Its large, showy verticils are easily distinguished, causing it to be one of the most commonly recognized plants of the Coal-measures.

Stems.—The remarkable specimens of *Annularia stellata* described by Schenk in Richthofen's China (Vol. IV, Pl. XXXIX), and by Renault and Zeiller from the coal field of Commentry, showing the foliage attached to the branches and stems, confirm the view entertained by Grand'Eury and others, that the large trunks known as *Equisetites lingulatus* Germar[1] are but the stems of this Annularia. The trunk figured by Schenk is of calamitean aspect, and is over 5^{cm} in diameter, with an internode nearly 13^{cm} in length. Zeiller describes the stems (Valenciennes, p. 399) as having a width of 5 to 6^{cm}, with internodes 6 to 12^{cm} long. Though it is extremely rare that foliated branches are found attached to the large stems, it has been the good fortune of the distinguished French paleobotanists to find such among the Commentry plants. These discoveries seem to corroborate the description and conclusion of Mr. R. D. Lacoe, communicated to Prof. Lesquereux in 1884 and published in the third volume of the Coal Flora (p. 706), as follows:

I have upon four parts of a once large stone upwards of fifty verticils of *Annularia longifolia*, the leaves of which vary from 1½–3½^{cm} in length, the large ones attached to branches 4–5^{mm} in width, flattened. These branches come out from larger ones, or stems 15–16^{mm} wide, and upon the same stone, there is a *Calamites* stem which appears to be of the same species and measures 7½–8^{cm} in diameter. The articulations are 18–20^{cm} apart. One of them, with the branch still attached, which is 18–20^{mm} in diameter, is broken at its second articulation 35^{mm} from its point of origin. Upon the same fragment of stone there is another limb or branch 12–15^{mm} wide, passing under the main or large stem in the direction of its other articulation, and to this limb is attached one of the small branches with verticils of leaves. I have no doubt that all these fragments of stems of various sizes belong to the same species.

It is unfortunate that in the haste of preparation of the third volume of the Coal Flora this fine specimen could not have been figured. Renault, who has minutely described the structure of the silicified stem of this *Annularia*, finds it to be essentially parenchymatous, with an extremely thin development of the woody zone and cortex, while the smaller stems show a structure not essentially different from the living *Equiseta*.

Foliage.—From nearly all of the enlarged joints of the large stems spring pairs of branches, arranged distichously, in the same plane. These vary from ½–2^{cm} in diameter, with intervals sometimes as long

[1] Verst. Steink. Wettin u. Löbejün, p. 27, Pl. X.

as 7cm very finely, often indistinctly, striated, the verticils usually touching or slightly overlapping. These give rise in the same manner to other branches, springing from above the verticils at the joint, sometimes nearly at right angles, sometimes more obliquely. The latter are very long and slender, with a width of less than 5mm. The verticils of these branches occur at intervals of 1½–3cm, becoming smaller and overlapping one another sometimes nearly one-half their diameter. Renault and Zeiller illustrate in the second part of the Flora of Commentry (Pl. XLVI, Fig. 1) a large slab about 70cm long and 45cm wide, almost wholly covered by a portion of the ramification and foliage of an incomplete segment of a branch or stem of this species. Occasionally the leaves of *A. stellata* are found flattened in the shales, the result of decomposition or pressure. Renault has observed the leaves on the smaller branches to be as short as 1–1½cm, while the lateral leaves of the larger verticils measured 6–7cm. Notwithstanding its generally uniform habit, considerable variations have been observed in different specimens, perhaps due only to local influences or the circumstances of fossilization. Dr. Stur, who has examined many specimens with much painstaking, proposes[1] to divide *Annularia stellata* into three species, of which the first, *A. stellata* Stur (emend.), has the margin of the leaves thickened; the second, *A. Geinitzii* Stur,[2] has the upper surface of the leaves hairy; while the third, *Annularia westphalica* Stur,[3] is characterized by its strong stem prominently ribbed with more coaly substance, and the closer verticils of rigid leaves radiating to right and left, but not covering the stems. A deeply dissected specimen belonging to the last species he designates[4] as *Asterophyllites westphalicus*, on account of its asterophyllitean appearance, such a dual nomenclature being consonant with the author's view of the occurrence of forms referable to both *Asterophyllites* and *Annularia* on different parts of the same calamitean plant. It is doubtful whether these differences are constant or of more than varietal importance. Stur's illustration of *A. fertilis* Sternb.[5] seems hardly identical with Sternberg's type, which belongs to *A. stellata*, but in the proportions and laxness of the leaves it closely resembles *A. ramosa*.

Fructification.—The union of the stems and fruiting spikes observed by several authors in recent years corroborates the opinion long entertained that the fruiting of *Annularia stellata* was included among the strobili familiar under the name *Bruckmannia tuberculata*. Renault and Zeiller in the atlas of their magnificent work on the Commentry flora represent (Pl. XLV, Fig. 1) a stem of the *Equisetites lingulatus* type, over 3cm wide, with nodes at intervals of 1½cm, from the lower six of which radiate verticils of *Bruckmannia tuberculata* at an

[1] Carbon-flora d. Schatzlarer Schichten, II, p. 213.
[2] Op. cit., p. 215, Pl. XVI*b*, Figs. 1, 2, 3.
[3] Op. cit., p. 213, Pl. XIII*b*, Fig. 2.
[4] Op. cit., p. 216, Pl. IV*b*. Fig. 4.
[5] Op. cit., p. 216, Pl. XIV, Figs. 6, 7.

angle of about 45 degrees, while the upper part of the stem, poorly preserved, is foliate. From the large number of specimens obtained in the various coal basins of France, Zeiller describes [1] the strobiles as disposed in verticils on the principal branches and perhaps on the stem, twelve to sixteen to a single articulation, often for many consecutive nodes, short pediceled, cylindrical, 7–15^{cm} long, with axes 2½–5^{mm} wide, with low but quite distinct ribs, the joints provided with verticils of sterile bracts, while alternating verticils of sporangiophores are situated on the internodes. The bracts are linear-lanceolate, 4–6^{mm} long, tapering to a point, open or reflexed at the base, then curving upward and slightly inward. They occur in verticils of 16–32, springing from the joints of the axes, which are 4–6^{mm} apart. The sporangiophores are arranged in verticils situated in the intervals between the bract verticils, usually midway between the latter, the number of sporangiophores to the verticil being half as many as that of the bracts, each sporangiophore bearing four ovoid sporangia at its summit. The strobili have not been seen in pairs distichously, conforming to the plane of ramification. Often the upper sporangia are compressed and deformed by pressure between the reflexed sterile bracts above and the axis, and crowded against the sporangiophores so that they appear as a part of the latter. Schenk shows that this produces the effect of "rose thorns" with the convex side upward, so often mentioned in describing the sporangiophores of *Bruckmannia*. The strobili are seldom found except in fragments, and then the sporangia are often wanting. The ribs are marked by slight scars where the sporangiophores are fallen. Renault [2] describes and figures in detail the internal structure of silicified specimens, in which he finds one pair of sporangia above and one pair below each sporangiophore. The bracts are seen to have a single distinct nerve, which is all that shows on some specimens where the margins have disappeared. The sporangia consists of sacs about 2^{mm} long, $\frac{7}{10}$^{mm} thick, and 1$\frac{3}{10}$^{mm} in diameter. He found the spores of the upper part of the spike to be spherical, $\frac{4}{100}$^{mm} in diameter, and grouped in fours. From the lower part of the spike, however, he describes larger spores, $\frac{8}{100}$–$\frac{1}{10}$^{mm} in diameter, round like the former but isolated, which he considers as macrospores. The presence of both microspores and macrospores in *Annularia* brings it into closer relations with *Asterophyllites*, thus appearing to lend support to the conclusions reached by Stur (Carbon-flora, II) that *Annularia* and *Asterophyllites* are both the foliage of *Calamites*, the former representing the floating or submerged branches, the latter the ærial branches, on both of which were borne the *Bruckmannia* type of fructification. From its structure Renault was led to the generally prevalent view of the floating habit of *Annularia*. On the other hand, it was the opinion of Lesquereux and Zeiller that some, at least, of the

[1] Valenciennes, p. 400.

[2] Cours de botanique fossile, 2^{e} année, p. 130, Pl. XXI.

Annularia could not be floating, an opinion that is supported by the arrangement of the strobili about the stem.

Relations.—Neither the base of the stem, the rhizomes, nor the roots of *Annularia stellata* are known. Considering this, in connection with the facts that the largest known stems of this species are calamitoid in form, and that the *Annularia radiata*, whose fruiting spike is also a *Bruckmannia* differing but slightly from *B. tuberculata*, is, in part at least, the branchlets and foliage of *Calamites ramosus*, the conclusion becomes highly probable that the lower trunk and rhizomes of *A. stellata*, when found, will be entitled to a position in the comprehensive genus *Calamites*. *Annularia stellata*, as generally understood, is easily distinguished from the other species of its genus. It differs from *A. radiata* by the greater size of its leaves, which are generally more rigid and more spatulate than lanceolate, by the larger number of the leaves in the verticil, and their more obtuse apices, and by the distinct nerve usually depressed. Its fruit spikes are larger and much longer than those of *A. ramosa* or *A. sphenophylloides*, as is seen from the descriptions. *Annularia inflata* Lx. differs by its inflated leaves, oval in transverse section, and its obscure or wholly invisible costa, while *A. mucronata* Schenk is described as having a rounded tip with a mucronate point, and the leaves broader near the apex.

In his valuable report on the fossil plants of the Carboniferous,[1] in which he has done justice to many early authors, while doing good service to the science of paleobotany by restoring to use many names that should have priority according to the rules of nomenclature now generally obtaining in other branches of biology, Zeiller restores (p. 27) Schlotheim's species, identified in this country by Wood, as having priority over Brongniart's *Annularia longifolia*. This is certainly just; but it should be noted that Martin, in his Petrificata Derbiensia, 1809, a work accepted among paleozoologists, figures, Pl. xx, Fig. 4, and describes, p. 25, a specimen as *Phytolithus stellatus*, belonging to his family *Plantitæ*, which, if referable to our species, as it seems to be, would give priority to Martin, as earlier than Schlotheim, though the specific name *stellata* would remain the same. Whether Martin or Schlotheim has priority depends entirely upon the identity of the species figured by the former, a question which should be decided, if possible, by an examination of Martin's type.

Locality.—The species is represented by fragments of foliage and well preserved portions of strobili from McClelland's shaft.

ANNULARIA SPHENOPHYLLOIDES (Zenk.) Gutb.

1699. *Rubeola mineralis* Luidius, Lithophyl. brit., p. 12, No. 202.
1771. *Rubia sylvestris* Volkmann, Walch, Naturgesch. Verst., III, p. 117; Pl. ω, Fig. 1. 1804: Parkinson, Organic Remains, p. 428; Pl. v, Fig. 3.

[1] Explication de la Carte géologique de la France, vol. IV, pt. 2, Paris, 1879.

1828. *Annularia brevifolia* Brongniart, Prodrome, p. 156. 1849: Brongniart, Tableau, p. 53. 1853: Newberry, Annals of Science, vol. I, p. 97. 1855: Phillips, Man. Geol., p. 234. 1876: Heer, Fl. foss. Helv., p. 51; Pl. XIX, Figs. 6–9. 1880: Roemer, Lethaea geognost., p. 150; Fig. 7. 1880: Schimper in Zittel, Handbuch Pal., II, p. 167; Fig. 127. 1883: Schenk in Richthofen, China, IV, p. 233; Pl. XL. 1887: Stur, Carbon-Fl. Schatzlarer Sch., II, p. 223; Pl. XVIb, Figs. 3, 4.

1833. *Galium sphenophylloides* Zenker, N. Jahrb. f. Min., p. 398, Pl. V, Figs. 6–9.

1837. *Annularia sphenophylloides* (Zenk.) Gutbier, Isis v. Oken, col. 436. 1854: Lesquereux, Boston Journ. Nat. Hist., VI, p. 415. 1855: Geinitz, Verst. Steink. Sachsens, p. 11; Pl. XVIII, Fig. 10. 1858: Lesquereux, Geol. Penn., II, p. 852; Pl. I, Figs. 5, 5a. 1860: Roemer, Palaeontog., IX, p. 21; Pl. XI, Fig. 1. 1860: Lesquereux, 2d Rept. Geol. Surv. Ark., p. 314. 1866: Lesquereux, Geol. Surv. Ill., Paleont, II, p. 444. 1869: Schimper, Traité, I, p. 347; Pl. XVII, Fig. 12, 13. 1870: Unger, Sitzb. Acad. Naturw. Wien, math. nat. Cl., LX, 1, p. 783, Pl. I, Fig. 8. 1874: O. Feistmantel, Verst., böhm. Ablag., I, p. 129, Pl. XVII, Figs. 5, 6. 1878: Lesquereux, Rept. prog. Geol. Surv. Penn., "Q," p. 54. 1878: Zeiller, Vég. terr. houill.; atlas, Pl. CLX, Fig. 4; text (1879), p. 25. 1879: Lesquereux, Coal Flora, atlas, Pl. II, Figs. 8, 9; text (1880), I, p. 48. 1880: Fontaine and I. C. White, Permian Flora, pp. 20, 39. 1881: Weiss, Aus d. Flora d. Steink., Pl. IX, Fig. 47. 1882: Renault, Cours, bot. foss., II, p. 133; Pl. XX, Fig. 3. 1882: Sterzel, Zeitsch. d. deutsch. geol. Gesell., XXXIV, p. 685; Pl. XXVII, Figs. 1–10. 1883: Lesquereux, 13th Rept. Geol. Surv. Ind., pt. 2, p. 45; Pl. VII, Figs. 3, 4, 5. 1884: Lesquereux, Am. Nat., XVIII, p. 923. 1887: Lesquereux, Proc. U. S. Nat. Mus., X, p. 23. 1887: Kidston, Foss. Fl. Radstock Series, p. 344. 1888: Dawson, Geol. Hist. Plants, p. 122; Fig. 45b. 1886: Zeiller, Fl. foss. Valenciennes, atlas, Pl. LX, Figs. 5, 6; text (1888), p. 388. 1889: Lesley, Dict. foss. Penn., p. 28 (text fig.). 1890: Renault and Zeiller, Fl. foss. houill. Commentry, II, atlas, Pl. XLVI, Figs. 7–9.

1860. *Annularia microphylla* Roemer (nec Sauveur), Paleontogr., IX, p. 21; Pl. V, Fig. 1.

1887. *Annularia sarepontana* Stur, Carbon-Fl. Schatzlarer Sch., II. p. 221; Pl. XIIIb, Fig. 1.

FRUCTIFICATION.

1882. *Annularia sphenophylloides* Sterzel, Zeitschr. d. deutsch. geol. Gesell., XXXIV, p. 685; Pl. XXVIII, Figs. 1–4.

1876. (?) *Stachannularia calathifera* Weiss, Steink.-Cal., I, p. 27; Pl. III, Fig. 11. 1880: Ferd. Roemer, Lethaea geognost., I, p. 157.

1884. *Calamostachys* cf. *calathifera* Weiss, Steink.-Cal., II, p. 178.

Stems or primary branches slender, with rather fine longitudinal ribs, branches opposite at each node, nearly at right angles, biserial, the secondary and subsequent branches all in the same plane, branches and branchlets nearly at right angles, finely striate, usually bearing verticils close together but not overlapping, except in the ultimate divisions; leaves 15 to 20 to the verticil, 3–10^{mm} long, all spread out in the same plane as the branches, the lateral leaves sometimes slightly longer, giving the verticil a somewhat elliptical form, spatulate, wedge-shaped, enlarged towards the summit, which is abruptly rounded, with apex mucronate at the end of the single median nerve, or often emarginate, the surface of the leaves sometimes rough, the borders more or less recurved, frequently touching those of the next leaf; median nerve strong, sometimes broadening at the apex into an oval or sac-like form nearly twice as thick as its normal width.

Fructification in deciduous cylindrical strobili, 4–8^{cm} long, about 7^{mm} broad, short-pedicellate, situated biserially opposite at the joints of the branches, or perhaps in verticils, the joints of the axis 4–5^{mm} apart, bearing verticils of eight to twelve sterile bracts, the latter 3–4^{mm} long, $\frac{1}{2}$–$\frac{3}{4}$^{mm} wide at the base, close at the point of origin, open, slightly arched, linear, tapering to a slender point; sporangiophores in verticils alternating with and midway between the joints, normal to the axis, of the same number as the bracts and alternating with them with respect to their position on the stem, each sporangiophore bearing four ovoid sporangia at its apex; the sporangia, marked with meshes when well preserved, attached by their smaller ends and hanging centrad.

Like *Annularia stellata*, *Annularia sphenophylloides* is known only from its branches and appendages, although it is possible that the larger observed stems may belong to main trunks of the plant. The remarkably deciduous character of the ramification and foliage of the species leaves room for the belief that the lower unknown parts may be of considerable size, finding their place under some other name somewhere among the calamitoid stems. Schenk, in Richthofen's China,[1] figures as *Annularia brevifolia* a freely branching stem of *Calamites* about 15^{mm} in diameter with a node 8$\frac{1}{2}$^{cm} long, associated with leaves belonging to that species, which appears to bear fruiting spikes like those figured by Grand 'Eury[2] as *Volkmannia pseudosessilis*, regarded by the latter as the fruiting of *Annularia sphenophylloides*. The stem has the general habit of the branches of *Calamites ramosus* or *Calamites ramifer*, and is very likely a branch of a related *Calamites*. However, the leaf verticils do not appear in the illustration to be distinctly united to the branches, though their connection is perhaps as probable as that of the *Volkmannia* spikes. Judging from the figure, either verticils or spikes may be only intimately associated with the *Calamites*, as is the case with the pinnæ of *Pecopteris* lying among them. The fact that these strobili are quite different from those found organically united to *Annularia sphenophylloides* argues against their correlation with the latter species. The fact that *Annularia sphenophylloides*, *Annularia stellata*, and *Annularia ramosa* sustain such close specific relations one to another, the fact that their fructifications are likewise closely related, and the additional fact that *Annularia ramosa* (*Annularia radiata* in part) is but the foliar branch of a *Calamites* all indicate a similar calamitean rôle for *Annularia sphenophylloides* The presence at the joints, whence the branches spring, of lanceolate, acute leaves, like those on the stem of the specimen figured by Geinitz,[3] furnishes stronger proof than analogy, making it more probable that the *Volkmannia*, rather than the *Annularia*, is to be considered as extraneous, and that the verticils grew on the *Calamites* branches with which they are intermingled. In the second part of the Commentry flora,[4]

[1] Vol. IV, Pl. XL.
[2] Fl. Carb. Loire, p. 43, Pl. VI, Figs. 3, 3a.
[3] Verst. Steink. Sachsens. Pl. XVIII, Fig. 10.
[4] Atlas, 2d part, Pl. XLVI, Fig. 7.

the text to which has not yet appeared, Renault and Zeiller illustrate a slab about 25cm square, nearly covered by a part of the branches and foliage, apparently entirely originating from a larger stem about 25mm in diameter and about 7cm between the nodes, which are provided with slender asterophyllitean teeth similar to those on the specimen figured by Schenk. The union between this stem and the largest branch is distinct, and the whole of this beautiful specimen doubtless represents a part of a single system of ramification on which the verticils are still fixed. The larger stems previously recorded were from 8–12mm wide with the nodes 8–10cm apart.

Branches.—The greater of the leafy branches are usually nearly at right angles to the stems, and measure 1–5mm in width, with internodes 8–22mm long, the verticils at the nodes not overlapping. The branchlets, originating in the axis of the verticils and becoming more oblique toward the apex of the branch, are ½–1mm wide, with internodes 7–15mm long, while the final divisions are between ½ and 1mm in width, with nodes ½–1cm in length.

Foliage.—The leaf verticils vary considerably in their proportions. Usually they are nearly uniform in size for the entire length of the branchlet; in other cases they become slightly smaller toward the tip. Those on the smaller branchlets overlap more than those on the intermediary branches, the verticils of adjacent branches also overlapping. Frequently the verticils show a depression at the center, surrounded by a raised narrow ring where the bases of the leaves join together the wall of the stem. The fact that the verticils are sometimes slightly elliptical is thought by some authors to indicate that when living they were not quite in the plane of the ramification. Occasionally the leaves are thickened or inflated, by reason, perhaps, of an aqueous habitat. Often they appear obcordate, the end of the nerve concealed or visible, or sometimes enlarged to twice the natural size and appearing bladder-like at the tip. The surface of the leaves is rough under the lens, and when well preserved shows a series of filamentary markings radiating from the midrib to the margin. These appear to be composed of rows of scales.

In his excellent work on the *Calamariæ* of the Schatzlar stage[1] Stur separates *Annularia brevifolia* from *Annularia sphenophylloides* at the same time differentiating a new species, *Annularia sarepontana* Stur. As differentiated by the eminent Austrian paleontologist, *Annularia brevifolia* has the same form of leaves on branches and stems, without much variation in the size of the verticils; *Annularia sphenophylloides* has wedge-shaped leaves on the secondary branches, etc., but lanceolate leaves on the stem, the upper side of the leaves covered by microscopic scales. *Annularia sarepontana* branches much more rarely than the others, having over twice as many intermediate verticils, the latter twice as large, and the surface of the leaves marked

[1] Abhandl. d. k.-k. geol. Reichsanst., vol. XI, Abth. 2, Wien, 1887.

in a netted form like the nervation of *Lonchopteris*, but the reticulation is invisible without the aid of a glass. According to Stur the fructification known as *Stachannularia calathifera* Weiss belongs only to the last-named species, since he regards that as the only species found in the same horizon.

Of these three species of *Annularia* it is probable that the first two are inseparable, and they have been considered so almost universally. The last species is perhaps a more robust form of the other, and seems to be separated partly for geological reasons. Of the figures referred to in the above synonymy all but that given by Geinitz appear to represent *Annularia brevifolia* as defined by that author. Some of the American specimens show the filamentary markings of *Annularia sphenophylloides*, and all that I have seen have the verticils of the same form on the stems. One specimen in the collection of the U. S. National Museum shows a ramose stem with several pairs of branches coming from it, the verticil at the base of the lower pair being composed of lanceolate leaves like those in Geinitz's figure, while the succeeding verticils on the same stem at the bases of the branches preserve the usual form. It is probable that the leaves of the verticils at the bases of branches in the larger stems tend to the lanceolate or tapering form. The form which Stur differentiates as *Annularia sarepontana* may be comparable to the variety of *Annularia sphenophylloides* described by Lesquereux as *intermedia*.[1]

Fructification.—Branches of *Annularia sphenophylloides* with the strobiles attached were first made known by Sterzel,[2] who illustrated some specimens from the coal field of Saxony. In the large specimen figured the strobili are situated opposite, or possibly in whorls, coming from the verticillated joints at nearly right angles in the same habit as the sterile branches. The same branch bears typical verticils of *Annularia sphenophylloides* (*Annularia brevifolia* of Stur). The strobili differ from those of *Annularia stellata* chiefly by their shortness and rather smaller diameter. The sterile bracts taper from the base, arching upward and curving close about the sporangia, which are seen between, nearly equaling the internodes in length. The internodes with the sporangia in place present a globular appearance, while the bracts are seen under the lens to be transversely corrugated. Sterzel and Zeiller consider these strobiles as identical with those minutely described by Weiss as *Stachannularia calathifera*, a correlation hardly accepted by the latter author, although admitted as possible.

Relations.—Among the species of its size it is easily distinguished from both *Annularia microphylla* Sauveur (nec Roemer) and *Annularia Emersoni* Lx., by its wedge-shaped spatulate leaves, while, unlike the latter, it has a strong median nerve. Several authors have employed Brongniart's name, *Annularia brevifolia*, as having priority (1828) over

[1] Coal Flora, vol. III, p. 724.

[2] Zeitschr. d. deutsch. geol. Gesell., XXXIV, 1882, p. 685.

Zenker's *Galium sphenophylloides* (1833), changed by Gutbier to *Annularia*[1] before Brongniart had defined his species. But as Brongniart neither described, figured, nor made reference to any description or figure, we can only agree with Zeiller that his name can not stand.

Locality.—McClelland's shaft, near Belleville; and Hannam's shaft, near Carterville.

SPHENOPHYLLUM Brongniart. 1822.

Concerning the relations of the genus *Sphenophyllum*, which for more than half a century has been the subject of discussions, from various points of view, in which a large number of paleontologists and botanists have taken part, a strong disagreement still prevails. The rapid progress made in studying the internal structure of the Carboniferous flora, with its attending startling and revolutionary discoveries, has strongly affected the classification of many of the Paleozoic groups, including the *Sphenophylla*. The general characters of the internal structure of *Sphenophyllum* have been described by many authors. As to matters of detail and interpretation there yet remains much difference of opinion. In their general structure they seem to be intermediate between the *Calamariæ* and the Carboniferous *Lycopodiaceæ*. Renault, whose extensive researches in the internal structure of the coal measure flora is of the highest value, refers the genus to the *Rhizocarpeæ*, on account of its organization, foliage, and fructification, which he considers to be heterosporous. Zeiller considers it a distinct family, midway between the *Calamites* on the one hand and the *Lepidodendra* and *Sigillariæ* on the other. Schenk and Van Tieghm regard it as standing nearest to the *Lycopodiaceæ* by reason of its structure and the position of the sporangia on the spike, while Williamson, the distinguished present representative of a succession of fossil plant histologists, insists on its affinities to and union with the great family of the *Calamariæ* through its intimate relations, as he interprets them, with the *Asterophyllites*. Going still further, Stur, referring to the dimorphism appearing among the living *Equiseta*, regards *Sphenophyllum* as the heteromorphous macrospore-bearing branches of the *Calamites*, the *Asterophyllites* being the homomorphic branches.

In the continuity of the ribs, without alternation at the joints, *Sphenophyllum* resembles *Bornia*, the prototype of the calamarian family; and such a tendency to continuity in the ribs and furrows appears in *Calamites ramifer* and others of the older species of this genus. The bifurcation of the nerves also has its prototype in the same genus, as has been abundantly described and illustrated by Stur from excellent material in the Culm flora. Its articulated stems, with furrows and ribs and the pluri-nerved leaves in verticils at the joints, remove it

[1] Isis v. Oken, 1837, col. 436.

from the Lycopodiaceæ and bring it closer to the *Calamariæ*. The researches and illustrations of Newberry, Zeiller, and Stur show a tendency of the leaves in parts of *Sphenophylla* to simulate *Asterophyllites*.

Its structure, which is somewhat related to that seen in some forms described as *Asterophyllites*, presents hardly greater differences from these than are found in the organization in the many types among *Calamariæ*. Zeiller and Stur find the bracts of some *Sphenophyllum strobili* bifurcated like the leaves of some *Volkmanniæ*. Fontaine and White described their *Sphenophyllum latifolium* as having the leaves united at the base. Stur, in his magnificent work on the Schatzlar *Calamariæ* insists that indisputable specimens of *Sphenophyllum*, which he figures, were the branches of large stems of a type that has generally been described as *Calamites*.

In their atlas of the Carboniferous Flora of Commentry, Pt. II, the text for which I have not seen, Renault and Zeiller illustrate[1] as *Sphenophyllum oblongifolium* Germ., two branches of foliate branch-bearing stems of *Sphenophyllum* several centimeters long and about 5^{mm} wide, at whose joints, 10–12^{mm} apart, are found sheaths. These sheaths, which are found only on the main stems, are dissected nearly to the base into many slender, linear, acute teeth nearly 1^{cm} in length, some straight, some arching slightly inward, some outward, all inclined at a narrow angle of divergence from the stem.

For the reasons suggested above it may be excusable, at present, to regard *Sphenophyllum* as descended from a *Bornia* or *Archæocalamites* stock, in common with the rest of the calamitean family, to which its foliar members have the closest affinities through the Volkmannian and asterophyllitean types, while the trunks of the larger species will be found, I anticipate, to have been referred by various authors to that family under the names *Calamites*, *Macrostachya*, or, perhaps more properly, to *Calamitina*.

SPHENOPHYLLUM CUNEIFOLIUM (Sternb.) Zeill.

1823. *Rotularia asplenioides* Sternberg, Versuch, I, fasc. 2, p. 30; Pl. XXVI, Figs. 4 a, b.
1823. *Rotularia cuneifolia* Sternberg, op. cit., I, fasc. 2, p. 33; Pl. XXVI, Figs. 4 a, b.
1826. *Rotularia pusilla* Sternberg, op. cit., I, fasc. 4, Tent., p. xxxii.
1828. *Sphenophyllum dentatum* Brongniart, Prodrome, p. 68. 1850: Unger, Gen. et Species, p. 70. 1855: Phillips, Man. Geol., p. 234, Fig. 110.
1831. *Sphenophyllum erosum* Lindley and Hutton, Foss. Fl., I, Pl. XIII. 1847: Bunbury, Quart. Jour. Geol. Soc. London, III, p. 430, Pl. XXIII, Figs. 3a, 3b. 1864: Coemans and Kickx, Monogr. Sphen., p. 149; Pl. I, Figs. 5a, b, c. 1869: Schimper, Traité, I, p. 341. 1869: von Roehl, Foss. Fl. Steink. Westphalens, p. 30; Pl. IV, Fig. 19. 1869: Dawson, Acadian Geol., 3d Ed., p. 444, Fig. 165c. 1880: Lesquereux, Coal Flora, I, p. 55. 1881: Weiss, Aus d. Fl. Steink., Pl. X, Figs. 57, 57a. 1887: Lesquereux, Proc. U. S. Nat. Mus., X, p. 23. 1888: Dawson, Geol. Hist. Pl., p. 122, Fig. 45c. 1891: Newberry, Jour. Cincinnati Soc. Nat. Hist., XIII, p. 215, Pl. XIX, Fig. 1.

[1] Pl. L, Figs. 1, 2.

1869. *Sphenophyllum erosum* var. *saxifragæfolium* Schimper, Traité, I, p. 342; Pl. XXV, Fig. 10, 11–14.

1836. *Rotularia erosa* (L. & H.) Goeppert, Foss. Farrnkräuter, p. 431.

1848. *Sphenophyllum pusillum* (Sternb.) Sauveur, Vég. foss. terr. houill. Belg., Pl. LXIV, Fig. 4.

1855. *Sphenophyllum Schlotheimii* var. *β dentatum* et var. *ζ erosum* von Ettingshausen, Steink. Radnitz, p. 30; Pl. XI, Figs. 1–3.

1877. *Sphenophyllum dichotomum* (Germ. et Kaulf.) Ung., Stur, Culm-Flora, II, p. 119 (225). 1887: Carb.-Fl. Schatzlarer Sch., II, p. 233, f. 43; Pl. XV, Figs. 5a, b, c; Pl. XII b, Fig. 2.

1878. *Sphenophyllum cuneifolium* (Sternb.) Zeiller, Vég. terr. houill., p. 30, Pl. CLXI, Fig. 1. 1882: Renault, Cours bot. foss., II, p. 87, Pl. XIII, Fig. 10. 1882: Zeiller, Mém. Soc. géol. Nord, II, No. 2, p. 559. 1886: Kidston, Cat. Pal. Foss. Pl. Brit. Mus., p. 48. 1886: Zeiller, Fl. foss. Valenciennes, atlas, Pl. LXIII, Figs. 1–3, 6, 7, (Fruit, Pl. LXIII, Figs. 3, 4, 5, 10) text (1888), p. 413. 1888: Howse, Cat. Hutton Collect., p. 37 (52).

1886. *Sphenophyllum emarginatum*, Sterzel, Fl. Rothl. n.-w. Sachsen, p. 23 (pars).

Forma [var?] SAXIFRAGÆFOLIUM Sternb.

1826. *Rotularia polyphylla* Sternberg, Versuch, I, fasc. 4, p. 42, Tent., p. xxxii, Pl. L, Fig. 4.

1828. *Sphenophyllum fimbriatum* Brongniart, Prodrome, p. 68.

1848. *Sphenophyllum saxifragæfolium* (Sternb.) Goeppert in Bronn, Index Pal., I, p. 1166. 1854: Geinitz, Fl. Hain. Ebersdorf., p. 37, Pl. XIV, Fig. 7–10. 1869: von Roehl, Foss. Fl. Steink. Westphalens, p. 31, Pl. IV, Fig. 17. 1878: Zeiller, Vég. foss. terr. houill., atlas, Pl. CLXI, Figs. 4, 5, text (1879), p. 31.

1848. *Sphenophyllum multifidum* Sauveur, Vég. foss. terr. houill. Belg., Pl. LXIV, Figs. 1, 2.

1852. *Sphenophyllum Schlotheimii* var. *β dentatum* et var. *ζ erosum*, Ettingshausen, Steinkohlenfl. Stradonitz, p. 6, Pl. VI, Fig. 6.

1854. *Sphenophyllum trifoliatum* Lesquereux, Bost. Jour. Nat. Hist., VI, No. 4, p. 415. 1858: Lesquereux, Geol. Penn., II, p. 853, Pl. I, Fig. 7. 1880: Fontaine and I. C. White, Permian Flora, p. 20.

1855. *Sphenophyllum Schlotheimii* Brongn., Geinitz, Verst. Steink. Sachsens, Pl. XX, Fig. 6.

1847. *Sphenophyllum emarginatum* Brongn. var. *β saxifragæfolium*, O. Feistmantel, Verst. böhm. Ablag., I, p. 134, Pl. XVIII, Fig. 4.

1891. *Sphenophyllum erosum* L. & H., Newberry, Jour. Cincinnati Soc. Nat. Hist., XIII, p. 215, Pl. XIX, Figs. 2–4.

1864. *Sphenophyllum erosum* L. & H., var. *saxifragæfolium*, Coemans and Kickx, Monogr. gen. Sphenophyllum, p. 151, Pl. I, Fig. 6 a–d. 1880: Schimper, in Zittel, Handb. Palæont., II, p. 179, Fig. 135 [3, 4].

1886. *Sphenophyllum cuneifolium* var. *saxifragæfolium*, Zeiller, Fl. foss. houill. Valenciennes, atlas, Pl. LXII, Fig. 1; Pl. LXIII, Figs. 4, 5, 9, 10; text (1888), p. 413.

Foliate branches isolated on the larger stems, 1–3^{mm} wide, rather strongly ribbed, nodes at intervals of 5–14^{mm}, slightly enlarged, verticils spread out, the leaves generally turned towards the sides and lower parts of the circle, leaves usually six to the verticil, or 12 by division, rather narrowly cuneiform, 6–12^{mm} long, the lateral margins straight or slightly concave, apices truncate, about 4^{mm} wide, the border straight, with 6–14 sharply pointed teeth, or more often cleft by a shallow median fissure, or even laciniate; a single nerve at the base, strong, dichotomizing three or four times in the entire or bilobate leaves, to form 6–14 nervils at the apex, each nervil entering a tooth, or forking only two or three times in the bifurcate or laciniate leaves.

Fruiting spikes terminal on the branches, cylindrical, 3–10^{cm} long,

5–12^{mm} in diameter, consisting of an axis 1–2^{mm} thick divided into internodes 2–3^{mm} long, with low ribs, and bearing at each node a verticil of sporangiferous bracts 5–10^{mm} long, open at the base, then curving upwards more or less abruptly, sometimes rather crowded, eight to twelve bracts to the verticil, perhaps united at the base, bifurcating at a distance of 1–2^{mm} from the base, into two lanceolate, uninerved laminæ tapering to a sharp point, those of one verticil overlapping those of the next above, each bract bearing an ovoid sporangium 1½–5^{mm} long, with surface finely shagreened, attached at a distance of 2–3^{mm} from the axis and crowded together.

Sphenophyllum cuneifolium is another of the great number of Carboniferous plants whose description is limited chiefly to foliar characters, and whose lower parts are unknown. Zeiller, to whose zeal we are indebted for the discovery of its fructification, describes the larger stems as attaining a width of 1^{cm} with internodes as long as 3^{cm}, smooth or faintly striate. I have not seen leaf-bearing fragments of stems more than 3^{mm} wide, although much larger fragments, apparently belonging to the same species, are present. The average smaller branches are about 1^{mm} in width, strongly ribbed, usually exhibiting three rounded ribs on the side, the furrows between them having the same shape and size as the ribs, the whole covered with a thin coaly substance, finely striated. The nodes, usually 9–11^{mm} apart, are but slightly enlarged, the base of the verticils appearing to form a small cup, or possibly a sheath at the joint, before they spread outward. The leaves, as a rule 6 in the verticil, are, in most cases, with a shallow median fissure, about 1½–2½^{mm} deep, but many have none. I have observed verticils of entire leaves succeeding others with bilobate leaves on the same branch. These entire or simply bilobate leaves are generally 9–11^{mm} long and about 4½^{mm} broad at the truncate top. The teeth are pointed at the tip. In these leaves the basal nerve branches two or three times, its distinct nervils running into the teeth, which more often number 7 to each of the two lobes of the leaf. In the best preserved specimens, in which these nerves appear black and coaly, the upper surface of the leaf presents a minutely striated appearance, the filamentary lines running in a direction conforming to the nervation. As they seem to cover the black veins as well as the dark brown substance of the leaves, they perhaps represent the arrangement of the epidermal cells, or possibly rows of scales. Very often the median cleft extends half way or more down the leaf, in which cases secondary and even tertiary fissures appear, giving the leaves a wide range of forms including a number that have been described and figured as *Sphenophyllum saxifragæfolium*. These may take a twice bifurcated form, similar to that described by Lesquereux as *Sphenophyllum bifurcatum*, only smaller than that species, or one of the primary divisions may be tridentate, one tooth deeply separated from the rest, or the leaves may become laciniate or nearly fimbriate. While I am strongly inclined to believe that certain forms, not belonging to this species, have been described as *Sphenophyllum saxifragæfolium*, it seems equally probable that to the latter species have been re-

ferred a great many specimens of the more dissected leaves of *Sphenophyllum cuneifolium*. The frequent and intimate association of these forms with the entire or bilobate forms in a large number of localities has been pointed out by several authors and has led these authors to regard the *Sphenophyllum saxifragæfolium* as only a variety of *Sphenophyllum cuneifolium*. Whatever the propriety of such a reference of the forms not definitely correlated with the *Sphenophyllum cuneifolium* type, the relation of some to the *saxifragæfolium* forms is so intimate and consistent with the *cuneifolium* type, occasionally appearing in the lower parts of the same stem, that there seems no good reason for referring them to a variety at all, but rather it is probable that they merely represent the lower or submerged leaves of the same plant. This view of the relations of the filiform or *saxifragæfolium* leaves, first expressed by Dr. J. S. Newberry in 1853[1], and independently proposed by Coemans and Kickx,[2] in 1864, has recently been more fully elaborated and illustrated by Dr. Newberry.[3] The illustrations cited as (?) var. *saxifragæfolium* in the above synonymy are such as seem to agree with the forms in the present collection.[4] Frequent among my specimens are examples resembling *Sphenophyllum bifurcatum*, though much smaller, and certain laciniate palmatifid forms like those figured by Zeiller in the flora of the Valenciennes basin.[5] Although Zeiller describes and illustrates[6] *saxifragæfolium* forms on the same stems with the *Sphenophyllum cuneifolium* and doubts not the identity of the two to a large extent, he is disposed to preserve the name as a variety for the reason that the fruiting spikes are found at the ends of branches with the saxifragæfoliate leaves, a circumstance at variance with the theory of the submerged condition of life of the portions of the plant with the laciniate leaves. The fruiting spikes figured in the Commentry Flora, from which the above description of the fructification is taken, are borne on relatively robust stems, measuring 2–3^{mm} in diameter, with joints about 3^{mm} long. It is noticeable in the foliar parts of this species that the portions bearing the dissected leaves generally show a shortening of the joints, while the stems are stouter, as would be natural in the lower parts of the same plant. The relation appears in the fruiting spikes as well. A possible explanation suggesting itself is that the finer and more deeply dissected foliage is also characteristic of the fertile branches, which approach, in their development, the two-lobed, *Volkmannia*-like bracts of the strobili.

Fructification.—A fine series of strobili in different stages of devel-

[1] Proc. Am. Assoc. Adv. Sci., VII, p. 157; Annals of Science, I, Cleveland, 1853, p. 269.

[2] Monographie des Sphenophyllum d'Europe. Bull. Acad. Roy. d. Belgique, 2e sér. XVIII, p. 139.

[3] The Genus Sphenophyllum. Jour. Cincinnati Soc. Nat. Hist., XIII, 1891, pp. 212–217, Pl. XIX.

[4] The *Sphenophyllum saxifragæfolium* Germ. described by Lesquereux in the third volume of the Coal Flora, p. 726, Pl. XCIII, Figs. 9, 9a, with "about four" primary nerves, "some of them forking above," seems to be quite different from those referred to above under that name. As yet, however, I have not been able either to consult the original specimen nor find another corresponding to its description and illustration from the same region.

[5] Fl. foss. bassin houill. d. Valenciennes, Atlas, 1886, Pl. LXIII, Figs. 4, 8, 8a, 8b, 9, 9a, 9b.

[6] Op. cit., Pl. LXII, Fig. 1. See also Bunbury, Quart. Jour. Geol. Soc., London, III, 1847, Pl. XXIII, Fig. 3a.

opment has been examined by Zeiller, who describes the bracts of the spikes as two-lobed, quite narrow at the base, broadening to the point where they curve upward, then tapering to a sharp point. These appear to be slightly united at the base, and it is not certain that they are not so united. The sporangia, equaling the lobes of the bracts in number, are borne on the bract, at some distance from the axis, and are marked at the lower end, the point of attachment, by a small circular umbilical depression. The mode of discharging the spores is unknown.

Relations.—*Sphenophyllum cuneifolium* can most easily be distinguished from *Sphenophyllum Schlotheimii* by its narrower proportions and truncate apex, provided with sharp-pointed teeth. It has more and sharper teeth than *Sphenophyllum emarginatum*, whose teeth are short and rounded, and whose leaves do not pass into the dissected forms common to this species. *Sphenophyllum majus*, which it resembles in many respects, is very much larger, while the leaves of *Sphenophollum oblongifolium* have their lateral margins convex instead of straight, or more often concave, as is the case with *Sphenophyllum cuneifolium*. Zeiller, to whose valuable services in behalf of paleobotanical nomenclature I have already made allusion, has with good reason adopted Sternberg's name, *cuneifolium*. This species, first called by Sternberg *Rotularia asplenioides*, was changed[1] in the same fascicle, appearing in the same date, to *Rotularia cuneifolia*. Three years later he proposed the name *Rotularia pusilla*.[2] The eminent French paleobotanist, while admitting the author's right to change the name from *asplenioides* to *cuneifolium* in the same part, appearing at the same time, justly insists that Sternberg has no further right to change it after the fascicle had been published and was in use. All three of Sternberg's names are obviously prior to *Sphenophyllum erosum* L. & H., which has generally been employed.

Locality.—Abundant in the shales from McClelland's shaft; also found at Aurora, Lawrence county.

SPHENOPHYLLUM MAJUS Bronn.

1828. *Rotularia major* Bronn, in Bischoff, Kryptogamischen Gewächse, II, p. 89 (described in footnote); Pl. XIII, Fig. 2a, b.

1835. *Sphenophyllum majus* Bronn, Lethæa geognost., p. 32, Pl. VIII, Figs. 9a, 9b. 1886: Zeiller, Fl. foss. Valenciennes, atlas, Pl. LXIV, Figs. 1, 1a, 2, 2a, text (1888), p. 420.

1848. *Sphenophyllum multifidum* Sauveur, Vég. foss. terr. houill. Belgique, Pl. LXIV, Figs. 1, 2.

1855. *Sphenophyllum longifolium* (Germ.) Gein. et Gutb. (non Sauveur), Geinitz, Verst. Steink. Sachsens, p. 13, Pl. XX, Figs. 15, 16, 17. 1860: Lesquereux, 2d Rept. Geol. Surv. Ark., p. 315. 1869: Schimper, Traité, I, p. 340, Pl. XXV, Fig. 22 (non 23). 1880: Fontaine and I. C. White, Permian Flora, p. 38. 1880: Lesquereux, Coal Flora, I, p. 53. 1883: Lesquereux, 13th Ann. Rept. Geol. Surv. Ind., pt. 2, p. 46, Pl. VII, Figs. 10, 11. 1884: Lesquereux, Am. Nat., XVIII, p. 923. 1884: Lesquereux, Coal Flora, III, p. 726, Pl. XCI, Fig. 6. 1891: Newberry, Jour. Cincinnati Soc. Nat. Hist., XIII, p. 215.

[1] Versuch, I, fasc. 2, 1823, p. 37.

[2] Op. cit., fasc. 4, 1826, Tent., p. xxxii.

1855. (?) *Sphenophyllum saxifragæfolium*, Geinitz, Verst. Steink. Sachsens, p. 13, Pl. XX, Figs. 8, 9.

1866. *Sphenophyllum latifolium* Wood (nec Font. et White, necque Ren. et Zeill.), Trans. Am. Phil. Soc., XIII, p. 347, Pl. VIII, Fig. 3.

Stems long, robust, with prominent, rather angular, ribs; nodes at intervals of 2–3^{cm}; joints slightly enlarged; branches solitary at the nodes, about 1–2½^{mm} wide, with articulations 12–26^{mm} apart; verticils of six to eight wedge-shaped leaves, open, with straight lateral margins, truncate, 12–24^{mm} long or perhaps longer, usually bifid by a shallow median cleft, sometimes with a secondary fissure less deep, but occasionally deeply cleft, more or less distinctly dentate, the teeth more or less obtuse, or parted in acuminate laciniæ; nerves strong, two at base, dividing dichotomously to form from fourteen to twenty-four nervils, entering as many teeth.

The above description is based exclusively on the features seen in the types to which the specimens before us belong. These characters have been incorporated into the diagnoses of *Sphenophyllum longifolium* (Gutb.) Gein. et Gutb., and *Sphenophyllum majus* Bronn. Judging from the great diversity in the features of the plants described under these names, especially as seen in the leaves, ranging from 12^{mm} to 6^{cm} with veins reduced to two at the base, or not confluent at all, according to the different authors, one must conclude either that this is a very remarkable species in itself or that two or more distinct types have been united under one name. Most authors have either ignored the name, *Sphenophyllum majus*, or have made it a synonym of *Sphenophyllum longifolium*. The result is the description of a variety of forms mostly named *Sphenophyllum longifolium*, of which too few have been figured and described in detail to permit either a satisfactory union or differentiation among them. I employ Bronn's name because it has priority, and because his description and figure agree more nearly with the specimens in hand. *Sphenophyllum longifolium*, as described and figured by Germar[1] has its leaves usually 2–3^{cm} long, while the nerves appear to dichotomize two or three times from four nerves distinct at the base. Many of the other characters agree. The plants figured by Schimper,[2] Coemans and Kickx,[3] Weiss,[4] von Roehl,[5] Renault,[6] Renault and Zeiller,[7] and the very doubtful leaves referred by Heer[8] to that species all have a Noeggerathian appearance, the leaves long, the nerves not confluent at the base, and forking but two or three times. Those figured by Geinitz[9] have a closer resemblance to our American species.

Specimens consisting of detached portions of stems and foliage are very numerous all through the shales in the collection. The branches,

[1]Isis v. Oken, 1837, col. 426. Foss. Fl. Steink, Wettin u. Löbejün, 1845, p. 17, Pl. VII, Fig. 2.

[2]Traité, I., 1869, p. 340, Pl. XXV, Fig. 23 (copied from Germar).

[3]Monogr. d. Sphenophyllum, Bull. Acad. Roy. Belg., 2e sér. XVIII, 1869, p. 147, Pl. I, Fig. 4.

[4]Aus der Flora d. Steinkohlenform, 1881, Pl. X, Fig. 60.

[5]Foss. Fl. Steink.-Form. Westphalens, 1869, p. 31, Pl. IV, Fig. 14.

[6]Cours bot. foss., 2e année, 1882, p. 88, Pl. XIII Fig. 18 (from Coemans and Kickx).

[7]Atlas terrane houill. Commentry, Fl. fossile, pt. 2, Pl. L, Figs. 12–17.

[8]Fl. foss. Arct., IV, 1877, No. 1, Beiträge zur fossilen Flora Spitzbergens, p. 15, Pl. II, Fig. 22, 22B.

[9]Verst. Steink. Sachsens, 1855, Pl. XX, Figs. 15–17.

scarcely enlarged at the joints, are marked with three rounded ribs. The verticils almost invariably contain six leaves, often spread out in a circle, though more generally confined to the lower three quadrants. Occasionally in the smaller branches the verticils overlap nearly one-half their diameter. The leaves are very slender at their attachment and are fixed at an oblique angle to the branch, but curve abruptly outward about 1^{mm} from the base, so that the specimen frequently presents a round pit at the center of the verticil. The average length of the leaves is about 19^{mm}, the width of the top being generally 10 or 11^{mm}. The fissure, usually present at the top, is normally about 2–3^{mm} deep, though much deeper in the laciniate leaves. The nerves, which are strong, forking three to five times, often appear to coalesce in a single nerve for a short distance in the slender neck of the leaf, but they apparently only lie side by side, the vascular bundles of each remaining separate, while immediately above the point of attachment they are seen, in some cases at least, to diverge suddenly, the one to the right, the other to the left, to join the vascular system of the branch. In a few cases the circumstances of fossilization are such that one of the fine black vascular bundles seen running along the ribs of the branch is observed to pass up into the leaf. In the middle third of the leaf, in the best preserved specimens, the nerves occasionally appear double, their borders being marked by two coaly lines. The laciniate leaves of this species are not rare, though I have seen none with the large proportions of one of the specimens described by Lesquereux in the Coal Flora,[1] or that figured in his Paleozoic Flora[2] as *Sphenophyllum longifolium*. The other specimens figured by Lesquereux in the latter work,[3] and in the third volume of the Coal Flora[4] under the same name, as well as those described in detail and illustrated by Zeiller,[5] under Bronn's name, agree well with mine. To this species probably belongs also *Sphenophyllum latifolium* Wood, described in the Transactions of the American Philosophical Society.[6]

Relations.—The relations of *Sphenophyllum majus* Bronn to *Sphenophyllum longifolium* (Germ.) Gein. et Gutb. are not clear, since there does not seem to be sufficient data either for absolutely combining or definitely distinguishing the forms described under these names. From *Sphenophyllum cuneifolium* the species is easily separated by its greater size, the two nerves not united at the base and the more numerous, generally blunter, teeth. It differs by its proportionately narrower leaves, usually bifid and distinct to their bases, from the palmately nerved *Sphenophyllum latifolium*, described by Fontaine and I. C. White (non Wood) in their Permian Flora,[7] as well as from the

[1] Vol. I, p. 54.
[2] 13th Ann. Rept. State Geologist, Indiana, 1883, Pt. 2, Pl. VII, Fig. 11.
[3] Op. cit., Fig. 10.
[4] Pl. XCI, Fig. 6.
[5] Fl. foss. bassin houill. Valenciennes, p. 420, Pl. LXIV, Figs. 1, 1a, 2, 2a.
[6] Vol. XIII, 1866, p. 347, Pl. VIII, Fig. 3.
[7] 2d Geol. Surv. Penn., Report "PP," 1880, p. 36. Pl. I, Figs. 10, 11.

species closely resembling the latter, named *Sphenophyllum latifolium* by Renault and Zeiller (non Font. et White, nec Wood), and figured in the Atlas of the Fossil Flora of Commentry.[1]

Locality.—Scattered all through the shales from McClelland's shaft; also found at Hannam's shaft, near Carterville.

PINNULARIA Lindley & Hutton. 1834.

HYDATICA Artis. 1825.

1834. *Pinnularia capillacea* Lindley and Hutton, Fossil Flora, II, p. 81; Pl. CXI. 1855: Geinitz, Verst. Steink. Sachsens, p. 10; Pl. XVIII, Fig. 4. 1858: Lesquereux, Geol. Penn., II, p. 878; Pl. XVII, Fig. 22. 1869: Von Roehl, Foss. Fl. Steink. Westphalens, p. 27; Pl. I, Fig. 7 *b*; Pl. II, Fig. 5 *a*; Pl. IV, Fig. 11. 1873: O. Feistmantel, Steink. u. Permabl. n.-w. Prag, p. 72, Pl. I, Fig. 2.

1854. *Pinnularia pinnata* Lesquereux, Bost. Jour. Nat. Hist., VI, No. 4, p. 431. 1858: Geol. Penn., II, p. 878; Pl. XVII, Fig. 18.

1854. *Pinnularia fucoides* Lesquereux, Bost. Jour. Nat. Hist., VI, No. 4, p. 431. 1858: Lesquereux, Geol. Penn., II, p. 878; Pl. XVII, Fig. 19.

1854. *Pinnularia horizontalis* Lesquereux, Bost. Jour. Nat. Hist., VI, No. 4, p, 431. 1858: Geol. Penn., II, p. 878; Pl. XVII, Fig. 21 (also Figs. 15, 16, same plate).

The rootlets known as *Pinnularia* are believed to belong for the most part to the *Calamariæ*, and particularly to *Annularia* and *Asterophyllites*. However, the rootlets of widely different forms of plants often appear so much alike that the differentiation of the species is of little value, as Lesquereux himself suggested in 1858. Since, nevertheless, these pinnate-appearing rootlets are probably destined in the future, as they have been in the past, to be called by some name, it would perhaps be much more proper to call them *Hydatica*, the name proposed for them by Artis in 1825, rather than to continue the application of Lindley & Hutton's name, *Pinnularia*, proposed in 1834, which was preoccupied, having been proposed four years earlier by Ehrenberg[2] for a genus of diatoms, many of whose representatives are found fossil.

Locality.—McClelland's shaft.

FILICINEÆ.

SPHENOPTERIDEÆ.

DIPLOTHMEMÆ.

The group *Diplothmemæ* as founded by Stur (1877) and emended by Zeiller (1879) includes ferns whose fronds are composed of a more or less flexuous naked axis bearing alternating naked branches, each of which dichotomizes at the top into either (1) two divergent foliate pinnæ; or (2) two short naked branches, each branch forking at a short distance for its origin into two divergent slightly unequal fronds. According to Zeiller's division and restriction of Stur's original genus *Diplothmema* that name is retained for the first section, characterized by a division of the primary pinnæ into two divergent sections regularly

[1] Pl. L, Figs. 8, 9 (changed to *S. alatifolium* in text, p. 487).

[2] Fide Goeppert in Bronn: Index Palæont. See Monatsber. Berlin. Akad., 1843, p. 62.

pinnate, bipinnate, or tripinnate, bearing sphenopteroid pinnules, which are contracted at the base, with the margin more or less deeply divided, lobed, or denticulate.

The second section, with quadripartite primary pinnæ, the four divisions of which are regularly simple or more often bipinnate or tripinnate, with pecopteroid pinnules attached to the rachis by their entire base, often somewhat decurrent toward the base and more or less united, constitutes the genus *Mariopteris* of Zeiller. In this genus the outer pinnæ, with reference to the bifurcation, are described as rather smaller than the others, the laminæ well developed with the margins entire or feebly lobed or dentate, the median nerve usually distinct and passing almost to the summit, the nervils generally oblique, dichotomizing at very narrow angles, some of them in the lower part of the pinnules springing directly from the rachis.

While the bifurcation of the rachis constitutes a salient distinctive character, indicating the relationship of the species in a natural group, it is, from the very mode of occurrence and exploitation of fossil plants, relatively rarely possible to observe the union of the divisions of the fronds or even such fragments as to furnish positive proof as to which genus the species belongs. Accordingly, although the genera are perhaps distinct enough, it is, in practice, when dealing with each species, often impossible to tell to which of the genera it belongs. Moreover, several species, the details of whose foliage indicate an identity with one genus, are found, on the strength of the rachial characters, to belong to the other. In working, the reference of a species to either genus must therefore be necessarily often uncertain and governed largely by its affinities. The discovery of the fructification will doubtless show the present generic divisions of the groups to be quite artificial, though temporarily convenient.

Dr. Stur is disposed to consider the axis of the *Diplothmemæ*, described above, as a stem and the branches as alternate or spirally arranged petioles bearing bipartite fronds, comparing the latter with those of *Acrostichum* (*Rhipidopteris*) *peltatum*. Zeiller and Crépin, on the other hand, regard them as having rather the habitat of *Lygodium*.

DIPLOTHMEMA Stur. 1877.

DIPLOTHMEMA GENICULATUM (Germ. et Kaulf.) Stur.

Pl. I, Figs. 1, 1*a*, 2, 2*a*.

1831. *Sphenopteris geniculata* Germar und Kaulfuss, Nova Acta Acad. C. L. C. nat. cur., XV, pt. 2, p. 224; Pl. LXV, Fig. 2. 1836: Goeppert, Systema, p. 107. 1833: Sternberg, Versuch, II, fasc. 5 u. 6, p. 61. 1887: Kidston, Radstock Series, p. 346; Pl. XXI, Fig. 1.

1836. *Trichomanites Kaulfussii* Goeppert, Systema, p. 264.

1869. *Sphenopteris* (*Trichomanides*) *Kaulfussii* (Goepp.) Schimper, Traité, I, p. 412.

1877. *Diplothmema* (*Sphenopteris*) *geniculatum* (Germ. et Kaulf.) Stur, Culm-Fl., II, p. 124 (230).

1885. *Diplothmema geniculatum* (Germ. et Kaulf.) Stur, Carbon-Fl. d. Schatzlarer Sch., I, p. 297, Pl. XXXV, Fig. 1.

Fronds bifurcated into two unequal divisions above a naked axis, each division or primary pinna ovate or triangular, acute; primary rachis thin, terete flexuose-geniculate, bordered by narrow laminæ; secondary pinnæ alternate, at right angles to the rachis or oblique, lanceolate; tertiary divisions or pinnules alternate, the lower ones subpalmato-laciniate, the upper ones diminishing by fewer laciniæ, becoming more pinnately dissected; laciniæ equal, sometimes forking, linear, acute, each segment traversed by a single nerve.

This rare species is represented by five specimens, all showing the geniculate bordered rachis, and the peculiar delicate subpalmately divided pinnules, whose form, size, and arrangement are especially characteristic. The rachises of the secondary pinnæ are less geniculate than those of the primary pinnæ, and are bordered by a narrow lamina, which is distinctly seen decurring from and uniting the constricted subpedicellate pinnules. The latter are rather distant and distinct, seldom overlapping, the lowest ones nearly at right angles to the rachis, the upper ones becoming more oblique. The larger pinnules appear, at first glance, palmatifid, but the mode of division is sympodially dichotomous or divaricate, as is seen in those higher up on the pinnæ, the latter becoming more elongated, with fewer laciniæ, there being less forking in the upper pinnules. A good indication of the habit of these pinnules is seen in Pl. I, Fig. 2, the larger figures failing to give the true aspect of the arrangement of the segments and their form. Near the apex of the pinnæ the pinnules become merely bifid or even simple. While the laciniæ or ultimate segments vary much in the same pinnules, they are, relatively, of nearly uniform size in all parts of the frond, the larger ones averaging about 4^{mm} in length and but little over $\frac{1}{2}^{m}$ in width. The nervation is fairly clear. The rachises of the smallest pinnæ are rounded and generally slightly decurring at their junction with the larger rachis.

The specimens in hand agree well with the figures given by Kidston in the Radstock flora[1] and Fig. 1 on Pl. XXXV of Stur's Schatzlar ferns,[2] as well as with the original illustration by Germar and Kaulfuss.[3] As to the specimen figured by Stur, Fig. 1, Pl. XXVIII in the above-mentioned work, and some of those published by Heer,[4] I am inclined to believe, with Kidston, that they may belong to *Diplothmema furcatum* and *Sphenopteris bifida* L. & H., respectively, while the other fragment figured by Heer[5] under this name seems possibly referable to *Diplothmema subgeniculatum*.

Relations.—*Diplothmema geniculatum* is said to differ from *D. subgeniculatum* by the smaller size, the more divided fronds, and the more

[1] Trans. Roy. Soc. Edinb., XXXIII, 1887, Pl. XXI, Figs. 1, 1a, 1b, p. 346.

[2] Carbon-Fl. d. Schatzlarer Sch., p. 297.

[3] Ueber einige merkwürdige Pflanzenabdrücke aus der Steinkohlenformation. Nova Acta Acad. C. L. C. Nat. Cur., vol. XV, pt. 2, 1831, p. 224, Pl. LXV, Fig. 2.

[4] Fl. Foss. Arct., vol. IV, No. 1, Pl. I, Figs. 7, 8, 10.

[5] Op. cit., Fig. 9.

slender laciniæ of the latter.[1] *Diplothmema furcatum* is considerably larger than *Diplothmema geniculatum*, the frond more divided, the pinnules spreading farther, and the laminæ broader and much more obtuse. From *Sphenopteris lanceolata* it differs by its strongly flexuous or geniculate rachis, much more slender, its foliage very much thinner, its pinnules not appearing pinnately divided, its lobes not short and obtuse, while it is quite easily distinguished from *Sphenopteris trichomanoides* by its subpalmately divided pinnules, which have uniformly longer lobes, obtusely rounded at the apex. So far as known, *Sphenopteris Hildreti* has its rachis not geniculate, the pinnules elongated, appearing pinnately divided, the lobes proportionately longer.

Locality.—McClelland's shaft.

MARIOPTERIS Zeiller. 1878.

MARIOPTERIS (PSEUDOPECOPTERIS)[2] MAZONIANA Lx. sp.

1870. *Alethopteris mazoniana* Lesquereux, Geol. Surv. Ill., IV, p. 391, Pl. IX, Figs. 1–8; Pl. XIII, Figs. 5, 6.

1879. *Pseudopecopteris mazoniana* Lesquereux, Coal Flora, atlas, Pl. XXXII, Figs. 1–7, text (1880), I, p. 190.

Fronds pinnately divided in the lower part, dichotomous at the apex; primary rachis striate, canaliculate, flat on the borders; secondary pinnæ either long, sublinear, gradually tapering to the apex, or short, more distinctly linear, obtuse, pinnately lobed; pinnules alternate, slightly distant, constricted at the base in the lower part of the pinnæ, decurrent, bordering the rachis with a lamina, coriaceous; median nerve rather strong, thinning upwards, depressed, decurrent, passing nearly to the apex of the pinnule; secondary nerves oblique, distant, parallel, forking below the middle.

The above description, based upon that given in the Coal Flora, seems to include the characters of our fragments, and I have referred them, with but little doubt, to *Mariopteris mazoniana*, all the speci-

[1] I have seen no genuine specimens of *D. subgeniculatum*, the only specimen from our Coal-measures ever identified by that name, I believe, having proved on examination to be, as was suggested by Lesquereux himself (Proc. U. S. Nat. Mus., vol. XI, 1888, p. 84), only a portion of a sterile frond of *Sphenopteris Harveyi*, with which it was associated. The latter species, according to Lesquereux and Kidston (Cat. Pal. Pl. Brit. Mus., p. 250), is probably identical with *Zeilleria delicatula* (Sternb.) Kidst. (Quart. Jour. Geol. Soc. London, vol. XL, 1884, p. 592, Pl. XXV.)

[2] The name *Pseudopecopteris*, applied by Lesquereux to a restricted portion of the genus *Diplothmema*, as originally proposed by Stur, including those forms of *Pecopteris* and certain round pinnuled species of *Sphenopteris* with dichotomous rachises, usually bordered near the top by a narrow lamina from the decurrent pinnules, was proposed without knowledge of Zeiller's genus *Mariopteris*, founded in 1879 to contain essentially the same group of species. Inasmuch as *Mariopteris*, originally defined, probably includes most of the forms referred by Lesquereux to *Pseudopecopteris*, it has priority over the latter name, which I have, however, included as more familiar to American geologists. *Mariopteris* is described in Bull. Soc. géol., France, 3e sér., VII, 1878–'79, p. 93; Fl. foss. terr. houill., 1879, p. 68; Fl. foss. houill. Valenciennes, p. 159. The peculiar quadripinnate structure of these fronds was first made the basis for a generic separation by Ad. Brongniart, who gave the specimens in the Muséum d'histoire naturelle the manuscript name *Heteropteris*. Owing to the fact that ordinary specimens rarely show the dichotomous character of the plant, many species have been referred to the group on account of their general resemblance to ascertained members of the group. As a generic differentiation it is doubtless somewhat artificial and may perhaps be found to contain several genera. In assigning several species whose true generic characters have not, I believe, been observed to the genus *Pseudopecopteris*, Lesquereux seems to have followed Stur, who originally included them in his genus *Diplothmema*.

mens being of the types figured by Lesquereux in Pl. XXXII, Figs. 1 and 6. The pinnules are somewhat oblique to the rachis, generally ovate-triangular in outline, the lower ones constricted to a narrow attachment at the base, irregularly, but not deeply, lobate, especially on the lower side, the lowest lobe rather auricular, crenulate on the upper side, strongly resembling the pinnules of *Mariopteris speciosa* in the middle portion of Pl. LI of the Coal Flora. Those higher in the pinna are less distinctly lobed, becoming more deltoid, and attached by the whole base, those near the apex being much smaller, rounded, gradually more united and coalescing with the very small terminal pinnule. The midrib is strong and depressed, the secondary nerves are indistinct except as the parenchyma of the pinnule sometimes arches slightly between them. The surface of the pinnules is black and coaly, the margins being slightly curved backwards.

From the descriptions given by Lesquereux of specimens of *Pseudopecopteris mazoniana* in his hands, as well as from the affinity of the species, it seems probable that this species lies within the limits of the genus *Mariopteris*.

Relations.—*Mariopteris mazoniana* differs from all others by the polymorphous character of its pinnules, mingling pecopteroid and alethopteroid characters. The pecopteroid pinnæ, such as those represented in the present collection, differ from the resemblant species, *Mariopteris latifolia* and *Mariopteris speciosa*, by the size of the pinnules, which are less deeply lobed, sometimes tending toward gemination, the pinnules of the former species being much smaller and differently disposed, the median nerve thin, while the pinnules of the latter are more obtuse, lobed near the tip, the nerves inflated and distinct.

Locality.—McClelland's shaft.

MARIOPTERIS (PSEUDOPECOPTERIS) DECIPIENS LX. sp.

Pl. I, Figs. 5–8, 5*a*; Pl. II, Figs. 1–3, 3*a*.

1854. *Sphenopteris decipiens* Lesquereux, Bost. Jour. Nat. Hist., VI, No. 4, p. 420. 1858: Lesquereux, Geol. Penna., II, 2, p. 862; Pl. XVIII, Fig. 2. 1860: Lesquereux, Rept. Geol. Surv. Ark., II, p. 312, Pl. V, Figs. 1–1*a*. 1863: Dawson, Can. Nat., VIII, p. 445. 1866: Dawson, Quart. Jour. Geol. Soc. London, XXII, p. 156.

1860. *Sphenopteris dilatata* Lesquereux (non L. & H.), Rept. Geol. Surv. Ark., II, pp. 310, 315, Pl. II, Figs. 3, 3a.

1869. *Sphenopteris* (*Aneimoides*) *decipiens* Lx., Schimper, Traité, I, p. 401.

1879. *Pseudopecopteris decipiens* Lesquereux, Coal Flora, atlas, Pl. LII, Figs. 9?, 10, 10a, text (1880), p. 214.

1889. *Pseudopecopteris* (*Sphenopteris*) *decipiens* Lx., Lesley, Dict. Foss. Penn. II, p, 798, (fig.)

Fronds large, dichotomous below, tripinnate or quadripinnate, spreading; primary rachis broad, flat, 2–7^{mm} or more in width, rather lax, somewhat flexuous, somewhat geniculate below, tapering rapidly toward the apex, irregularly striate, punctate, covered in portions by a thin,

often shiny, epidermis, the upper portion bordered by narrow laminæ from the decurrent pinnules; primary pinnæ at right angles or oblique toward the apex, oval-lanceolate, somewhat contracted below, tapering above to a slightly obtuse apex; secondary rachis rather lax, finely punctate, often flexuous, usually sulcate or depressed above, round below, somewhat decurrent at the base; secondary pinnæ alternate, at right angles to the rachis, or oblique, the lower ones often curved backward, close, usually parallel, with margins close, generally touching or slightly overlapping, 1½–6cm or more in length, linear-lanceolate, 8mm to 3cm wide, obtuse, terminating in large, broad sub-lobate, oval, ovate, or deltoid pinnules with sinuate margins and rounded tip; pinnules slightly polymorphous, alternate, more or less oblique, close, generally nearly contiguous, sometimes slightly overlapping, thin, 3mm–2cm long, 2–9mm broad, the lowest ones broader, oval, ovate, or obovate, sometimes orbicular at the base of the pinnæ, occasionally oblong in the largest pinnæ and on the tip of the primary pinnæ, always rounded above, decurrent and more or less connate by the decurrent laminæ, the margins usually slightly thickened and marked by a shallow furrow on the upper side; those toward the lower end of the larger pinnæ contracted at the base, especially on the anterior margin, rounded below with a broad attachment to the rachis, connate by a narrow, decurring lamina; those higher up in the pinna oval or obovate, curving outward, rounded at the base above by a deep and narrow sinus, decurrent below; those still higher on the pinna not so deeply divided, becoming united somewhat below, and passing into the terminal pinnule, which is often nearly as broad as the pinna; pinnules of the upper secondary pinnæ less deeply separated, attached by the whole width; secondary pinnæ succeeded, in passing toward the apex of the primary pinnæ, by pinnatifid pinnules, lobed at the base, large oblong above, becoming entire with slightly sinuate margins in passing upwards, then entire, oblong, ovate, or obovate, and with broadening attachments to the rachis, as in the secondary pinnæ; lower pair of pinnules at the base of each secondary pinna usually shorter, more rounded at the base and broader than those succeeding; the one on the upper side of the pinna more or less orbicular or truncate above, the distal border often marked by a broad, shallow sinus or slight fissure in the more mature specimens; the pinnule on the lower side more or less triangular or alate, the longest side, opposite the attachment, bilobate, more or less deeply cleft in the more mature specimens, dividing the pinnule into two unequal lobes, the distal lobe usually longer and broader, the proximal lobe rounder and somewhat auriculate, or overlapping the rachis; pinnules of the lower secondary pinnæ becoming oblong, with slightly undulate margins, then lobed below, becoming, in passing downward, like those near the tip of the primary pinnæ, gradually pinnatifid, the terminal pinnule long, broad, and obtuse, and assuming the forms and proportions of the secondary pinnæ, the divisions corresponding to the lower basal pinnule of the secondary pinnæ, shorter, with anomalous pinnatifid divisions diverging from the attachment of the original pinnule.

Nervation generally obscure, except in the lower part of the pinnule; primary nerves rather strong, diverging from the rachis usually at a very narrow angle and arching more or less gradually into the pinnules, giving off branches at a narrow angle during their passage, and dissolving below the apex; primary bundles, often several, perhaps springing directly from the rachis in the smaller pinnules, and diverging somewhat flabellately towards the margins, branching several times, but only one becoming developed as a median nerve in each of the

largest basally constricted pinnules, in which it is strong, depressed, and minutely punctate below, diminishing above by finer branches, arching slightly and branching repeatedly in passing to the margin, where the very slender and slightly flexuous nervils count about thirty-five to the centimeter; nerves of the basal pinnules of the pinnæ more or less flabellate from the broad entering band of nerves at the base, forking, and passing, arched, to the lateral margins, nearly straight towards the top; fructification unknown.

The fern described above is represented by over seventy-five specimens, all preserving the same characters of pinnation and nervation. The more distinctive features are the obtuseness of the secondary pinnæ, which usually end in large, broad, terminal pinnules, and the oblong, or elliptical, or oval lateral pinnules, always rounded above, not lobed, except in the case of the lowest pair of each pinna or the largest forms becoming pinnatifid, when they are lobed at the base, and large oval above, as seen in Pl. 1, Fig. 7; the broadly, more or less distinctly orbicular-bilobate form of the lower pair of pinnules, seen in Pl. 1, Figs. 5, 7, the upper lobe of the lower pinnule often elongated and rarely lobed again, the lower lobe more or less auriculate, and overlapping the primary rachis; and the nervation, more or less flabellate from one, two, or more principal nerves diverging from the rachis by a curve, rather strong at the base and diminishing in size and distinctness, so that the nervils are very fine, rarely becoming observable.

The specimens are preserved brown. The broad, flat rachises covered, in portions, by a thin, somewhat shiny brown lamella and bordered in the upper part by a narrow, decurring wing, dichotomize below, thus indicating their position in the group *Mariopteris*. From the appearance of the pinnules under the lens I suspect that they may be minutely pubescent. The presence of large fragments of rachis, over 3^{cm} in diameter, similar to fragments seen with *Mariopteris muricata* from Alabama, associated with the foliage of and probably belonging to our species, may be construed as indicating a very large size for the fern. The nervation of the larger oblong pinnules is much like that seen in the larger pinnules of *Mariopteris* (*Pseudopecopteris*) *speciosa* (Coal Flora, Pl. LI, Fig. 1*b*) except that the nerves are closer and the median nerve dissolved sooner in larger branches.

It is only after much hesitation that I refer our specimens to *Mariopteris* (*Pseudopecopteris*) *decipiens*, a species which, to judge from the descriptions and figures, is either extremely polymorphous or quite ill-defined. None of the specimens described have the pinnules so oblong and distinct as seen in my specimens. The one figured in the Geology of Pennsylvania and copied by Lesley in the Dictionary of Fossils, showing the pinnatifid pinnules, is lobed much higher and more irregularly than the Missouri plant, as seen in Pl. I, Fig. 5, Pl. II, Fig. 2, the latter preserving the tendency to a large broad terminal pinnule characteristic of all my specimens. In the latter the nerves entering the lobes are frequently not joined in one, like those of the Pennsyl-

vania specimen, which shows a tendency towards a subdivision of some of the intermediate lobes. There is nothing in the collection closely resembling the fragment figured in the Arkansas report[1] as *Sphenopteris dilatata*, later referred by Lesquereux in the Coal Flora[2] to *Pseudopecopteris decipiens*, nor the specimen[3] doubtfully included under the latter name in the same work, while Fig. 10 of the atlas is in some respects suggestive of the upper secondary pinnæ of the *Sphenopteris Lesquereuxii* of Newberry, illustrated in the Geology of Pennsylvania,[4] regarded by Lesquereux as probably belonging to his *Pseudopecopteris anceps*. Fig. 10 differs somewhat from the Missouri plants by having its secondary pinnæ pinnatifid to the apex and terminating in a small round pinnule; by its shorter lateral divisions more truncate, and imbricated, and the basal pinnules nearly like the others. The nervils, which are described as distinct, very different from my specimens, are rather more distant, with less tendency to coalesce at the base, and arch gently to the rachis. The *Sphenopteris decipiens* represented in the Arkansas Report[5] has more characters in common with the Missouri fern, though its pinnules are much more irregular, the nervils more distant, the apex of the pinnæ smaller and more deeply lobed, the primary rachis narrower, naked, and terete.

Through the courtesy of Mr. R. D. Lacoe, I have been able to examine a good specimen from his collection from Dade, Ga., identified by Professor Lesquereux as *Pseudopecopteris decipiens*. Its general aspect is much like that of the specimen figured in the Arkansas report last referred to, or to the Fig. 10 of the Coal Flora. In its dilated basal and broad terminal pinnules it is closer to my specimens, though the lateral pinnules are rather shorter, with their margins somewhat more arched, the nervation coarser and more distinct. Still more nearly like my material are two small fragments, No. 1037 of the U. S. National Museum collections, from Van Buren, Arkansas, identified by Lesquereux as *Pseudopecopteris decipiens*. One of the fragments corresponds quite closely to the pinnæ figured in Pl. II, Fig. 1, though the pinnæ of the former are less obtuse than those of the latter. But there is also from the same locality a small specimen, No. 1027 of the Museum collection, labeled *Pseudopecopteris cordato-ovata* Weiss sp., with pinnules rounded above, which is clearly identical with the terminal portions of large pinnæ with oblong pinnules like those seen in Pl. I, Fig. 5, of our specimens. On the same specimen of rock and lying about 2^{cm} distant in the same plane of deposition, is the counterpart of one of the specimens, No. 1037, already referred to, labeled *Pseudopecopteris decipiens*, thus showing both the probable specific identity of the specimens from the same rock labeled under two names, and the quite probable identity of

[1] Geol. Surv. Ark., II, Pl. II, Figs. 3, 3*a*, p. 310.
[2] Vol. I, p, 214.
[3] Pl. LII, Figs. 9, 9*a*.
[4] Vol. II, pt. 2, Pl. XI, Fig. 1.
[5] Vol. II, p. 312, Pl. V, Figs, 1, 1*a*.

the *Pseudopecopteris decipiens* with our specimens through the assured identity of the *Pseudopecopteris cordato-ovata.*

Notwithstanding then, the disagreements between all the published descriptions and figures of *Pseudopecopteris decipiens*, on the one hand, and the facies and characters of the Missouri specimens on the other—being unwilling to increase the number of species more than is absolutely necessary—I have thought it best to assign to my specimens, for the present, that name, for the reason that among the wide range of types identified by Prof. Lesquereux as belonging to that species, some specimens are apparently identical with the Missouri type, and also because it is improper to attempt to revise and redefine or illustrate the species without first examining the types and material originally studied by Lesquereux, which I have not yet been able to consult.

The above description, however, is based purely on the rich material before me in the Missouri collection, and will represent the new species, if, as I suspect will be the case, it is found necessary to separate it from the *Pseudopecopteris decipiens*, with whose types, figures, and descriptions it has very little in common.

Three specimens show tapering pinnæ terminating in a prolongation of the rachis. At first sight this would appear to be due to accident or removal of the pinnules in working out the specimens, but a careful examination under the lens shows the rachis, which is more rigid and terete than usual, to be bordered on each side by a narrow lamina about $\frac{1}{2}^{mm}$ wide ascending from the sinus above the highest pinnules, the thickened margin of the pinnule clearly continuing along the border of the lamina. In all three specimens the end of this extension of the rachis is broken and lost at a distance of $3–5^{mm}$ above the highest pinnules. These prolongations of the rachis may, possibly, be regarded as evidence, though not conclusive, that the fructification of this species was borne on the reduced apinnulate terminal portion of the pinnæ. In these specimens the pinnules of the pinna decrease more rapidly in size, the uppermost being small and foreshortened, strongly resembling the *Pecopteris incompleta* of Lesquereux,[1] or perhaps less suggestive of *Mariopteris muricata* or *Diplothmema Jacquoti* as illustrated by Zeiller,[2] and *Sphenopteris coarctata* of von Roehl.[3]

A few of the fragments like Fig. 5, Pl. I, are suggestive of *Pseudopecopteris cordato-ovata* as figured by Lesquereux in the Coal Flora,[4] whose identity with the *Neuropteris cordato-ovata* of Weiss[5] has recently been questioned by Zeiller[6] on account of the more acutely pointed pinnules and rather more crowded nervils of the latter. Of the Old World plants identified as *Sphenopteris decipiens*, the one from

[1] Geol. Penna., II, 2, 1858, p. 868, Pl. I, Figs. 12, 12*a*.
[2] Fl. foss. houill. Valenciennes, Atlas, Pl. XX, Figs. 3, 4; Pl. XVIII, **Fig. 5.**
[3] Foss. Fl. Steink. Westphalens, Pl. XIV, Fig. 5.
[4] Pl. XXXVII, Figs. 4, 5.
[5] Fl. jüngst. Steink. u. Rothl., p. 28, Pl. I, Figs. **1, 1 *a*.**
[6] **Fl. foss. houill. Autun et Épinac, p. 35.**

Bohemia described and figured by R. Andree,[1] whose identification was probably followed by Karl Feistmantel[2] in his plants from the same region seems hardly identical with the American forms of which the nearest related is the *Sphenopteris dilatata* figured in the Arkansas report.[3]

Relations.—It is unadvisable to attempt to point out the differentiating characters between this and other species until it shall have been better defined.

My specimens differ from the *Mariopteris speciosa* Lx., by their rachis flat, not round, not so broadly alate, the pinnæ more evenly pinnate, more obtuse, the pinnules smaller, not lobate, the basilar ones bilobate, the nervils indistinct, closer and not inflated, while from *M. polyphylla*, as identified by Lesquereux in specimens from Alabama, they are easily distinguished by the larger pinnules of the latter species, lobed irregularly, and usually more pointed.

Locality.—McClelland's shaft.

SPHENOPTERIS Brongniart. 1822.

SPHENOPTERIS (PSEUDOPECOPTERIS) OBTUSILOBA Brongn.

1829. *Sphenopteris obtusiloba* Brongniart, Hist. Vég. foss., p. 204, Pl. LIII, Fig. 2*. 1833: Sternberg, Versuch, II, fasc. 5 u. 6, p. 63. 1848: Sauveur, Vég. foss. Belg., Pl. XV, Fig. 2. 1853: Newberry, Ann. Sci., I, No. 9, p. 106. 1855: Ettingshausen, Steinkohlenfl. Radnitz, p. 37, Pl. XXI, Fig. 2. 1860: Lesquereux, Rept. Geol. Surv. Ark., II, p. 315. 1860: H. C. Wood, Proc. Acad. Nat. Sci. Philada., XII, p. 440. 1866: Lesquereux, Geol. Surv. Ill., II, p. 435. 1874: O. Feistmantel, Studien Kohlen. Böhmen, Pl. I, Fig. 9. 1876: Ferd. Roemer, Lethaea geognost., I, atlas, Pl. LI, Figs. 1*a*, 1*b*; text (1880), p. 169. 1876: Lesquereux, Rept. Geol. Surv. Ala. for 1875, p. 75. 1878: Zeiller, Vég. foss. terr. houill., atlas, Pl. CLXIII, Figs. 1, 2; text (1879), p. 39. 1879: Schimper in Zittel, Handbuch, II, p. 108, Fig. 77. 1880: Fontaine and I. C. White, Permian Flora, p. 11. 1881: Weiss, Aus. d. Fl. d. Steink., Pl. XI, Figs. 67, 67*a*. 1883: Renault, Cours bot. foss., III, p. 190, Pl. XXXIII, Figs. 5, 6. 1886: Zeiller, Fl. foss. houill. Valenciennes, atlas, Pl III, Figs. 1, 1*a*, 2, 2*a*; Pl. IV, Fig. 1; text (1888), p. 65.

1833. *Sphenopteris irregularis* Sternberg, Versuch., II, fasc. 5 u. 6, p. 63, Pl. XVII, Fig. 4, fasc. 7 u. 8, p. 132. 1855 (?): Geinitz, Verst. Steink. Sachsens, p. 14, Pl. XXIII, Figs. 2–4 (excl. syn.). 1860: F. A. Roemer, Palæontographica, IX, p. 24, Pl. IV, Fig. 5. 1866: Andrä, Vorweltl. Pfl. Steink., p. 26, Pl. VIII; Pl. IX, Fig. 1. 1869: von Roehl, Foss. Fl. Steink. Westphalens, p. 56, Pl. XVI, Fig. 2 (?); Pl. XXXI, Figs. 5, 6.

1836. *Cheilanthites obtusilobus* (Brongn.) Goeppert, Systema, p. 246.

1836. *Cheilanthites irregularis* (Sternb.) Goeppert, Systema, p. 247.

1836. *Sphenopteris latifolia* Lindley and Hutton, Fossil Flora, III, Pl. 178.

1848. *Sphenopteris trifoliolata* (Art. ?) Brongniart, Sauveur, Vég. foss. terr. houill. Belg., Pl. XIX, Fig. 2; Pl. XXI. 1869: von Roehl, Foss. Fl. Steink. Westphalens, p. 65, Pl. XVI, Fig. 3 (excl. syn.).

1869. *Sphenopteris (Aneimioides) obtusiloba* Brongn., Schimper, Traité, I, p. 399, Pl. XXX, Fig. 1.

[1] N. Jahrb. f. Min., 1864, p. 167, Pl. IV, Figs. 2, 3.
[2] Steinkohlenbecken von Klein-Přilep, p. 55.
[3] Vol. II, Pl. II, Figs 3, 3*a*.

1869. *Sphenopteris* (*Gymnogrammides*) *irregularis* Sternb., Schimper, Traité, I, p. 373.
1877. *Diplothmema* (*Sphenopteris*) *obtusilobum* (Brongn.) Stur, Culm-Fl., II, p. 124 (230).
1877. *Diphlothmema* (*Sphenopteris*) *irregulare* (Sternb.) Stur, Culm-Fl., II, p. 124 (230). 1885: Stur, Carbon-Fl. Schatzlarer Sch., I, p. 296.
1879. *Pseudopecopteris irregularis* (Sternb.) Lesquereux, Coal Flora, atlas, pl. LII, Figs. 1–3, 8 ?; text (1880), p. 211.
1884. *Pseudopecopteris obtusiloba* (Brongn.) Lesquereux, Coal Flora, III, p. 753.
1885. *Diplothmema obtusilobum* (Brongn.) Stur, Carbon-Fl. Schatzlarer Sch., I, pp. 296, 354, Pl. XXV, Figs. 8a–c; Pl. XXVb, Fig. 1.
1890. *Diplothmema irregulare* (Sternb.) Stur, Sandberger, Jahrb. d. K.-k. geol. Reichsanst., XL, pp. 84, 87, 90.

Fronds tripinnate or quadripinnate below; rachis strong, flat, naked, striated, slightly undulate below, becoming more flexuous towards the tip; primary pinnæ broad, lanceolate, acute, pinnatifid to near the extreme apex; secondary pinnæ at right angles below, becoming oblique above, alternate, distant, contiguous or slightly imbricated, linear-lanceolate, acute, straight or curved, those in the middle and lower portions of the primary pinnæ provided with pinnæ of the third order, those above bearing reduced tertiary pinnæ or pinnatifid pinnules, those still nearer the top being provided with large, broad, rather triangular-ovate pinnules, divided into 3–5 more or less deeply dissected, round-obtuse lobes; secondary and tertiary rachises narrow, more or less distinctly flexuous to correspond to the insertion of the pinnæ or pinnules, but sometimes appearing nearly straight, sulcate above, rounded on the lower side, finely and evenly striate, bordered by narrow laminæ; tertiary pinnæ distinct, alternate, usually close, sometimes distant, or even overlapping, the lower ones at a right angle to the secondary rachis, the upper somewhat oblique, 12–22^{mm} long, 5–12^{mm} wide, more or less acutely pointed, provided with 2 to 5 pairs of alternate, sessile, or broad pedicellate, half-round, ovate, or reniform and dilated, usually more or less distinctly trilobate pinnules, generally close or slightly imbricated, those in the lower part of the frond more distant, slightly decurrent; surface of the pinnules coriaceous, curved backward somewhat near the border, and marked between and parallel to the nerves with close, minute striæ; margins apparently thickened and traversed on the upper side by a narrow furrow or gutter; pinnules of the upper secondary pinnæ broad, more or less deeply dissected into three, sometimes four, broad, rounded or truncate-rounded, or obovate lobes, the lowest pair of the pinnules of the pinnæ subpalmately divided into four to six lobes, one or more of the divisions sometimes elongated, those pinnules toward the top of the pinnæ becoming less distinctly lobed and approaching the proportions of those borne on the tertiary pinnæ; primary nerves originating at a narrow angle and curving outwards, dichotomizing, the secondary nerves forking and curving, indistinct, to the border; fructification unknown.

Although much difference of opinion exists as to the basis of the separation of *Sphenopteris obtusiloba* and *Sphenopteris trifoliata*, no two authors agreeing on the lines of distinction between those species, most paleobotanists, including Zeiller, Kidston, Renault, and the late Dr. O. Feistmantel, are agreed that the forms described by various writers as *Sphenopteris obtusiloba* and *Sphenopteris irregularis* are only different portions of the same fronds. The identity of Andrä's specimens described as *Sphenopteris irregularis* with Brongniart's *Sphenop-*

teris obtusiloba, first pointed out by Stur,[1] was concurred in by Zeiller,[2] who also verified the identification after an examination of Brongniart's type of *Sphenopteris obtusiloba*. But while Zeiller and Kidston insist on the identity of these with Sternberg's type also, Dr. Stur, who combines specimens described and figured by Andrä and von Roehl under *Sphenopteris irregularis*, excludes, without stating his reasons, Sternberg's original identification.

The identity of the species from the zinc region with that represented by a magnificent series of specimens from Clinton, Missouri, brings portions of nearly the entire plant before me. Large fragments of the frond show the upper secondary pinnæ of the species to be provided with large ovate-deltoid, obtusely lobed pinnules agreeing exactly with the *Sphenopteris irregularis* illustrated by Andrä[3] or like the *S. obtusiloba* figured by Brongniart[4] and Zeiller,[5] or the upper portion of Stur's *Diplothmema obtusilobum*.[6] These forms I believe to be more predominant in the upper part of the lateral primary pinnæ. The lower secondary pinnæ, with more fully developed pinnules or tertiary pinnæ, are similar to those figured by Lesquereux[7] as *Pseudopecopteris irregularis*, by Andrä[8] as *Sphenopteris irregularis*, by Stur[9] as *Diplothmema obtusilobum*, and by Zeiller[10] as *Sphenopteris obtusiloba*. Usually, however, my specimens show the tertiary pinnæ ending in a small, more or less narrow deltoid, acute pinnule, somewhat different from the specimens figured by Stur[11] and Zeiller,[12] the pinnules in most of the specimens being also slightly larger. The American species agree well with specimens labeled *Sphenopteris obtusiloba*, from Radnitz, Bohemia, now in the collection of the U. S. National Museum.

Relations.—Although this species appears to have a close relationship to the *Diplothmemata*, no specimen has, so far as I am aware, been discovered with the true *Diplothmema* ramification. Owing to the uncertain boundary of *Sphenopteris obtusiloba*, I shall not attempt to point out the distinctions between it and other related species, although I am strongly inclined to regard many of the figures inscribed by various authors as *Sphenopteris trifoliata* to be only forms belonging to *Sphenopteris obtusiloba*, or to other species quite different from Artis's type.

Locality.—Aurora.

---

[1] Verh. d. K.-k. geol. Reichsanst., 1876, p. 286.
[2] Vég. foss. terr. houill., 1879, p. 40.
[3] Vorweltl. Pfl. Steink., Pl. VIII, Figs. 1–3.
[4] Hist. Vég. foss., Pl. LIII, Fig. 2.*
[5] Vég. terr. houill., Pl. CLXIII, Fig. 1; Fl. foss. Valenciennes, Pl. III, Figs. 2, 3.
[6] Carbon-Fl. d. Schatzlarer Sch., I, Pl. XXV, Fig. 8.
[7] Coal Flora, atlas, Pl. LII, Figs. 1–3.
[8] Op. cit., Pl. IX, Fig. 1.
[9] Op. cit., Pl. XXV, Fig. 8.
[10] Op. cit., Pl. III, Fig. 4.
[11] Op. cit., Pl. XXV, Fig. 1.
[12] Op. cit., Pl. III, Fig. 1.

SPHENOPTERIS (PSEUDOPECOPTERIS) MACILENTA L. & H.

Pl. I, Fig. 4, 4*a*.

1835. *Sphenopteris macilenta* Lindley and Hutton, Fossil Flora, II, Pl. CLI. 1855: Geinitz, Verst. Steink. Sachsens, p. 14, Pl. XXIII, Fig. 1. 1880: Fontaine and I. C. White; Permian Flora, p. 12. 1887: Kidston, Radstock Series, p. 348.

1835. *Sphenopteris lobata* Gutbier (non Morris) Abdrücke, p. 44, Pl. I, Figs. 11–15; Pl. X, Figs. 1–3.

1836. *Aspidites macilentus* (L. & H.) Gœppert, Systema, p. 357.

1869. *Sphenopteris* (*Aneimioides*) *macilenta* L. & H., Schimper, Traité, I, p. 400.

1877. *Diplothmema macilentum* (L. & H.) Stur, Culm-Flora, II, p. 124 (230). 1885: Stur, Carbon-Fl. Schatzlarer Sch., I, p. 375.

1877. *Diplothmema lobatum* (Gutb.) Stur, Culm-Flora, II, p. 123 (229). 1885. Stur, Carbon-Fl. Schatzlarer Sch., I, p. 375.

1880. *Pseudopecopteris macilenta* (L. & H.) Lesquereux, Coal Flora, III, p. 754, Pl. XCVIII, Fig. 2. 1889: Lesley, Dict. Foss. Penn., p. 799, (Fig. ?).

1888.? *Pseudopecopteris* (*Sphenopteris*) *macilenta* (L. & H.) Lesquereux, Proc. U. S. Nat. Mus., XI, p. 85.

Fronds tripinnate; rachis rather strong, slightly flexuous; primary pinnæ oblique, distant, oval-lanceolate, acute; secondary pinnæ alternate, distant, oblique or sometimes at right angles or even reflexed below, linear-lanceolate, 2–8^{cm} or more in length, 1–3^{cm} in width; secondary rachis rather narrow, slightly depressed above, raised below, usually flexuous to correspond with the position of each pinnule; naked in the lowest parts, bordered by a narrow decurrent margin of the pinnules above; pinnules large, thin, alternate, distant, oblique to the rachis, except those at the base of the pinnæ, more or less cuneate, usually irregularly tri-sublobate, the borders slightly arched; those in the middle portions of the pinnæ broad, rather ovate, cuneate below or rounded cuneate to the decurrent base, bordering the rachis with a narrow lamina, those above becoming more cuneiform below, less distinctly lobate, sometimes bilobate, or rounded and entire at the apex, with broader attachments, gradually becoming more and more united, the uppermost being narrow, cuneate, rounded, passing on to the connate, narrow, obtuse terminal pinnule; those in the lower portions of the pinnæ more distinct, less oblique to the rachis, more contracted below, appearing pedicellate, broader, sometimes rhomboidal, rather more indistinctly trilobate, the lobes decurrent and sometimes feebly irregularly lobed again, always rounded below, the basal pinnules less oblique, more deeply, and often palmately, lobate; principal nerves distinct below, very acutely decurrent, slender, arching outward, and forking two to four times as the pinnules broaden, becoming faint near the border; fructification unknown.

As will be seen by the figures, the Missouri specimens agree quite satisfactorily with illustrations given by Lindley and Hutton and by Geinitz. It is represented by but eight specimens in the collection, all of which are of the type figured. As a rule the pinnules are of a generally cuneate outline below, curving downward at the attachment, and generally indistinctly trilobate above, sometimes bilobate, or irregularly lobed, appearing crenate in some cases, but with all the lobes short and rounded. I have not seen specimens showing the quadripartite character of *Mariopteris* and *Pseudopecopteris*, or the bipartite feature of *Diplothmema* to which the species has been referred by Stur. Its in-

clusion in *Pseudopecopteris* by Lesquereux may have been the result of the examination of specimens, or perhaps it was only following Stur's reference of the species to *Diplothmema*.

Relations.—*Sphenopteris macilenta* is one of the most distinct Sphenopterids. It differs from *S. obtusiloba* and *S. trifoliata* by the much larger size of the pinnules, which are more cuneate below, less deeply and regularly trifoliate, not elongating, not pinnatifid except on the primary rachis just above the secondary pinnæ. *Cyclopteris valida*, as described and figured by Dawson, has a strong, rough primary rachis, the pinnules less developed near the apex of the pinnæ, the secondary nerves springing from a single primary nerve. *Sphenopteris adiantoides* has its pinnules smaller and proportionately broader, less cuneate, not so clearly trifoliate, and apparently not connate by a decurrent margin.

SPHENOPTERIS LACOEI n. sp.

Pl. II, Figs. 5, 5a, 6.

1884.? *Pseudopecopteris nummularia* (Gutb.) Lesquereux, Coal Flora, III, p. 751 (2d type, excl. syn.).

Fronds quadripinnate, spreading; primary pinnæ broad, at right angles or somewhat oblique to the rachis; primary rachis finely striated, flat, or slightly arched, naked; secondary pinnæ alternate, close, often somewhat overlapping, oblique above, at right angles in the middle and curving backward below, slender, linear-lanceolate acute, slightly contracted towards the base, nearly straight or gently flexuous and curving, simply pinnate, or pinnatifid below, the largest divisions being developed as ultimate pinnæ, with the same relations to the secondary pinnæ as those of the latter to the primary pinnæ; secondary rachis rather narrow, slightly flexuous to correspond to the position of the pinnules, and bordered, at least in the upper part, by a very narrow lamina decurring from the pinnules; pinnules coriaceous, dull, flat, alternate, at right angles to the rachis below, oblique above, close, sometimes contiguous, or overlapping, usually with a decurrent attachment to the rachis, cordate-ovate, or somewhat querciform, slightly obtuse at the apex, alternately lobed, more or less constricted at the base, especially on the distal side, the blade connate by a narrow decurrent lamina; the larger pinnules, about 6^{mm} long, 3^{mm} wide, constricted at the base so as frequently to appear pedicellate, the smaller ones above, becoming sessile by the slightly contracted base; lobes in the lower part of the larger pinnules divided to near the midrib, larger than those above, more or less distinctly cuneate toward the base, or rhomboidally rounded or rounded-truncate at the broad top, slightly separated by a narrow, decurrent rounded sinus, becoming in passing upwards more connate and obovate, smaller, more united, and more obtusely rounded, gradually passing into the small indistinct terminal pinnule; lobes of the pinnatifid pinnules broadening, becoming more distant, more pointed and crenate, sessile by the slightly contracting base, then lobate and finally full developed pinnules; primary nerves strong, somewhat decurrent, especially in the upper part of the pinnæ, though often appearing simply inclined or at right angles to the rachis in the lower part, sometimes appearing as a short pedicel; nervation obscure, a primary nerve passing into each lobe, and emitting nervils that usually fork once, but a portion of the nervils in the lower part of

the lobes apparently spring directly from the mid-rib; fructification unknown.

In the third volume of the Coal Flora,[1] Prof. Lesquereux describes two types under the name of *Pseudopecopteris nummularia* (Gutb.) Lesq., remarking that the description of the specimens in hand did not agree entirely with the descriptions and figures of the European authors, and suggesting that they might represent one or even two new species, one type including the plants from Clinton, Missouri, and Cannelton, Pennsylvania, the other having been found at Campbell's Ledge at Pittston, Pennsylvania, and in strata of nearly the same age in Arkansas. Finding the specimens in the collection to be apparently identical with others now in my hands from Clinton, Missouri, I was led to conclude that these represented the second or Clinton-Cannelton type of *Pseudopecopteris nummularia*, although this type is obviously different from Gutbier's type of *Sphenopteris nummularia*, which has been referred by some authors to *S. obtusiloba*, or from Heer's figure,[2] which is accepted by others as a good species. From specimens from Cannelton and Pittston, kindly loaned me by Mr. Lacoe, the difference between the two types of Lesquereux is seen to be quite distinct. The Pittston plant is most like the figure given by Heer. As to the other type, Mr. Lacoe informs me that Prof. Lesquereux, in a manuscript note, observes that the Cannelton plant is "certainly a species different from that of Campbell's Ledge." No name for the new species is given in the Lesquereux manuscript now in the hands of Mr. Lacoe, which it is earnestly hoped may be published at an early date. Being unable to identify it with any other described species, I have dedicated it to Mr. Lacoe, who has done more than any other to promote the study of the Paleozoic flora of the United States, and to whom I am greatly indebted for counsel and for the use of specimens in the preparation of this paper. There is but little difference between the specimens from Clinton and Belleville and those from Cannelton, except that the former are usually rather more open, with the midrib somewhat thinner, tending in some cases towards flexuosity. The nervation in the Cannelton plants is obscure on account of the roughness of the epidermis, which often simulates a close venation, and which has led the artist to draw the nervils too close in the detail of the Cannelton pinnule.

Among the many closely related or resemblant species assigned by various authors to *Sphenopteris*, *Hapalopteris*, *Oligocarpia*, *Hymenophyllites*, and *Renaultia*, *Sphenopteris Lacoei* is quite easily distinguished by the size of its pinnules, which are rather acute, contracted at the decurrent attachment and narrowly bordering the rachis, decurrently lobed, the lobes entire, the lower ones cuneate below, truncate-rounded above, the succeeding ones narrower, becoming more united, ovate, the apex obtuse, passing into confluence with the very small, ill-defined terminal pinnules.

[1] P. 751, Pl. CIII, Figs. 1–3.

[2] Fl. foss. Helv., Pl. XIV, Figs. 6, 6b.

Relations.—Among the nearest allied species *Sphenopteris Lacoei* differs from the forms referred to *S. stipulata*, *S. quercifolia*, *S. Laurentii*, and *S. gracilis*, by the irregular lobation among the latter, the lobes being more or less distinctly divided. The last-named species, which as figured has its pinnules hardly decurrent, I am unable satisfactorily to separate from some of the upper and looser portions of *S. mixta* Schimper. The latter differs from *S. Lacoei* by its rachis rough, sulcate, more slender and more flexuous in the smaller divisions, the secondary and ultimate pinnæ usually overlapping, the pinnules rougher with borders arching slightly backward, more obtusely pointed, not so regularly nor deeply lobate proportionately, the lobes not cuneate downwards, not so decurrent, broader at the base, more pointed, crenate or sometimes sublobate, the sinuses more acute, the nerves distinct in relief on the lower surface, and more flexuous. *Sphenopteris marginata* Dawson, whose foliage is somewhat similar, is described as having the pinnæ short, obtusely pointed, the pinnules less dissected, the nerves simple; while *Hapalopteris* (*Sphenopteris*) *rotundifolia* (Andrä) Stur, which strongly resembles our species, has its pinnules rather larger, less decurrent, the lobes not cuneate, the terminal lobe large and round. From *Sphenopteris nummularia* it strongly differs, the size of the pinnules being much greater, the pinnules of that species being hardly decurrent, the midrib straight, the lobes more distant, broadly ovate, pointed above, roundly contracted at the base, pedicellate, becoming trilobate in the lower part of the pinnule, bilobate in the middle, and elliptical above, the terminal lobe large and oval, more or less distinct, similar to forms of *S. trifoliolata* or *S. obtusiloba*, to which it has been assigned by several authorities. The normal lobes of *S. nummularia*, pedicellate with entire margins, have the size of those small crenate or feebly lobed sessile pinnules of *Sphenopteris Lacoei* which are passing into ultimate pinnæ.

Locality.—McClelland's shaft.

SPHENOPTERIS HILDRETI Lx.

1854. *Hymenophyllites Hildreti* Lesquereux, Bost. Jour. Nat. Hist., VI, No. 4, p. 421. 1858: Geol. Penna., II, 2, p. 863; Pl. IX, Figs. 5, 5a. 1861: Lesquereux, Geol. Surv. Ky., IV, p. 434.

1877. *Diplothmema* (*Hymenophyllites*) *Hildreti* (Lx.) Stur, Culm-Flora, II, p. 122 (228), 124 (230). 1885: Stur, Carbon-Flora Schatzlarer Sch., I, p. 296.

1880. *Sphenopteris* (*Hymenophyllites*) *Hildreti* Lesquereux, Coal Flora, I, p. 283. 1889: Lesley, Dict. Foss. Penna., I, p. 292 (figure).

Fronds polypinnate; rachis narrow; pinnæ more or less oblique, pinnately divided; pinnules oblique, decurring to the winged rachis, ovate in outline, pinnately lobed; lobes cut to the base or to the middle in two to five linear, acute laciniæ; primary nerves divided according to the subdivisions of the lobes, each lobe being entered by a simple branch.

The specimens, three in number, which I have referred to *Sphenopteris Hildreti*, agree excellently with the original figures of that species as

well as with the description in the Coal Flora which I have quoted above. The rachis is slender, striate, and slightly sinuate. The pinnules, which are slightly coriaceous, appear sympodially dichotomous rather than pinnate in their mode of division, the effect being a pinnate appearance.

From the affinities of the species with *Diplothmema furcatum* and *D. geniculatum* it seems quite probable that it also belongs to the genus *Diplothmema*, to which Dr. Stur assigned it in 1877.[1] Kidston[2] has suggested that it may be referable to *Diplothmema furcatum*. My specimens, which are identical in character with that illustrated and described in the Geology of Pennsylvania,[3] seem quite distinct from *Diplothmema furcatum*, and it may be added that there are no true specimens of that species in the collection.

The specimen from the Middle Devonian at St. John, New Brunswick, figured, but not described, by Sir William Dawson as *Hymenophyllites Hildreti* Lx., appears to represent a different species, with irregularly dissected pinnules and much broader laciniæ, resembling more in its aspect the *Sphenopteris subfurcata* described by him[4] from the same locality.

Relations.—*Sphenopteris Hildreti* was described by Lesquereux as differing from *Diplothmema furcatum* by its narrower rachis, not geniculate, the pinnules all pinnately lobed, none palmately, the laciniæ shorter and more distinctly lanceolate-acute. It is also much more delicate than *Diplothmema furcatum*. I have not seen sufficient material to ascertain whether there is a difference in the division of the primary rachis or whether both species are Diplothmemæ. It appears to differ from *Diplothmema geniculatum*, to which it stands closest, by its rachis, not geniculate, its foliage more dense, the divisions of the pinnules not so palmately spreading from the base, and not so long relatively, the sinuses not rounded at the bottom. *Sphenopteris trichomanoides* and *Sphenopteris lanceolata* are not so broadly divided; the laminæ are shorter and more obtuse, the rachis of the latter species being much stronger and its divisions more bushy.

Locality.—McClelland's shaft.

SPHENOPTERIS, SPECIES.

Pl. I, Fig. 3.

Two small specimens in the collection appear to be different from any species represented in material that I have seen. I have figured one of them with the hope that it may be recognized by some more experienced paleontologist. The rachis is striate and rough. The median nerve is thin, slightly decurrent, and flexuous. Pinnules coriaceous,

[1] Culm-Flora, II, p. 122 (228). Carbon-Flora Schatzlarer Sch., I, 1885, p. 296.
[2] Cat. Pal. Pl. Brit. Mus., p. 81.
[3] Vol. II, pt. 2, 1858, p. 863, Pl. IX, Figs. 5, 5*a*.
[4] Foss. Pl. Dev. and Upp. Sil. Can., 1871, pp. 54, 86, Pl. XVI, Fig. 181.

slightly oblique, deeply dissected. The divisions are ovate, pedicellate, decurrent, bordering the midrib, the lower ones suggesting the outline of an acorn, only they are round at the apex. The real condition of each division is trilobate, the two basal lobes narrow and insignificant, slightly reflexed, the third and upper lobe ovate, rounded, constituting three-fourths of the entire division. In this respect it differs from the trilobate forms of *Sphenopteris trifoliata*, *Sphenopteris obtusiloba*, or *Sphenopteris nummularia* Gutb.,[1] the last named of which it resembles more closely in the general proportions. The form of the division is much like that seen in portions of the *Sphenopteris Böckingiana* figured by Weiss.[2] The nerves are rather strong and close, branching alternately from the median nerve and forking again.

The second fragment, apparently belonging to the same species, has its divisions of the same character. It represents the tip of a pinna, the uppermost divisions being either macerated or otherwise deprived of parenchyma. It is possible that both specimens represent fertile pinnæ of some species, though no distinct evidence of fructification is visible.

Locality.—McClelland's shaft.

PECOPTERIDEÆ.

PECOPTERIS Brongniart. 1822.

PECOPTERIS DENTATA Brongn. (non Will.)

1828. *Pecopteris dentata* Brongniart, Prodrome, pp. 58, 170. 1834: Brongniart, Histoire p. 346, Pl. CXXIII, CXXIV. 1835: Lindley and Hutton, Fossil Flora, II, Pl. CLIV. 1838: Sternberg, Versuch, II, 7 u. 8, p. 152. 1870: Lesquereux, Rept. Geol. Surv. Ill., IV, 2, p. 404. 1876: Ferd. Roemer, Lethaea geognost., I, atlas, Pl. LII, Figs. 1a, b; text (1880), p. 176. 1878: Zeiller, Vég. foss. terr. houill., atlas, Pl. CLXVIII, Figs. 3, 4; text (1879), p. 86. 1879: Lesquereux, Coal Flora, atlas, Pl. XLIV, Figs. 4, 4a; text (1880), p. 240. 1880: Fontaine and I. C. White, Permian Flora, p. 66, Pl. XXII, Figs. 1, 2, (3-5 ?). 1883: Renault, Cours bot. foss., III, p. 121, Pl. XXI, Figs. 4, 5. 1884: Lesquereux, Amer. Nat., XVIII, p. 922. 1887: Lesquereux, Proc. U. S. Nat. Mus., X, p. 25.

1828. *Pecopteris plumosa* (Artis?) Brongniart, Prodrome, p. 58, 171. 1835 or 1836: Brongniart, Histoire, p. 348, Pls. CXXI, CXXII. 1838: Presl, in Sternberg, Versuch, II, 7 u. 8, p. 152. 1858: Lesquereux, Geol. Penn., II, 2, p. 867. 1866: Lesquereux, Geol. Surv. Ill., II, Palæont., p. 442. 1869: von Roehl, Foss. Fl. Steink. Westphalens, p. 88, Pl. XXXIII, Fig. 4. 1881: Weiss, Aus d. Fl. d. Steink., Pl. XVII, Figs. 104, 104a. 1888: Howse, Trans. Nat. Hist. Soc. Northumb., etc., X, 1, p. 89.

1828. *Pecopteris triangularis* Brongniart, Prodrome, pp. 58, 171.

1832. ? *Sphenopteris caudata* Lindley and Hutton, Fossil Flora, I, Pl. XLVIII.

1833. *Cyatheites dentatus* (Brongn.) Goeppert, Systema, p. 325. 1855: Geinitz Verst. Steink. Sachsens, p. 26, (pars), Pl. XXIX, Figs. 10-12; Pl. XXX, Figs. 1, 2. 1869: von Roehl, Foss. Fl. Steink. Westphalens, p. 87, Pl. XXXIII, Fig. 6. 1876: Heer, Fl. foss. Helv., p. 30, Pl. XI; Pl. XII, Figs. 1-5.

[1] Abdrücke, 1835, p. 43, Pl. IV, Figs. 5, 5a, 5b, 5c; Pl. X, Figs. 7, 8, 8a; Pl. XI, Fig. 3. Heer, Fl. Foss. Helv., p. 14, Pl. XIV, Fig. 8, Andrä, Vorweltl. Pfl., p. 35, Pl. XI.

[2] Foss. Fl. jüngst. Steink. u. Rothl., Pl. VII, Figs. 1, 1a.

1838. *Pecopteris Brongniartiana* Presl, in Sternberg, Versuch, II, 7 u. 8, p. 160.
1848. *Cyatheites plumosus* (Artis?) Goeppert, in Bronn, Index palæont., p. 365.
1869. *Cyathocarpus dentatus* (Brongn.) Weiss, Foss. Fl. jüngst. Steink., p. 86.
1869. *Pecopteris* (*Cyatheites*) *dentata* Brongn., Schimper, Traité, I, p. 508.
1877. *Senftenbergia dentata* (Brongn.) Stur, Culm-Flora, II, p. 187 (293).
1877. *Senftenbergia plumosa* Stur, Culm-Flora, II, p. 187 (293). 1885: Stur Carb.-Fl. Schatzlarer Sch., vol. I, p. 92 (pars), Pl. LI, Figs. 1, 2, 3.
1883. *Dactylotheca dentata* (Brongn.) Zeiller, Ann. Sci. nat., [6] bot., XVI, pp. 184, 207, Pl. IX, Figs. 12–15. 1884: Zeiller, Ann. Soc. géol. Nord, XI, p. 206. 1888: Zeiller, Fl. foss. Valenciennes, p. 30, Figs. 16a, b. 1890: Zeiller, Fl. foss. Autun et Épinac, I, p. 21, Figs. 17a, b.
1885. *Senftenbergia acuta* (Brongn.) Stur, Carb.-Fl. Schatzlarer Sch., I, p. 96, Pl. LI, Figs. 4, 5.
1886. *Pecopteris* (*Dactylotheca*) *dentata* Brongn., Zeiller, Fl. foss. houill. Valenciennes, atlas, Pl. XXVI, Figs. 1, 1a, b, 2, 2a–e; Pl. XXVII, Figs. 1, 1a, b, 2, 2a, 3, 3a, 4; Pl. XXVIII, Figs, 4, 5, 5a; text (1888), p. 196. 1890: Zeiller, Fl. foss. Autun et Épinac, I, p. 66, Pl. IXa, Figs. 3, 3a.
1887. *Dactylotheca plumosa* (Artis?) Kidston, Radstock Ser., p. 381. 1886: Kidston, Cat. Pal. Pl. Brit. Mus., p. 128. 1889: Kidston, Trans. R. Soc. Edinb., vol. XXXV, 2, No. 10, p. 409. 1890: Kidston, Proc. Roy. Phys. Soc. Edinb., X, pp. 368, 375, 386.
1887. *Dactylotheca plumosa* var. *dentata*, Kidston, Radstock Ser., p. 382.

Fronds large, tripinnate, quadripinnatifid below; primary rachis large, 5–12^{mm} wide, finely trichomatose; secondary rachis 1–5^{mm} broad, grooved on the upper surface and finely punctate; primary pinnæ alternate, at right angles or oblique, often reflexed in the lower part of the frond, usually overlapping slightly, 3½–11^{cm} apart, oval-lanceolate, 18–50^{cm}, or more, long, 3½–12^{cm} wide at the middle, somewhat contracted at the base, the sides of the larger ones parallel in the middle portion, and tapering to a sharp point above; secondary pinnæ alternate, 6–12^{mm} apart, usually overlapping somewhat, the upper ones oblique, the middle nearly at right angles, the lower ones often reflexed and shorter, often flexuous, linear-lanceolate, the larger ones 2½–6^{cm} long, 5–25^{mm} wide, tapering to an obtusely acuminate point; pinnules alternate, more or less triangular, somewhat arched, generally obtusely pointed or rounded, sometimes acuminate at the tip or appearing oblong, somewhat oblique, sessile, contiguous and slightly connate at the base, those in the middle of the secondary pinnæ 35^{mm} long, averaging about 2^{mm} in width at base, the margins generally more or less reflexed so as to make them appear sharply triangular, the laminæ arching between the nervils, either entire or with a few rounded, usually indistinct lobes; the lower basilar pinnule of each secondary pinna generally shorter and lobate, sometimes appearing auriculate; pinnules towards the top of the secondary pinnæ gradually becoming confluent, passing to the entire or slightly lobed apex of the pinnæ; pinnules of the lower secondary pinnæ near the base of the frond, 5–13^{mm} long, 2–4^{mm} wide, pinnatifid, or perhaps pinnate, the divisions being about 1½^{mm} long and 1^{mm} wide, the uppermost secondary pinnæ with pinnules becoming united and passing into primary pinnules, pinnatifid below in rounded lobes, the succeeding ones crenulate, then entire; nerves usually quite distinct, the median nerve passing to the top, but very slightly, if at all, decurrent, emitting nervils at a wide angle, the lower nervils forking, the upper ones simple, those of the large pinnatifid pinnules giving off other simple nervils in the lower lobes.

Considerable difference of opinion exists among paleobotanists as to the range of forms to be included in this somewhat polymorphous species. While most authors agree in uniting *Pecopteris dentata* and *P. plumosa* (Artis?) Brongn., a few, including so distinguished a paleobotanist as Director Stur, insist on their distinction as two separate species. But Stur, referring to Brongniart's figures and descriptions, joins[1] *P. pennæformis* Brongn. to *P. plumosa*. On the other hand, *P. delicatula* Brongn., which is made a variety of *P. plumosa* by Kidston[2] and of *P. dentata* (*P. plumosa* Brongn. non Artis) by Zeiller,[3] is united by Stur[4] with *P. acuta* Brongniart. Kidston is inclined, on the basis of distribution, to partially separate *Pecopteris dentata* as a variety of *Pecopteris plumosa*. Happily, as one of the important results of the painstaking examination of many of Brongniart's type specimens, Zeiller has been able to clear up many of the doubts respecting this as well as many other species described in the Histoire, and he has given excellent and elaborate new descriptions, amplifying and redefining those species, in his classical work on the Valenciennes flora. As the result of his investigations of the old specimens as well as of much new material, he finds both *P. plumosa* and *P. dentata* in the same species, thus verifying the conclusions of Schimper, Lesquereux, Geinitz, and others of the older paleobotanists.

The specimens in the present collection are identical with others labeled by Lesquereux in the U. S. National Museum collections, as well as with a fine series communicated by Dr. J. H. Britts from Clinton, Missouri, whence some of the specimens described in the Coal Flora[5] originated. The agreement of these fine specimens with Zeiller's figures and descriptions[6] is good in nearly every detail. The figure given by Lesquereux on Pl. XLIV does not represent the pinnules so small nor so crenulate or lobed, nor so pointed as they appear in my specimens. The laminæ in the latter are more arched between the nerves, the margins rolled back so as to give them a sharper appearance, the strong midrib sunken and tending to become flexuous in the partly macerated specimens, and the lower basal pinnules of the secondary pinnæ lobed or more or less auriculate. Some of the pinnules are acute, like *P. acuta* Brongn., which *P. dentata* further resembles by the simple veined pinnules of the upper part. The general habit, as seen in our species, is better indicated by Fontaine and I. C. White in their Permian or Upper Carboniferous Flora, Pl. XXII, Figs. 1 and 2, though the latter seem to somewhat resemble *P. acuta*. The variety *parva*, Fig. 2, of these authors is similar to the pinnatifid pinnules near the base of the lower secondary pinnæ. The Missouri representatives of this species are most adequately represented by the figures of Brongni-

[1] Carbon-Fl. Schlatzlarer Sch., I, p. 93.
[2] Foss. Fl. Radstock Ser., p. 381; Trans. Yorkshire Nat. Union, pt. 14, 1888 (1890), p. 36.
[3] Fl. foss. houill. Valenciennes, p. 196.
[4] Op. cit., p. 97.
[5] Vol. I, p. 241.
[6] Op. cit., p. 196, Pl. XXVI.

art,[1] Stur,[2] and Zeiller.[3] One large fragment of the basal portion of a primary pinna shows the pinnules delicate and slender as in *P. delicatula*,[4] though I do not venture to refer it to that form.

Although it is believed by many authors that the type of Artis's *Filicites plumosus*[5] is specifically identical with Brongniart's *Pecopteris plumosa* Artis sp., and that Artis's name has therefore priority over *P. dentata* Brongn., the incompleteness of Artis's description and figure and the indistinctly indicated fructification near the margin, differing from that seen in *P. dentata* (*P. plumosa* Brongn.), render the evidence too uncertain, as it seems to me, to warrant such a conclusion, and I am disposed to follow Zeiller in retaining *P. dentata* for the present. *Filicites plumosus* Artis seems to be represented in form, nervation, and fructification by the *Pecopteris* (*Aspidites*) *silesiaca* of Goeppert.[6]

The fructification of *Pecopteris dentata* worked out by Zeiller from abundant silicified material constitutes the type of the genus *Dactylotheca*.[7] It consists of exannulate ovoid sporangia, separate from one another, obtuse at the base, 0.5–0.75^{mm} long, 0.2–0.25^{mm} broad, tapering to an acute apex, each sporangium lying on one of the ultimate nervils of one of the lower pinnules, the apex pointing toward the border.

The *Aphlebiæ*, which, in spite of their caducity, are frequently found attached to the rachis near the origin of the primary pinnæ of this species, have been observed by Fontaine and White, Stur, and Zeiller. They have been described as oval in outline, lying close to the rachis, often obscuring it, deeply pinnatifid in close linear lobes, the lower ones themselves pinnatifid, with surface finely striate and apparently covered with fine hairs. A few such aphlebian fragments were found in the collection, but none are attached to rachises with other pinnules. One large rachial fragment from Clinton resembles the *Aphlebia filiciformis* found by Geinitz[8] on the rachis of *Pecopteris dentata* Geinitz (non Brongn.).

Relations.—*Pecopteris dentata* differs from *P. pennæformis* by its sulcate and rather more strongly punctate rachis, its pinnæ larger and more flexuous, and its pinnules more triangular. *P. pennæformis* is described as having the secondary nerves simple or forking but once, the laminæ folded upwards in sharp ridges between the nervils, and the fructification apparently in two rows of round dots, one on each side of the midrib. *Pecopteris acuta* Brongn. has its rachis rather smoother,

[1] *P. plumosa*, Histoire, Pls. CXXI, CXXII, Figs. 3, 4, and *P. dentata*, Pls. CXXIII, CXXIV.

[2] *Senftenbergia plumosa*, Foss. Fl. Schlatzlarer Sch., I, Pl. LI, Figs. 1, 2, 3, and *S. acuta*, Figs. 4, 5.

[3] Fl. foss. houill. Valenciennes, Pls. XXVI, XXVII, Figs. 2, 3, 4.

[4] Brongniart, op. cit., Pl. CXVI, Fig. 6. Zeiller, op. cit., *P. dentata*, var. *delicatula*, Pl. XXVIII. Figs. 5, 5a.

[5] Antedil. Phytol., Pl. XVII.

[6] Systema, p. 364, Pl. XXVII.

[7] Ann. Sci. Nat. [6], Bot., XVI, 1883, pp. 184, 207, Pl. IX, Figs. 12–15. Fl. foss. houill. Valenciennes, 1888, pp. 30, 198, Pl. XXVI, Figs. 2, 2a, d. Fl. foss. Autun et Épinac, 1890, p. 21, Fig. 17a, b, p. 67.

[8] Verst. Steink. Sachsens, p. 26, Pl. XXV, Fig. 11.

the pinnules more acutely falcate, and the nerves almost invariably simple, while *P. aspera* Brongn. is distinguished by its shorter parallel pinnæ at right angles to the rachis, the pinnules more rounded, the terminal ones distinct and obtuse, and the nerves more flexuous.

Locality.—McClelland's shaft.

PECOPTERIS (PTYCHOCARPUS) UNITA Brongn.?

Fronds large, bipinnate or tripinnate; primary pinnæ broad, lanceolate, tapering to an acute point; primary rachis broad, flat, striated; secondary pinnæ alternate or subopposite, 2–5^{mm} apart, nearly at right angles to the rachis or somewhat oblique, parallel, linear, 2–4^{cm} long, 5–11^{mm} wide, the borders nearly parallel, converging slightly near the rounded apex, crenulate, lobate, or pinnatifid, according to their position higher or lower on the primary pinnæ; secondary rachis round, slender, flexuous in the smaller pinnæ, more or less decurrent and dissolving just below the apex; secondary pinnæ succeeded above on the primary pinnæ by and passing into distant, oblique, linear pinnules, rounded at the apex, crenulate, then crenulate below and entire above, becoming entire in passing upward, decurrent and connate by a decurring border, united more deeply in approaching the tip of the frond; pinnules of the ultimate pinnæ, represented by crenation, lobes, and well-defined pinnules according as the pinnæ occur lower on the frond, united about one-half their length in the average pinnæ, curving outward to nearly a right angle, the apices gradually rounded, the margins slightly reflexed, the texture rather thin, the more mature pinnules 6–7^{mm} long, close, alternate, decurring somewhat, contiguous to the middle, united below, the margins converging a little towards the rounded apex; median nerve originating at a narrow angle, arching outward towards the tip of the pinnule; secondary nerves alternate, usually simple except in the larger pinnules, nearly straight or curving toward the apex, not anastomosing, and marked near the border by fusiform enlargements, the distal ends of these enlargements being rather thicker than the proximal ends.

The specimens, numbering about twenty-five, which I refer with some doubt to the above species, are apparently members of the same fern, but, owing to the rather macerated appearance of a portion of them, some of the characters seem too obscure in parts of the frond to allow an absolute identification with *P. unita*. The simple pinnules at the upper end of the primary pinnæ have their nervation too poorly preserved for an accurate description, besides which they are rather farther apart than those commonly described as belonging to that species. The upper secondary pinnæ agree very well with those illustrated by Stur[1] as *Diplazites longifolius* Brongn. sp., and by Lesquereux,[2] Kidston[3], and Zeiller[4] as *Pecopteris unita*, the crenulate forms becoming more nearly entire towards the apex, which is rounded, as seen in Fig. 3 of Stur's plate, which illustrates the secondary pinnæ of my specimens better than any I have seen, although his figures of the pinnules

[1] Carbon-Flora d. Schatzlarer Sch., Pl. LXIII, Figs, 2, 3.
[2] Coal Flora, Pl. XL, Fig. 2.
[3] Foss. Fl. Radstock Ser., Pl. XXIV, Fig. 4.
[4] Fl. houill. Valenciennes, Pl. XVIII, Figs. 1, 2.

of the upper primary pinnæ are widely different from those described at the lower portions of these pinnæ. The more deeply lobed secondary pinnæ, similar to Fig. 2 of Stur, bear evidence of fructification, but these pinnæ are too macerated to reveal the characters of the sori in the mingled coaly material. The thickening of the ultimate nervils, like that seen in *Diplazites* as figured by Göppert, Stur, and other authors, construed as indicating the beginning of the sori, appears somewhat farther up on the nervils and rather more obtuse at the upper end than is commonly represented in *P. unita*. The secondary pinnæ taper but little towards the apex, while those more fully developed have their pinnules rather broad and arched backward, as shown by Kidston[1] and Lesquereux.

On account of the uncertainty attached to the specific reference of my plant, I have not attempted to give the synonymy of *P. unita*, which is made by many authors to include *P. emarginata* and *P. longifolia*, but have left the description of the specimens to wait ultimate absolute identification or separation.

Relations.—The specimens in this collection differ perhaps from *P. unita* or *P. emarginata*, as those species are usually described, by the greater distance between the fully developed pinnules, the slender, rather flexuous rachis of the median secondary pinnæ, and the large, rounded pinnule forming the apex of the secondary pinnæ.

Locality.—McClelland's shaft.

PECOPTERIS (ASTEROTHECA) LESQUEREUXII n. sp.

Pl. II, Fig. 4.

1880. *Pecopteris arborescens* (Schloth.) Brongn., Lesquereux, Coal Flora, I, p. 230, (pars excl. syn. et fig.).

1884. ? *Pecopteris aspidioides* Brongn., Lesquereux, Coal Flora, III, p. 756.

Fronds tripinnate; primary pinnæ broad, tapering rapidly to an acute point; secondary rachis rather broad, striate, more or less distinctly and finely punctate; secondary pinnæ alternate, open, close, somewhat caducous, linear, 7^{mm}–3^{cm} wide, slightly narrowed at the base, the borders converging very gently in the middle, contracting more rapidly toward the tip to an acute apex; pinnules alternate, open or slightly oblique, usually nearly at right angles to the rachis, very close, often contiguous, occasionally flexuous, linear, the length usually four to six times the width, flat, or rarely with margins slightly arched, the lateral borders nearly parallel or slightly converging, the apex gradually rounded, united near the base, sometimes a little contracted in the largest pinnules, the rachis being bordered by a narrow, decurrent margin; median nerve strong, distinct, passing to the apex, usually slightly decurrent, but frequently at right angles to the rachis in the larger pinnules; secondary nerves of the smaller pinnules, simple, alternate, slightly arching to the borders or nearly straight, or, rarely, even goniopteroid; a few of the nerves in pinnules of the average size sometimes forking once near or above the middle, the lowest pair usually forking near the base, but most of the upper ones simple, while in

[1] Foss. Fl. Radstock Ser., Pl. XXIV, Figs. 3, 9.

the larger pinnules of the largest secondary pinnæ and those above the secondary pinnæ on the primary rachis the nerves fork once at a rather wide angle below the middle, the upper division usually forking again; fertile pinnules of the same form and arrangement as the sterile; fructification in oval or round sori, disposed in two rows, one on each side of the median nerve, nearly covering the lower surface of the pinnules; sporangia, four or five in the sorus.

This species, represented by a large number of specimens, is distinctly characterized by the long slender pinnules, contiguous or a little distant, usually slightly decurrent in the smaller pinnules, united for about 1^{mm} at the base, the borders converging slightly, the blade flat, the apex obtuse, not round truncate, and by the peculiar nervation. The nerves of the smaller pinnules are simple, as in *P. arborescens* or *P. hemitelioides*. In those of the average size, about 9^{mm} long and 2$\frac{1}{4}^{mm}$ wide, the lower pair of nerves fork, and here and there, irregularly, in the pinnule other nerves fork, like those of *P. cyathea* or *P. paleacea*. Only in the largest pinnules, 10–15^{mm} in length and 2$\frac{1}{2}$–3^{mm} in width, are the nervils, all branching near or above the middle, similar to those of *P. Candolliana* and *P. Monyi*, the upper division occasionally forking again, especially in the pinnules succeeding the secondary pinnæ. In these largest pinnules there is an occasional constriction at the base, suggestive of *P. Candolliana*, but the rachis is bordered by a narrow decurrent lamina, uniting the pinnules, which have the surface very nearly flat, are not constricted at the middle, and which are proportionately considerably longer than the pinnules of *P. Candolliana*.

In general habit the pinnæ and pinnules resemble *Pecopteris lepidorachis*[1] and *P. cyathea*,[2] though its pinnules are flatter, not distinct to the base, and irregular in length as in the latter. The closest similarity in the arrangement of the pinnules and nervation is with *P. hemitelioides*, except that our pinnules are not separate and all simple nerved, and with *P. Monyi*,[3] whose pinnules are much more oblique, decurrent, much broader proportionately, the margins converging more rapidly. The latter species appears somewhat closely related to *P. venulosa* Lx.,[4] but Lesquereux's species has the pinnules less united, shorter, more curved, the midrib stronger, and the nerves curving upward. Some of the smaller pinnæ are suggestive of *P. platyrachis* as figured in the Coal Flora. However, the figure given by Lesquereux[5] is a copy of Fig. 5 on Plate CIII of Brongniart's Histoire, in which work it is first assigned by Brongniart (p. 312) to *P. platyrachis* and again on the following page to *P. lepidorachis*. However, since a smooth rachis is one of the distinctive characters of the former species as diagnosed by Brongniart, it seems more probable that the reference to *P. lepidorachis* is the one the author intended should remain, although the pinnules are

[1] See Brongniart, Histoire, Pl. CIII, Fig. 1; also, Zeiller, Fl. houill. Commentry, I, Pl. XII, Fig. 5.
[2] Brongniart, op. cit., Pl. CI, Fig. 4.
[3] See Zeiller, op. cit., Pl. XI, Figs. 6, 7, and Pl. XVII, Figs. 3, 4.
[4] Coal Flora, I, p. 230, Pl. XLI, Figs. 1, 1a.
[5] Atlas, Pl. XLI, Fig. 5.

much like *P. cyathea*. It is possible that the specimens forming the basis of Lesquereux's description[1] may be referable to *P. lepidorachis* or *P. cyathea*, both of which have been referred by many authors to *P. arborescens*. Renault and Zeiller have with reason, as it seems to me, separated them as species, after an examination of the original types together with new material, with concise and distinct definitions.

In the entire collection, containing over one hundred and fifty specimens belonging to this species, I have not seen any fragments referable to *P. arborescens*. My specimens are apparently identical with those in the museum collection labeled by Lesquereux as belonging to *P. aspidioides*. But *P. aspidioides*, characterized by Brongniart as having contiguous elliptical-oblong pinnules, distinct to the base, with simple, oblique nervils, and as differing from *P. arborescens* only in its greater size, longer, obtuser pinnæ, and less truncated pinnules, is generally regarded as belonging either to *P. arborescens*, to which the above author regarded it as very closely related, or to *P. cyathea*, the agreement of the figures being quite close. Since the name *Pecopteris aspidioides* can not therefore be retained and employed to designate our species, no new name can be more appropriate than that of the great student and elaborator of the American coal flora.

Relations.—*Pecopteris Lesquereuxii* differs from *P. arborescens* by its much broader pinnæ with the apices more obtuse, the pinnules usually more than double the length of those of the latter species, not distinct at the base, more often slightly apart, sometimes slightly decurring in the smaller pinnules, gradually rounded, not truncate-rounded, at the tip, the nervils sometimes branching once irregularly in the larger pinnules, the upper division occasionally branching again in the largest pinnules, generally curving more or less to the border. *P. cyathea* has its pinnules contiguous, separate to the rachis, often reflexed, shorter proportionately, unequal in length, the margins often curved backward, the sporangia in pairs or fours. *P. lepidorachis* has the rachis strongly punctate, its pinnules contiguous, distinct to the base, the nerves always forked below the middle. *P. hemitelioides*, whose form ours resembles closely, has its rachis rougher, the pinnules rather broader proportionately, usually separate at the base, and all the nerves simple. *P. Candolliana* is easily distinguished by its pinnules contracted and distinct at the base, the margins usually rolled back, frequently so as to give it a contracted appearance in the middle, and by the nerves always forked. *P. Monyi* and *P. venulosa* have the pinnules more rapidly tapering, shorter proportionately, those contiguous at the base becoming separate above, the midrib of the larger pinnules more decurrent, and but few of the nervils forking once in the larger pinnules, the former species having a thinner median nerve, while the latter has the median nerve thickened near the base.

Locality.—McClelland's shaft.

[1] Coal Flora, I, p. 232.

NEUROPTERIDEÆ.

NEUROPTERIS Brongniart. 1822.

NEUROPTERIS FIMBRIATA Lx.

1852. *Cyclopteris fimbriata* Lesquereux, Proc. Boston Soc. N. H., IV, p. 177. 1854: Lesquereux, Boston Jour. N. H., VI, 416. 1858: Lesquereux, Geol. Penn., II, p. 855, Pl. IV, Figs. 17, 18. 1863: Dawson, Can. Nat., VIII, p. 442. 1866: Wood, Trans. Am. Phil. Soc., XIII, p. 348. 1878: Dawson, Acadian Geol., 3d ed., p. 481. 1878: Lesquereux, in I. C. White, Rept. Prog. Geol. Surv. Penn., "Q," p. 54. 1880: Fontaine and I. C. White, Permian Flora, p. 17.

1857. *Neuropteris fimbriata* Lesquereux, 3d Rept. Geol. Surv. Ky., p. 536. 1860: Lesquereux, 2d Rept. Geol. Surv. Ark., p. 315. 1866: Lesquereux, Geol. Surv. Ill., II, Paleont., p. 430. 1870: Lesquereux, Geol. Surv. Ill., IV, Pt. 2, p. 384, Pl. VI, Fig. 4. 1874: Schimper, Traité, III, p. 474. 1879: Lesquereux, Coal Flora, I, Pl. V, Figs. 1–6; text (1880), p. 81. 1880: Fontaine and I. C. White, Permian Flora, p. 51. 1883: Lesquereux, 13th Ann. Rept. Geol. Surv. Ind., Pt. 2, p. 52, Pl. X, Fig. 2. 1887: Kidston, Foss. Fl. Radstock Ser., p. 361, Pl. XXI, Figs. 3–5.

1860. *Cyclopteris Wilsoni* H. C. Wood, Proc. Acad. Nat. Sci. Phila., XII, p. 519.

Fronds tripinnate; primary pinnæ apparently large, triangular; secondary pinnæ linear, slightly oblique; rachis round, undulate, finely striate, more or less punctate, bearing alternate, distant, oval or oblong, or nearly round, rarely entire pinnules, generally fringed from the middle upward, auricled and entire at the broad base, pedicellate in the upper pinnules, which are slightly decurring; veins distinct, flabellate and dichotomous from the base, dividing three or four times in the larger pinnules, generally twice in the smaller ones, slightly arched toward the borders, and ascending to the top of the long, narrow, acute, undulating fimbriæ.

The foliage of this beautiful fern has been fully illustrated by Prof. Lesquereux in the Illinois and Pennsylvania reports. My specimens show considerable variation in the closeness of the nervation of the large pinnules, the fimbriæ in some pinnules becoming correspondingly crowded and much closer than in Lesquereux's figures. The latter are slender, sometimes as much as 7^{mm} in length, usually tapering from the base to a fine sharp point, and wavy. In one large pinnule, which is parted below the middle into two lobes, dichotomously, the long laciniæ are largely dichotomous, lending an Aphlebian aspect to portions of the margin. A similar bifurcation of the laciniæ on a small scale seems to be present on one specimen figured in Kidston's Radstock Flora.[1] The nervation in some pinnules seems fully as close as that in Heer's figure of *Cyclopteris lacerata*,[2] and appears to justify the inclination of Schimper and Kidston to unite the two species, though Weiss regarded Heer's species as belonging in part to *Neuropteris heterophylla*.[3] Should the American and Swiss species prove to be identical, *Neuropteris fimbriata* will have priority.

Relations.—This fern is quite easily distinguished in its large pinnules by the normally fimbriate margins. It differs from *Neuropteris*

[1] Trans. Roy. Soc. Edinb., XXXIII, p. 361, Pl. XXI, Fig. 3.

[2] Fl. foss. Helv., p. 17, Pl. VI, Fig. 17.

[3] Verhandl. Nat. Hist. Ver. pr. Rheinl. u. Westfalens, XXV; Jahrg. 1868, p. 78.

dentata Lx. and *Neuropteris laciniata* Lx. by its thinner, more delicate texture, and from the former by its margin, fringed instead of jagged toothed. The small pinnules differ from *Neuropteris flexuosa* and *Neuropteris heterophylla*, to both of which this species is closely allied, by its pinnules distant and its nervils fewer than in the latter and more distant than in either.

Locality.—Found in fragments of pinnæ and distorted pinnules from McClelland's shaft and Hannam's shaft.

NEUROPTERIS SCHEUCHZERI Hoffm.

1826. *Neuropteris Scheuchzeri* Hoffmann, in Keferstein, Teutschland, IV, p. 157, Pl. 1b, Figs. 1b-4. 1840: Jackson, Rept. Geol. Agricult. Surv. R. I., 1839, p. 288, Pl. v, Fig. 10. 1857: Kimball, Fl. Appal. Coal Field, p. 9, Pl. 1, Fig. 1. 1869: Schimper, Traité, I, p. 434. 1887: Kidston, Radstock Ser., p. 356, Pl. XXIII, Fig. 1, 1a, 2.

1830. *Neuropteris Scheuchzeri* Hoffm., Brongniart, Hist. vég. foss., p. 230, Pl. LXIII, Fig. 5. 1882: Zeiller, in Barrois, Terr. anc. Asturies, p. 559. 1886: Zeiller, Fl. foss. houill. Valenciennes, atlas, Pl. XLI, Figs. 1, 1a, 2, 3; text (1889), p. 251.

1830. *Neuropteris angustifolia* Brongniart, Hist. vég. foss., p. 231, Pl. LXIV, Figs. 3, 4.

1830. *Neuropteris acutifolia* Brongniart, Hist. vég. foss., p. 231, Pl. LXIV, Figs. 6, 7.

1832. *Neuropteris cordata* Brongn., Lindley and Hutton, Fossil Flora, I, p. 119, Pl. XLI. 1847: Bunbury, Quart. Jour. Geol. Soc. London, III, p. 423, Pl. XXI, Figs. 1, 1a–f. 1853: Newberry, Annals Sci., I, No. 9, p. 106. 1865: (?) Göppert, Foss. Fl. Perm. Form., p. 100, Pl. XI, Figs. 1, 2. 1878: Dawson, Acad. Geol., 3d ed., p. 446, Fig. 166b. 1880: Lesquereux, Coal Flora, p. 91 (pars). 1888: Dawson, Geol. Hist. Pl., p. 126, Fig. 51b. 1889: Lesley, Dict. foss. Penn., II, p. 452, figure.

1836. ——— Morton, Amer. Jour. Sci., XXIX, Pl. XI, Fig. 26.

1838. *Neuropteris angustifolia* Brongn., Foster, N. Jahrb. f. Min., p. 535. 1862: (?) Geinitz, Dyas II, p. 139, Pl. XXVII, Fig. 9. 1869: (?) v. Roehl, Foss. Fl. Steinkohlen. Westphalens, p. 33, Pl. XIV., Fig. 7. 1870: Lesquereux, Geol. Surv. Ill., IV, p. 467. 1879: Lesquereux, Coal Flora, atlas, Pl. VIII, Figs. 2, 3, 6, 8, 10, 11; text (1880) p. 89. 1880: Fontaine and I. C. White, Permian Flora, p. 17. 1883: Lesquereux, 13th Rept. Geol. Surv. Ind., Pt. 2, p. 52, Pl. X, Fig. 1. 1884: Lesquereux, Coal Flora, III, p. 734. 1889: Lesley, Dict. foss. Penn., II, p. 451, figure.

1847. *Neuropteris cordata* Brongn., var. *angustifolia*, Bunbury, Quart. Jour. Geol. Soc. London, III, p. 424. 1866: Dawson, Quart. Jour. Geol. Soc. London, XXII, p. 154.

1854. *Neuropteris hirsuta* Lesquereux, Boston Jour. Nat. Hist., VI, No. 4, p. 417. 1857: Lesquereux, Geol. Surv. Ky., III, p, 534, 556, Pl. VI, Fig. 4. 1858: Lesquereux, Geol. Penn., II, p. 857, Pl. III, Fig. 6; Pl. IV, Figs. 1–16. 1860: Lesquereux, Geol. Surv. Ark., II, p. 315. 1866: Lesquereux, Geol. Surv. Ill., II, Paleont., p. 427. 1869: Schimper, Traité, I, p. 445. 1870: Lesquereux, Geol. Surv. Ill., IV, Paleont., II, p. 380. 1875: Dana, Manual Geol., 2d ed., p. 327, Fig. 635. 1879: Lesquereux, Coal Flora, atlas, Pl. VIII, Figs, 1, 4, 5, 7, 9, 12; text (1880), p. 88. 1880: Fontaine and I. C. White, Permian Flora, pp. 16, 17, 47, Pl. VIII, Figs. 7, 8. 1881: C. A. White, Rept. Geol. Surv. Ind., 1879–'80, p. 152, Pl. IX, Figs. 1, 2, 3. 1882: Le Conte, Geol., p. 365, Fig. 473. 1883: Chamberlain, Geol. Wis., I, p. 216, Fig. 67f. 1887: Lesquereux, Ann. Rept. Geol. Surv. Penn., 1886, Pt. 1, p. 517. 1889: Lesley, Dict. foss. Penn., II, pp. 460, 461, 462, figures.

1855. *Neuropteris acutifolia* Brongn., Ettingshausen, Steinkohlenfl. Radnitz, p. 32, Pl. XVIII, Fig. 5. 1876: (?) O. Feistmantel, Verst. böhm. Ablag., III, p. 64, Pl. XVII, Fig. 4. 1880: Fontaine and I. C. White, Permian Flora, p. 20. 1881: Weiss, Aus d. Fl. d. Steink., Pl. XIV, Fig. 89.

1857. *Neuropteris Rogersii* Kimball (non Lx.), Fl. Appal. Coal Field, p. 10, Pl. I, Fig. 1.

1884. *Neuropteris angustifolia* Brongn. var. *hirsuta* Lesquereux, Coal Flora, III, p. 885.

Fronds tripinnate, spreading, dichotomizing below; primary pinnæ large; primary rachis robust, lineate; secondary pinnæ alternate or sub-opposite, oblique, lanceolate, or linear-lanceolate, somewhat contracted at the base, frequently overlapping; ultimate pinnæ alternate or sub-opposite, oblique or at right angles to the rachis, close or distant, sometimes overlapping, very caducous, and generally trifoliate, consisting of a large oblong-lanceolate, lanceolate, or linear-lanceolate more or less obtusely pointed, entire, or undulate, often somewhat falcate, short pedicellate median pinnule 3–11^{cm} long, having close at its rounded or more or less auricular base one or two small somewhat polymorphous pinnules, the latter usually unequilateral, round, oval, or reniform, but sometimes becoming double, enlarging into lobate-lanceolate or even digitate cyclopterid pinnules; ultimate pinnæ succeeded above on the secondary pinnæ by large pinnules similar to the median pinnules of the ultimate pinnæ, but sessile on the thorn-like attachment to the rachis, and more or less distinctly cordate, auriculate, or lobed at the base, the upper side rounded, the lower auriculate or lobed, passing into the pinnate form; lower surface of the pinnules generally provided with rather rigid hairs or bristles 1–3^{mm} in length, generally visible to the naked eye, scattered irregularly about, close or distant, and lying in various directions, but mostly in a direction somewhat parallel to the midrib, or the course of the nerves, often producing a dictyopterid effect; margins of the leaves usually slightly arched backward; basilar or cyclopterid pinnules often naked, with nervation rather coarser than in the terminal pinnules and generally flabellate from the base; primary nerve originating usually from a broad, short pedicel, distinct in the terminal or long pinnules, though rather thin, ascending three-fourths of the length of the pinnule or more before vanishing; nervils originating at a narrow angle to the midrib, arching gradually and dichotomizing three or four times before they have passed a little more than half way from the median nerve to the border, some of them forking a fifth time, thin, close, often undulating, usually more or less immersed in the epidermis, which is raised between them, meeting the border somewhat obliquely, except in the lower part of the pinnules, and numbering thirty-five to forty-five per centimeter at the border.

This species is one concerning which great confusion has existed during many years; and while many paleontologists, including at one time Prof. Lesquereux, have been disposed to regard forms described by Brongniart under the names of *Nevropteris Scheuchzeri*, *N. angustifolia*, and *N. acutifolia* as ill-defined and belonging perhaps to the same species, an opinion first suggested by Brongniart himself, the question remained unsolved, for lack of sufficient material and a better knowledge of Brongniart's type, until Mr. Zeiller, in the course of his critical and exhaustive researches in the floras of the French coal fields, made a thorough and painstaking examination of Brongniart's specimens,

and elaborated the original descriptions. To the invaluable investigations by Zeiller of the types in the Museum d'Histoire Naturelle and by Kidston among the types in the British Museum, the Geological Society of London, and other collections, we are especially indebted for a knowledge of the real characters and identity of these as well as many other species described or figured, often imperfectly, by Brongniart and Lindley and Hutton.

The affinities of the above-mentioned forms as well as the variations among the specimens belonging to each of the species that have been distinguished in this country are incidentally indicated in the following notes, which, so far as they relate to American material, are based on specimens in the collection of the U. S. National Museum examined and labeled—many of them recorded in the "Register"—by Lesquereux at various times since the appearance of the first two volumes and atlas of the Coal Flora.

Neuropteris Scheuchzeri Hoffm.

Although, in his original description of *Neuropteris Scheuchzeri*, Hoffmann[1] fails to mention the hirsute character of his species, both the agreement of his figures and descriptions and the identification and description of the same fern by various European paleontologists show that it is identical with the *Neuropteris cordata* described and illustrated by Lindley and Hutton and Bunbury, which in turn is proved specifically identical with Brongniart's types of *N. angustifolia* and *N. acutifolia*. Zeiller does not seem to have had access to Brongniart's type of *N. Scheuchzeri*, and is not assured[2] of its identity with Hoffmann's species, though the figure in the Histoire[3] agrees fairly well with the fragment represented in Fig. 2 on Hoffmann's plate, or equally with the specimen from Pennsylvania figured as *Neuropteris Scheuchzeri* by Kimball.[4] The type of *N. Scheuchzeri* as described and figured by Brongniart came from Wilkesbarre, Pa., whence that author had types of *N. angustifolia* and *N. acutifolia*, and he was disposed to consider the former as perhaps identical with *N. Scheuchzeri*, though it was impossible to tell from so little material, consisting of isolated pinnules. The identity of the Pennsylvania specimens described as *N. Scheuchzeri* with the Old World forms is further indicated by a comparison with the descriptions and figures of foreign authors, especially with those of the magnificent fragment of a pinna given by Kidston in the Flora of the Radstock Series.[5]

[1] Keferstein's Teutschland geognostisch-geologisch dargestellt, mit Charten und Zeichnungen welche einen geognostischen Atlas bilden, vol. IV, Weimar, 1826, p. 157, Pl. I b, Figs. 1–4.

[2] Fl. Foss. houill. Valenciennes, p. 254.

[3] Pl. LXIII, Fig. 5.

[4] Flora of the Appalachian Coal-Field, Göttingen, 1857, p. 9, Pl. I, Fig. 1.

[5] Trans. Roy. Soc. Edinb., XXXIII, 1887, p. 256, Pl. XXIII, Figs. 1, 2.

Neuropteris hirsuta Lx.

In his original description[1] of *Neuropteris hirsuta*, as well as in that published with the illustrations in Rogers's Geology of Pennsylvania,[2] Lesquereux inscribes *Neuropteris angustifolia*, *N. acutifolia*, *N. Scheuchzeri*, and *N. cordata* as synonyms, referring in the last case to both Brongniart's and Lindley and Hutton's works. In his remarks Prof. Lesquereux notes that "near the summit of the pinnæ the pinnules become simple, narrowly lanceolate (in which case they belong to *Neuropteris angustifolia* Brongn."), and that "*Neuropteris Scheuchzeri* Hoffm., sent to Mr. Brongniart from Wilkesbarre, belongs probably to this species also; nevertheless, we have never seen a leaflet with the petiole attached to it as it is figured by this eminent author." But in the Coal Flora[3] the pinnules of this species are distinctly described and figured as pedicellate when compound. He further adds, that "except the villosity the characters of this species are much like those of the following [*N. angustifolia*], and in some cases it is very difficult to ascertain the reference of the leaflets generally found detached from the rachis and often mixed together;" and Schimper[4] was disposed to accept the species, in default of a better definition of the other species, on account of the presence of the hairs. Except the occurrence of these hairs in *N. hirsuta* the only other distinctions between it and *N. angustifolia* that I am able to derive from the descriptions are a wider pinnule, less acute for the former, while in the latter the pinnules are perhaps more distant, the midrib proportionately stronger and extending farther up the pinnule, and the veins of the cyclopterid pinnules rather closer than in those of *N. hirsuta*. In *N. hirsuta* the median pinnules are "more rapidly narrowed upward, but never pointed," the nerves counting forty to fifty per centimeter at the margin.

Among the specimens labeled *Neuropteris hirsuta* in the Museum collection the following are examples: Number 1454, from Mazon Creek, represents the lower part, 8^{cm} long, of a pinnule 3^{cm} wide, somewhat falcate, the borders parallel, rounded toward the base with slight auricles near the pedicel, like those seen in *N. decipiens*.[5] The pedicel is flat, 5½^{mm} long, 2^{mm} wide; the surface of the pinnule is hirsute, the midrib and nervation exactly that of *N. decipiens* and counting twenty-eight to thirty per centimeter at the border. No. 1451 is a pinnule 9½^{cm} long, 2½^{cm} wide, oblong-lanceolate, rather bluntly pointed, the base broken; hirsute, external characters identical with the former, nervation twenty-eight to thirty per centimeter. No. 1016, an entire pinnule, 6½^{cm} long, 2½^{cm} wide, oblong lanceolate, rather acute at the tip, somewhat narrowed below, auriculate, hirsute; 26 or 27 nervils per centimeter. No. 1450, ovate-lanceolate, 6^{cm} long, 2½^{cm} wide near the

[1] Bost. Journ. Nat. Hist., VI, 1854, No. 4, p. 417.
[2] II, p. 857, Pl. III, Fig. 6; Pl. IV, Figs. 1–16.
[3] Vol. I, p. 88, Pl. VIII.
[4] Traité, I, p. 445.
[5] Coal Flora, III, Pl. XCIV, Fig. 2, terminal pinnule.

base, rather obtuse above, the base like 1454, distinctly pedicellate; midrib very thin, dissolving in the upper quarter; hirsute; nervils twenty-six per centimeter. This pinnule has the outline and thin midrib characteristic of the American *N. cordata*, as seen in specimens from Cannelton, labeled by Lesquereux. The form is similar to that of the *N. cordata* figured by Zeiller in the Commentry Flora, Pl. XXVIII, Fig. 2, though the nervation is very different. No. 1452 contains a fragment of the middle of a pinnule 32^{mm} wide, showing the characteristic nervation of the Mazon Creek pinnules, the nervils numbering twenty-eight to thirty per centimeter. No. 1455 is a linear-lanceolate pinnule, 8½^{cm} long, 2½^{cm} wide near the base, tapering upward to a rather acute point; base wanting; borders undulate; hirsute; nervils twenty-nine to thirty per centimeter. This specimen agrees in outline with the typical *N. hirsuta*. All of the above specimens said to belong to *N. hirsuta* are from Mazon Creek. All have the same form and nervation, and the same number of nervils per centimeter on the margin as *Neuropteris decipiens* Lesq., described[1] as abundant at Mazon Creek, from which locality a large number of specimens of the latter species have been compared. These specimens labeled *N. hirsuta* are said to have passed under Lesquereux's hand since the publication of the description of *N. decipiens*, from which the only distinction made seems to be that the pinnules of the latter are comparatively larger and the nerves twenty-five to twenty-eight per centimeter on the border, but after a critical examination and comparison I can find no character in them that is different from those seen in specimens in the same collection labeled *N. decipiens*.[2]

Of the other specimens labeled *Neuropteris hirsuta*, No. 2188, from Eugene, Indiana, represents the greater part, including the tip of a linear-lanceolate pinnule, 9¼^{cm} long, 2^{cm} wide, tapering to a long slender tip which is rounded at the apex. A fine midrib passes nearly to the top. The specimen is distinctly hirsute; the nervils thirty-five to thirty-eight per centimeter. It appears to represent the form described by Brongniart as *N. angustifolia*, though larger than his *N. acutifolia*, while it is nearly as acute as the latter. Another specimen with the same number, from the same locality, is linear-lanceolate, 7^{cm} long, the top wanting, 17^{mm} wide, somewhat falcate, slightly contracted towards the base, tapering in the upper half, the border undulate, rounded at the base, and agreeing excellently with Brongniart's and Kimball's *N. Scheuchzeri*, except that the midrib is not strong, and the pedicel, 3^{mm} long, 1½^{mm} wide, is not round as Brongniart's figure represents. The nervils count thirty-five to forty per centimeter. No 1290, from the Excelsior Colliery, is a long linear-lanceolate leaf 10½^{cm} long, 19^{mm} in greatest width, somewhat falcate, with a characteristic unequal base and pedicel, and tapering from the base to a rather slender acute tip, the extreme

[1] Coal Flora, III, p. 733.

[2] The apparent confusion regarding this species is probably due to the fact that it was not fully diagnosed until the third volume of the Coal Flora was published.

apex slightly rounded; the slender midrib passes to near the tip; the margin is rather undulate; surface hirsute in portions; nervils thirty-five to thirty-eight per centimeter. This pinnule, which has the form of *N. angustifolia* in Brongniart's plate, though more tapering and more slender than his *N. acutifolia*, is much larger than any of the slender acute pinnules that I have seen figured, the nearest illustration being that of *N. Scheuchzeri*, Fig. 2 of the Pl. XLI in the atlas to Zeiller's Valenciennes flora. The specimen, identified in 1881 or 1882, appears to contradict the statement in the Coal Flora that the pinnules of *N. hirsuta* are "never pointed." No. 1948 is a very interesting specimen from Wilkesbarre, the locality whence came some of Brongniart's specimens of *N. acutifolia*. It agrees excellently with Brongniart's figure of *N. acutifolia*, except that the upper side of the base is not so truncate. It is also comparable to Bunbury's Fig. 1c[1] of *N. angustifolia*. The apex is fully as acute as in Brongniart's figure. The pinnule, which is over $7\frac{1}{2}^{cm}$ long and 20^{mm} wide, is densely hirsute. There can hardly be any doubt of the specific identity of this specimen with that described by Brongniart from the same locality. Two other fragments, No. 2185, from St. Clair, Schuylkill County, Pennsylvania, showing the same characters of nervation and apex, are less distinctly hirsute and have their nerves forty-one to forty-five per centimeter. Another specimen, No. 1299*a* contains the greater part of a pinnule, including the base, $6\frac{1}{2}^{cm}$ long, 18^{mm} wide, linear, distinctly hirsute, with thirty-six to thirty-eight nervils per centimeter. The pinnule resembles somewhat the *N. cordata* figured by Lindley and Hutton, or still better the pinnule marked *X* in Kidston's fine specimen[2]. The back side of the same rock contains an unlabeled upper portion of a large hirsute, lingulate, obtusely pointed pinnule, of exactly the form illustrated in Fig. 5, Pl. VIII, of the Coal Flora. It is also characterized by elongated pits between many of the nerves, which I take to represent perhaps the markings described and figured by Fontaine and I. C. White[3] as fructifications of *N. hirsuta*. It is a suggestive fact that Brongniart also, in the description of *N. angustifolia*, notes "indications of fructification" between the nerves, similar to the supposed fructification of *N. flexuosa*. Another specimen of No. 2188, from St. Clair, contains fragments of several pinnules of the forms illustrated by Lesquereux in Rogers' Report[4] and Dr. C. A. White in Collet's Indiana Geological Report, 1879–1880.[5]

The nervation is forty to forty-two per centimeter at the border.

Neuropteris angustifolia Brongn.

Brongniart, in his description of the *Nevropteris Scheuchzeri* from Wilkesbarre, Pennsylvania, observes[6] that these isolated pinnules might be from a different part of the same plant as the *N. angustifolia*,

[1] Quart. Jour. Geol. Soc. London, III, Pl. XXI.
[2] Radstock Flora, Pl. XXIII, Fig. 1.
[3] Permian Flora, p. 47, Pl. VIII, Figs. 7, 8.
[4] Geol. Penn., II, 1858, Pl. III, Fig. 6.
[5] P. 152, Pl. IX, Fig. 1.
[6] Hist. Vég. foss., p. 230.

the identity of the localities making such a relation quite probable, but that the great difference in form made it necessary to consider them as distinct, although the disposition and fineness of the nervation were similar. The possibility that *N. angustifolia* was only a variety or even a part of the other is again stated[1] on the following page in the description of the latter species. No mention is made by that author of the occurrence of hairs on either species. It was singular and probably an oversight that Lesquereux, in his descriptions of Brongniart's *N. angustifolia*, whose chief and sole important difference from *N. hirsuta*, as stated above (Coal Flora, I, p. 89), consisted in the absence of hairs on the pinnules, the nervation being the same, should have followed Schimper in referring as a synonym to this smooth-pinnuled species Bunbury's *N. cordata* from Cape Breton, which was both described and figured as distinctly hirsute.

But an important light on the question of the relation of these species results from Zeiller's examination of Brongniart's original specimens of *Nevropteris angustifolia* and *N. acutifolia* from Wilkesbarre, Pennsylvania, and near Bath, England, in which he has found both species to have the same form and hairs characteristic of *N. Scheuchzeri*.[2] This fact, in connection with the following notes on specimens identified by Lesquereux as *N. angustifolia* in the Museum collection, tends to show that the fundamental and perhaps the only important distinction between *N. hirsuta* and *N. angustifolia* as differentiated by Lesquereux rests on a probable failure of observation or description.

I have found but four specimens labeled *Neuropteris angustifolia* in the Museum collection. Of these No. 1017, from Mazon Creek, is an inequilateral lanceolate pinnule $6\frac{1}{2}^{cm}$ long, 20^{mm} wide below the middle, somewhat contracted toward the base, which is auricled on one side, pedicellate, with a moderately thick midrib passing well up into the slender tip, which, though partially broken, was probably rounded; the margins are undulate; the surfase is sparsely hirsute; the nerves 25 to 27 per centimeter. No. 1017, from Mazon Creek also, is a bipartite pinnule similar to those figured by Lesquereux[3] as *N. hirsuta* and *N. angustifolia*. It is divided to within 5^{mm} of the base, the midribs joining in a common pedicel. The broader division is ovate lanceolate, auriculate on one side at the base, obtuse at the apex, 4^{cm} long, 19^{mm} wide; the other division is narrowly lanceolate, acute, slightly shorter, and about 9^{mm} wide. The nervils number 20 to 25 per centimeter, and the pinnule is distinctly hirsute. Were the two parts detached one should be referable, purely on account of its form, to *N. hirsuta*, while the other, for the same reason, would probably belong to *N. angustifolia*. But the characters are so exactly those of *N. decipiens*, though

[1] Cette plante, dont nous n'avons vu que des pinnules isolées, n'est peut-être qu'une variété de l'espèce précédente, ou peut-être n'est elle fondée que sur des folioles provenant de parties différentes de la même feuille; leur structure est la même; mais les pinnules sont constamment beaucoup plus étroites, quoique d'une longueur à peu près semblable.

[2] Fl. foss. houill. Valenciennes, p. 254. See Atlas, Pl. XLI, Figs. 1–3.

[3] Geol. Penn., II, Pl. IV, Figs 3, 4; Coal Flora, Atlas, Pl. VIII, Figs. 9, 11.

the form is not that described for the species, that they can be referred only to that hirsute species, which is so predominant in that deposit, and with whose nervation they fully accord. The remaining two specimens with this name are both from the original locality, Wilkesbarre. No. 1946 is a linear fragment $6\frac{1}{2}^{cm}$ long and 18^{mm} wide, the apex and a portion of the base being lost. Enough remains to show that the base is rounded on one side, while the upper portion tapers gradually; the margins are undulate; the nervation, which is indistinguishable from that seen in No. 1290 (*N. hirsuta*), is very nearly like that seen in some specimens of *N. cordata* from Cannelton. The nervils count 36 to 40 per centimeter. The specimen has the proportions and appearance of Hoffman's Fig. 3. Portions of the pinnule are clearly hirsute. The other specimen bears the same number. It represents the lower 5^{cm} of a lanceolate pinnule 21^{mm} wide. The thin midrib runs well up, the undulate sides are rounded toward the pedicellate base. The specimen is nearly a counterpart of Brongniart's figure of *N. Scheuchzeri*, except that the midrib is not so strong and distinct, but comparison by other European authors of his figures with the types has taught that the figures are not always trustworthy. The nervation is still closer to that of the Cannelton specimen—42 to 45 per centimeter. Numerous fragments of other pinnules on the same rock show the proportions of the *N. hirsuta*, in Pl. VIII, Fig. 5, of the Coal Flora, the upper part tapering to a rounded tip, the basal portion pedicellate and auriculate. The auricular lobes often seen in the bases of these forms, as well as in *N. decipiens* and *N. cordata*, have the rounded sinuses running upward along the pedicel, like that seen in Pl. XCIV, Fig. 2, of the Coal Flora, and Bunbury's Fig. 1c. Nearly all the fragments are plentifully supplied with distinct hairs. The first two specimens were identified by Lesquereux in 1881, the last two in 1884.

It was not, I believe, until 1870[1] that Lesquereux removed *N. angustifolia* from the synonymy of *N. hirsuta*, remarking that "the surface of the leaflet is smooth, without hairs; the veinlets somewhat coarser and not quite as distinct as in *hirsuta*," though he thought it might still be only a form of *N. hirsuta*. The difficulty often experienced by him in distinguishing between the two forms, expressed in 1880,[2] is further indicated in the discussion of the pedicels of the terminal pinnules of these two species, when, in describing *N. hirsuta*, he says: "It is probably upon one leaf of this kind that Brongniart made his species, *N. Scheuchzeri*, Hist. d. Vég. foss., p. 230, Pl. LXIII, Fig. 5. The characters are exactly those of *N. angustifolia*, a species commonly found at Wilkesbarre, wherefrom the author received the American specimen which he refers to it." Three pages farther in the volume a statement essentially the same is made with reference to *N. cordata*. The third volume of the Coal Flora contains a note on a "variety" of *N. angustifolia* "from

[1] Geol. Surv. Ill., IV, p. 467.
[2] Coal Flora, p. 89.

Ottawa and Osage City, Kansas, with leaflets hirsute, like those of *N. hirsuta*." They have a broad, deep percurrent medial nerve, with oblique, somewhat thick, lateral nerves counting thirty-five to forty per centimeter on the border. It was then regarded as midway between *N. hirsuta* and *N. decipiens*. This is probably the variety referred to in the table, op. cit., p. 885, as *N. angustifolia* var. *hirsuta*, whose sole distribution includes the above mentioned localities. I am wholly at a loss for any reason explaining why the presence of the hairs on the specimens from the Eastern states identified by him as *N. angustifolia* should not have been mentioned.

This examination of the authentic specimens in the Museum labeled by Lesquereux shows (1) that most of those marked *N. hirsuta* are more lanceolate, with a much more acute tip, than the specimens figured by him; and (2) that the apparent difference between the *N. hirsuta* and the specimens marked *N. angustifolia* lies in the fact that the latter name was usually applied to those narrower pinnules on which the hairs are less distinct. The nervils, counted at the border, do not average less in *N. angustifolia* than in *N. hirsuta*. Among the narrower pinnules of *N. Scheuchzeri* belong those identified as *N. angustifolia* by Brongniart; *N. Scheuchzeri*, by Jackson;[1] *N. Rogersii*, by Kimball,[2] the relation of which to Pl. VIII, Fig. 8, of the Coal Flora, or Pl. IV, Fig. 5, of the Pennsylvania Geology, is at once apparent; Ettingshausen's *N. acutifolia;*[3] Bunbury's Fig. 1 B; the *N. hirsuta* figured by Dr. C. A. White,[4] and the *N. Scheuchzeri* illustrated by Zeiller in the Valenciennes Flora.[5]

Neuropteris cordata.

Another species quite misunderstood in this country is that identified as *N. cordata* Brongn. Of this Prof. Lesquereux says:[6] "It seems to be a variety of *N. angustifolia*, from which it differs essentially by the broader terminal leaflets." The nervation and the form of the pinnules are described as being the same as in *N. angustifolia*, both species being found in the same locality, where in many cases *N. hirsuta* was identified.

The study of a large series of specimens of *N. cordata*, identified by Lesquereux in the Museum collection, reveals outlines common to both *N. hirsuta* and *N. decipiens*. The pinnules generally have their lateral margins rather more rounded than in the above-named forms, but many are linear-lanceolate, though slightly more obtuse, and as a rule, more nearly equal at the base. It differs somewhat in nervation from *N. Scheuchzeri*; the midrib, rather strong at the base, vanishes above the middle, or passes into the apex. The nervation often resembles

[1] Rept. Geol. and Agricult. Surv. R. I., 1839 (1840), Pl. v.
[2] Fl. Appalachian Coal Field, Pl. I, Fig. 2.
[3] Steinkohlenfl. Radnitz, Pl. XVIII, Fig. 5.
[4] Indiana Geol. Rept., 1879–'80, Pl. IX, Fig. 2.
[5] Atlas, Pl. XLI, Figs. 2, 3.
[6] Coal Flora, p. 92.

closely that of the Wilkesbarre specimens of *N. Scheuchzeri*, being very fine, and nearly as close near the midrib as at the border, where it is 40 to 50 per centimeter. It is difficult to distinguish some of the specimens from *N. Scheuchzeri*, and an examination shows in some cases (cf. Nos. 1083, 1084, 1084*a*), probable errors in identification, and identity in form, texture, nervation, and hirsuteness with that species. However, most of the specimens have their nervation rather finer, more evenly embedded in the parenchyma, and the surface smooth, appearing to constitute a distinct variety, if not a separate species.

The specimens described by Lindley and Hutton[1] as *N. cordata* Brongn., referred to by Lesquereux in the synonymy, have proved on examination by Kidston to be, like Bunbury's, hirsute and identical in all respects with *N. Scheuchzeri*. On the other hand, although the type of Brongniart's figure is lost, Zeiller has found many specimens in the Museum at Paris labeled by Brongniart, some of which are the true *N. cordata* figured in the "Histoire," while others are *N. Scheuchzeri*. The true *N. cordata* of Brongniart as newly described by Zeiller,[2] although resembling many of the Cannelton specimens in form and proportions, has the pinnules smooth, the midrib hardly more than a line, and the nervils distant, counting only eight to fifteen per centimeter.[3]

It may be noted also in this connection that Kidston and Zeiller unite in referring F. A. Roemer's hirsute *Dictyopteris cordata*[4] and *D. Scheuchzeri* founded on Brongniart's *N. cordata*, and Hoffmann's *N. Scheuchzeri*, respectively, to be the true *Neuropteris Scheuchzeri* Hoffm. Should this reference prove valid, the plants identified and briefly described, without illustration, by Lesquereux in the third volume of the Coal Flora[5] as *Dictyopteris cordata* and *D. Scheuchzeri*, need, if good species, to be more fully described and figured under other names. The undulation of the nervils, in *N. Scheuchzeri*, frequently simulating anatomosis, was pointed out by Lesquereux. It is well illustrated in the specimens No. 2188, described above.

The synonymy of the names correlated with *Neuropteris Scheuchzeri* Hoffmann affords a good illustration of the fallibility, frequently a positive evil, of identifying American species with those in a different hemisphere solely on the basis of their agreements with descriptions and figures (often imperfect, incomplete, or misleading), without having recourse to actual authentic specimens for comparison.

---

[1] Fossil Flora, p. 118, Pl. XLI.

[2] Fl. Foss. Commentry, p. 237, Pl. XXVII, Figs. 6-10; Pl. XXVIII, Figs. 1, 2. Fl. Foss. Autun et Épinac, p. 150, Pl. XI, Fig. 5.

[3] Mr. Lacoe informs me that in unpublished manuscript Prof. Lesquereux removes the species described as *N. cordata* Brongn. in the Coal Flora, declaring it to be probably new, and that he still later found the true *N. cordata* Brongn. with distant nervation, and also typical *N. Scheuchzeri*. Before completing the study of this group the health of the lamented pioneer and elaborator in the study of our Carboniferous flora became so impaired that he never so far advanced the manuscript as to rename the Cannelton species.

[4] Palæontogr., IX, 1860, p. 30, Pl. VI, Fig. 4; Pl. IX, Fig. 1. See von Roehl, Foss. Fl. Steinh. Westphalens, pp. 49, 50, Pl. XXI, Fig. 12 (?); Pl. XV, Fig. 6; Pl. XXI, Fig. 7*b*.

[5] Pp. 832, 833.

Neuropteris Clarksoni Lx.

It is frequently difficult to distinguish between some of the pinnules identified as *N. Clarksoni* and such of the more narrow and acute pinnules of *N. Scheuchzeri* as have not been preserved so as to show the hairs. An illustration of this is seen in a specimen from Cannelton, No. 1887 of the Museum collection, labeled *Neuropteris Clarksoni*. It consists of an entire pinnule, linear-lanceolate $10\frac{1}{2}^{cm}$ long, falcate, tapering gradually upward to a slender point, which is slightly rounded at the tip; it broadens at the base, which is sublobate, 31^{mm} in greatest width, unequal and auriculate and broadly pedicellate. This dilation of the base, which is greater than that I have seen in any specimens of *N. Scheuchzeri*, is comparable to what is seen in the *N. Clarksoni*, figured on Plate VI of Rogers's Report.[1] The upper portion of the pinnule is similar in form, size, and nervation to that seen in specimens No. 2188 and 1290, described above under *N. hirsuta*. The secondary nerves are, however, less distant near the thin midrib than is characteristic of *N. Clarksoni;* the margins are undulate and the surface clearly hirsute over most of its area. Another specimen, labeled *N. Clarksoni*, No. 1947, this time from Wilkesbarre, linear-lanceolate, somewhat falcate pinnule, is 8^{cm} long, 16^{mm} wide, tapering, but not quite so acute as in the last; the base is rounded, characteristic of *N. Scheuchzeri*, auriculate and pedicellate, the nerves count thirty-eight to forty per centimeter; the hairs on the surface are easily visible to the naked eye. Both species are referable to *N. Scheuchzeri*, No. 1947, representing the form known as *N. angustifolia*. In the true *Neuropteris Clarksoni* of Lesquereux, as represented by many specimens in the Museum the pinnules, which are not hirsute, are generally more narrowly acute, without basal cyclopterid pinnules, the auricles round and frequently overlapping at the base, the median nerve rather broad at the base, thinning gradually to the apex, its nerves in relief, much farther apart near the midrib and forking at a wider angle, arching towards and often forking near the border, which they meet nearly at right angles in the lower part, numbering twenty-eight to thirty-four per centimeter at the margin. It appears to me to be quite a different species from *N. macrophylla* Brongn., to which Kidston[2] has referred it.

Neuropteris fasciculata Lx.

Two other specimens identified by Lesquereux in the Museum collection are of some interest on account of their relation to our species. Specimen No. 1183 is the lower $6\frac{1}{2}^{cm}$ of an oblong lanceolate pinnule, 32^{mm} wide, unequally rounded, and pedicellate. The lower portion is somewhat compressed. The texture and nervation, twenty-five to twenty-eight per centimeter at the margin, are identical with that in No. 1202 or 1451, described above. No. 1181*a* contains the middle 6^{cm} of a sim-

[1] Geol. Penn., vol. II, 1858.

[2] Foss. Fl. Radstock Series, p. 354.

ilar pinnule, 3cm wide, tapering and rounding gradually toward the apex, the nervils twenty-six to twenty-eight per centimeter. Both of these specimens are labeled *Neuropteris fasciculata* Lx. But the characters in these specimens are in every respect, including the hairs, which are strong and visible to the naked eye, identical with those of the *N. decipiens* from the same place, to which only the pinnules can be referred. But *Neuropteris fasciculata* is described[1] as "evidently distinct from this last species [*N. hirsuta*], as is shown by its smooth (not hairy) surface," though the veins are said to be "about at the same distance as in *N. decipiens*." These two specimens, with their counterparts, are the only ones in the Museum labeled by Prof. Lesquereux as belonging to *N. fasciculata*. Their indisputable identity with *N. decipiens*, taken together with the fact that they come from Mazon Creek, where some of the types described and figured by Lesquereux were found and where the latter species is abundant, casts suspicion on the entire species, *N. fasciculata*. It is probable that both this species and *N. Collinsii* need a careful examination.

CONCLUSIONS.

My present observations warrant no claim to a final solution and differentiation of the vexed questions concerning the identities and relationships within this group of Neuropterids. The following conclusions may therefore be true only so far as they relate to the incomplete suites of specimens now in the Museum collection.

From the foregoing citations and notes it appears that the American types described and figured by Brongniart as *Nevropteris Scheuchzeri*, *N. angustifolia*, and *N. acutifolia* are all fragments of the same fern, and that all possess the hirsuteness which constituted the distinctive character of *N. hirsuta;* and that *N. hirsuta* is specifically inseparable from *N. angustifolia*, identified and described as smooth, though usually found at the same localities with the other. The identity of the American forms with the European fern *N. Scheuchzeri* is based purely on the comparison of American specimens in France by Brongniart and Zeiller, and the identification of the Cape Breton and British plants with the same species by Kidston. So far as the writer has been able to consult authentic specimens identified by Lesquereux, it also appears that the American *N. angustifolia*, like Brongniart's original, from the same locality, reveals, on a careful examination, the same characters, including the presence of hairs, as *N. Scheuchzeri*, to whose narrower pinnules, with less conspicuous hairs, the name *N. angustifolia* seems to have been applied. With reference to *N. cordata* it is seen that a portion of the specimens, slightly differing in form, and with a less dense nervation, identified by Lesquereux under this name, are indistinguishable in nervation and hirsuteness from *N. Scheuchzeri*, to which they may be referred, while the American *N. cordata*, as separated by Lesquereux, with a dense and more uniform nervation, is a distinct species, or va-

[1] Geol. Surv. Ill., vol. IV, p. 382, Pl. V, Figs. 1-4. Coal Flora, p. 93, Pl. XXIV, Figs. 5, 6.

riety at least, radically different from the true *N. cordata* described and figured by Brongniart.

So far as the collections of the U. S. National Museum are concerned, and the same is possibly true in other collections, it is quite clear that the specimens in the concretions from Mazon Creek, Illinois, identified by Lesquereux as *N. hirsuta*, are inseparable on any character from *N. decipiens*, Lx., all having the characteristic forms, texture, and nervation (counting twenty-four to thirty per centimeter on the border) of the latter species, while the nervils of the less robust species, *N. Scheuchzeri*, with generally narrower and more acute pinnules, number not less than thirty-four or thirty-five, and usually thirty-five to forty-five, per centimeter at the border. Also that those specimens labeled *Neuropteris fasciculata* Lx., in the Museum, from the same place, are identical in structure, disposition, including hirsuteness, and nervation, with *Neuropteris decipiens*, indicating in that species the presence of bilobate cyclopterid pinnules similar to those known in *N. Scheuchzeri*, thus rendering the intimate relationship of these two species still more apparent.

The difference between the more narrow and acute pinnules of *Neuropteris Scheuchzeri* and certain forms of *N. Clarksoni* is very slight, hirsute specimens of the former species having been identified and labeled under the latter name, although *N. Clarksoni* is, in general, quite distinct and well differentiated. It would not be invariably safe to conclude that the fact that a pinnule is hirsute is itself sufficient proof that it belongs to a species characteristically hirsute as ordinarily observed; neither should all the large linear-lanceolate *Neuropteris* pinnules that are provided with hairs or bristles be united in the same species. Fontaine and I. C. White report that the hirsute character of *N. hirsuta* is almost never seen in the upper beds of the Upper Barren Measures.[1] Moreover, the degree of hirsuteness, or even the absence thereof, may have been affected by environment, and this may be worthy of slight consideration as explaining the occurrence or absence of hairs on specimens otherwise identical, though it may be generally due to the circumstances of preservation.

Neuropteris decipiens may represent only a robust variety of *N. Scheuchzeri*, to which it is in habit, form and nervation very closely allied. But the broader, more oblong pinnules rounding up to an obtusely pointed apex, the hairs generally stronger, the midrib generally strong near the base, the more open nervation near the median nerve, and the constant limit of the nerves, twenty-four to thirty per centimeter at the margin, mark it as specifically distinct from *N. Scheuchzeri*, in which, as seen above (2188, 1290, 1290a, 1948, 2185, 1946, 1087, and 1947), they are closer from the midrib outward, numbering thirty-five to forty-six per centimeter at the margin.

Locality.—Abundant in the shales from Hannam's Shaft, Carterville.

[1] Permian Flora, p. 47.

NEUROPTERIS JENNEYI n. sp.

Pl. I, Fig. 7a, 7b; Pl. II, Figs. 7–12; Pl. III, Figs. 1–6, 6a, 7–10.

Fronds tripinnate; primary rachis irregularly but distinctly striate; primary pinnæ broad, tapering above to an acute tip, the portion above the secondary pinnæ being simply pinnate, with distant ovate-lanceolate, slightly triangular, obtusely-pointed pinnules 12^{mm}–4^{cm} long, 4½–15^{mm} wide, cordate at the base, the lowest ones short-pedicellate, the upper ones sessile, becoming decurrent and confluent at the base toward the apex of the pinna, which is deeply lobed and sinuate, without a distinct terminal pinnule; secondary pinnæ alternate or subopposite, usually distant but sometimes contiguous, very caducous, open, oblique, or reflexed, lax, ovate or linear-lanceolate, 3½–13^{cm} or more in length, 1½–4^{cm}, averaging about 2½^{cm}, in width, the uppermost trifoliate, the number of pinnules increasing in the pinnæ below, the apex of each pinna consisting of an elongated pinnule, the lower part of which is sublobate, decurrent, and crenate, the middle third straight or slightly crenulate, with parallel borders, the upper third tapering in lobes, becoming lanceolate, or, most commonly, crenate or deeply crenate toothed above to a rather acute apex; secondary rachis very lax, ribbon-like; pinnules of the secondary pinnæ caducous, alternate or subopposite, distant, oval, ovate, or oval-lanceolate, 6–21^{mm} long, 4–16^{mm} wide, with margins slightly reflexed, the lowest slightly auriculate and short pedicellate, those next becoming sessile by a narrow attachment to the lax rachis, then sessile and contracted at the base, the higher ones decurrent, those near the top obovate, odontopteroid, united at the base, passing, with shallower sinuses, into the terminal pinnule; upper rachial pinnules broad, deltoid, cordate, lobate-auriculate, obtusely pointed, 18^{mm}–3^{cm} or more in length, 17–29^{mm} or more in width, often with short, broad pedicels; lower rachial pinnules asymmetrically cordate, sessile by a broad attachment, distant or contiguous, acuminate or obtusely rounded, 4–6^{cm} long, 2½–5½^{cm} broad, or more or less orbicular or orbicular-ovate, 3½–5^{cm} or more in the longer diameter, 2½–4^{cm} or more in the shorter, with broad or partly clasping attachment; primary nerves thin in the upper, simple pinnules of the pinnæ hardly passing beyond the middle third, the secondary nerves, often thickened at the base, originating at a very narrow angle, those in the lower portion of the pinnule springing directly from the rachis, flabellate, forking four or five times at a narrow angle, arching to nearly a right angle to the border, where they count thirty to thirty-eight per centimeter; pinnules of the secondary pinnæ without a well-defined midrib, all the nerves and nervils appearing flabellate from the base in the oval pinnules, being developed from a single bundle passing from the base of the leaf down the rachis; nervils usually distinct, slightly thinner at the margin, where they number twenty-nine to thirty-five per centimeter; each lobe and crenulation of the terminal pinnule fed from a single bundle diverging from the axis of the pinna; primary nerve of the rachial pinnules thin or entirely wanting, secondary nerves usually stronger near the base, passing flabellately, arching more or less, to the border, at which they count about thirty-two to the centimeter.

The fronds of this species are unique as well as beautiful. Owing to the delicacy of the ramification and the lax texture of the ribbon-like rachis of the ultimate pinnæ, the latter are not only almost invariably detached, but the lower portions of the secondary pinnæ and those

pinnules that are so far developed as to be constricted at the base are generally detached. Consequently the fern is represented, in by far the greater number of the specimens, merely by the lower part of the terminal pinnules of the secondary pinnæ, with the preceding more or less united, and decurrent pinnules, as seen in Pl. III, Figs. 1, 2, 5, 6, and 8. These fragments are Odontopteroid in outline, suggesting *Odontopteris obtusiloba*.[1] In these pinnules, as well as in those in the lower part of the pinnæ, the nervation of each pinnule is seen to differ from that of *Odontopteris* by its origin in a single vascular bundle, curving in towards the axis of the pinnæ at a very acute angle, and passing for a considerable distance downward alongside of or contiguous to the rachial axis. This is imperfectly indicated in Pl. III, Fig. 6. In many cases which I have observed this bundle continues on until that from the preceding pinnule in its turn comes down close by its side, when frequently each is seen to continue for a time as an independent strand in the loose rachis. It is to this lax rachial constitution that I attribute both the frequent splitting of the rachis, Pl. I, Fig. 7*b*, and the almost invariable separation of all the pinnules that have not a sufficiently broad limb attachment to retain them in position. It may also account for the loose flexuous attitudes of the fragments of pinnæ in a matrix where the other fern remains are normal. In rare cases, however, the rachial axis is somewhat thick and rounded in the lower middle of the terminal pinnules in these secondary pinnæ, as seen in Pl. III, Fig. 8, perhaps remaining thin and sharp in passing downward, but in such cases the secondary nerves lie close to the axis for some distance before they become lost therein, while lower down the rachis becomes often thin and correspondingly delicate. The pinnules on the primary pinnæ and rachis are plurinerved from the base. The forms of the secondary pinnules are illustrated in Pl. III, Figs. 1, 5, and 6. From these it will be seen that while the secondary terminal pinnules are ovate-lanceolate and rather obtuse, as seen in Pl. III, Fig. 3, in the undeveloped pinnæ, in the more advanced stages the margins are nearly straight or slightly sinuate in the middle, becoming crenulate, lobed, and crenulate-dentate toward the tip, as seen in Pl. III, Figs. 7 and 9, a feature unknown, I believe, in any other species of *Neuropteris*. These upper lobes, like those below the middle, are each fed from a single bundle.

The relation of the broad deltoid pinnules, such as Pl. II, Figs. 7, 8, 11, and 12, to the secondary pinnæ, Pl. III, Fig. 6, is not definitely known to me, but from their obvious resemblance, their tendency towards lobation, and the occurrence of a few specimens intermediate between these and the simpler primary pinnules, Pl. II, Fig. 9, I am inclined to regard them as simple pinnules on the primary rachis, occurring perhaps between the secondary pinnæ, the larger and broader ones being situated nearer the base of the frond. One specimen in the collection

[1] See Weiss, Flora d. jüngst. Steink. u. Rothl., Pls. II, III.

shows two pairs of pinnules, of nearly the type and size of those in Pl. II, Fig. 9, placed opposite on a rachis less than $1\frac{1}{2}^{mm}$ in width, the lower pair being preceded on one side by a small pinna. Similar rachial pinnules between the secondary pinnæ are seen in other species of *Neuropteris*, such as *N. auriculata*, *N. Scheuchzeri*, and in *Odontopteris lingulata* (*O. obtusiloba*), whose secondary pinnæ are also suggestive of ours.[1] None of these triangular sublobate pinnules have been seen in direct connection with the common form of larger secondary pinnæ. The connection of the largest of the cordate or deltoid pinnules with larger fragments of rachis establishes their relations and brings them into comparison with the rachial pinnules of *N. auriculata* and *N. hirsuta* of Lesquereux.[2] These have a broad attachment, perhaps partially clasping the rachis. Their nervation is more or less flabellate, the nerves sometimes thickened below, forking 4–6 times and counting about thirty-four per centimeter at the border.

Relations.—In form and habit *Neuropteris Jenneyi* is somewhat intermediate between *Neuropteris* and *Odontopteris*. The simple pinnules near the end of the primary pinnæ, and the smaller oval pinnules of the secondary pinnæ closely resemble the group of trifoliate species of *Neuropteris*, including *N. Scheuchzeri*, *N. cordata*, and *N. decipiens*. The basal pinnules of these species, however, are not so elongated, nor is the origin of the pinnular nervation the same. The nervation of the first two is also closer than that of *N. Jenneyi*. The upper pinnules of the secondary pinnæ are most like those seen in *Odontopteris lingulata*, though the nervation of each pinnule, when carefully examined is seen to spring from a single bundle. The rachis of *O. lingulata* is thick and the terminal pinnules, while more or less undulate, are rounded at the tip, not deeply dentate, as in our species. The middle of the terminal pinnule of our species is much like that of *O. lingulata* and *O. Wortheni*, but is more sublobate, crenulate, or sinuate, without the strong median nerve of the others, while its tip has its only homologue in that of *O. Wortheni*,[3] whose pinnæ especially suggest ours in their habit, although they are hirsute and deeply lobate at the apex, not roundly dentate with rounded sinuses, as in *N. Jenneyi*, in which the dentition continues to the more or less acute point. The rachial pinnules are more uniformly deltoid and cordate than those of *N. auriculata* and *N. Scheuchzeri* (*N. hirsuta* Lx.) without the distinct median nerve of *N. Clarksoni*, and not so distinctly pedicellate as, and generally more triangular than, those of *O. lingulata*.

Locality.—McClelland's shaft, where it is the most abundant species; also present among the species from the Hannam shaft.

[1] Weiss, Flora d. jüngst. Steink. u. d. Rothl., p. 3a, Pls. II, III, VI, Fig. 12. See also *O. Sternbergii* Steininger, Geogn. Beschr., Fig. 3; Goeppert, Gattungen, Lief. 5, 6, Pl. VII, Fig. 1; and *O. obtusiloba* Naum. Geinitz, Dyas, II, Pl. XXVII, Figs. 1–4; Pl. XXIX, Figs. 1–4, 8–10.

[2] Geol. Surv. Ill., Vol. II, Palæont., p. 427, Pl. XXXV, Figs. 8, 9.

[3] Lesquereux, Geol. Surv. Ill., II., Palæont., p. 432, Pl. XXXVI, Fig. 1; Coal Flora, I, p. 130, Pl. XXII, Fig. 1.

NEUROPTERIS RARINERVIS Bunb.

Pl. v, Fig. 7, 6?.

1847. *Neuropteris rarinervis* Bunbury, Quart. Jour. Geol. Soc. London, III, p. 425, Pl. XXII, Figs. 1, 1a, b. 1858: Lesquereux, Geol. Penn., II, p. 859. 1860: Lesquereux, Amer. Jour. Sci., 2d ser., XXX, p. 68. 1863: Dawson, Can. Nat., VIII, p. 443. 1866: Dawson, Quart. Jour. Geol. Soc. London, XXII, p. 154. 1866: Lesquereux, Geol. Surv. Ill., II, Palæont., p. 428, Pl. XXXIII, Figs. 1–5; Pl. XXXIV, Figs. 1, 1a. 1869: Schimper, Traité, I, p. 440; (1874), III, p. 474. 1870: Lesquereux, Geol. Surv. Ill., IV, 2, p. 386, Pl. VIII, Figs. 1–6. 1871: Dawson, Rept. Geol. Struct. Min. Res. P. E. I., p. 44, Pl. II, Fig. 19. 1879: Lesquereux, Coal Flora, atlas, Pl. XV, Figs. 2–5; text (1880), p. 109. 1880: Fontaine and I. C. White, Permian Flora, pp. 16, 20. 1881: Lesquereux, Rept. Geol. Ind., 1879–'80, p. 152, Pl. X, Figs. 1, 2, 3. 1885: Dawson and Bain, Can. Rec. Sci., I, p. 158. 1886: Kidston, Cat. Pal. Pl. Brit. Mus., p. 91. 1887: Lesquereux, Proc. U. S. Nat. Mus., X, p. 24. 1887: Kidston, Foss. fl. Radstock Ser., p. 361. 1888: Dawson, Geol. Hist. Pl., p. 274. 1888: Kidston, Trans. Roy. Soc. Edinb., XXXV, pt. 1, p. 321.

1878. *Nevropteris heterophylla* Brongn., Zeiller, (pars) Vég. foss. terr. houill., atlas, Pl. CLXIV, Fig. 2; text (1879), p. 49.

1881. *Nevropteris rarinervis* Bunb., Six, Ann. Soc. géol. Nord, XI, p. 208. 1883: Zeiller, Bull. Soc. géol. Fr., (3) XII, p. 197. 1886: Zeiller, Fl. foss. Valenciennes, atlas, Pl. XLV, Figs, 1, 1a, 2, 3, 4, 4a; text (1888), p. 268.

Fronds very large, polypinnate, primary and secondary rachis thick, striate, dichotomous, often bearing, at or near the forks, sessile oval cyclopterid pinnules, sometimes orbicular or cordate at the base; pinnæ alternate or subopposite, open or oblique, broad or triangular in outline, overlapping one another, bipinnate in the greater part of their length, simply pinnate toward the tip; ultimate pinnæ alternate or subopposite, open or oblique, sometimes slightly arched upward, linear or linear-lanceolate, with borders touching or overlapping, contracted toward the apex, and obtusely pointed; pinnules alternate, open or oblique, distant or overlapping, rather small except at the top of the secondary pinnæ, flat or slightly arched at the borders, sessile, sometimes united at the top of the pinnæ, cordate at the base, occasionally attached by a portion of the base to the rachis in the upper part of the pinnæ, oblong, the borders parallel or gradually narrowed upward to the obtuse or rounded apex; terminal pinnule larger, comparatively long, somewhat hastate, cuneate below, usually sublobate, contracted in the upper part, lanceolate, often slightly undulate, rounded at the tip; midrib strong, appearing as a furrow on the upper side of the pinnule, raised beneath, passing nearly to the apex of the leaf; secondary nerves thick, often appearing double, sometimes in relief on both sides of the pinnules, springing at a narrow angle from the midrib, arched, forking two or three times into thick, distant nervils; nervation of the cyclopterid pinnules flabellate, coarse, often appearing double.

This species, well known on this continent, where it was discovered, has since been definitely recognized in France by direct comparison of specimens by Zeiller, and in Great Britain by Kidston. Zeiller describes[1] the fronds of the very fine specimens which he has examined as dichotomizing below, their general habit being nearly the same as

[1] Fl. foss. houill. Valenciennes, p. 270.

that of *N. heterohpylla*, only smaller in its development. Lesquereux describes fragments of the rachis, $3\frac{1}{2}^{cm}$ broad, covered with cyclopterid pinnules 7–8^{cm} in diameter, nearly round. The middle ultimate pinnæ are quite slender, averaging about 10^{cm} in length, those lower down becoming much longer, while the uppermost are but little over 2^{cm}, or slightly longer than the large pinnules succeeding them on the primary rachis. Frequently the margins are more or less crenulate or undulate. The leaf substance is quite coriaceous, especially in the larger pinnules. The length of the pinnules varies from about 3^{mm} in the smallest to 22^{mm} in the larger, which are somewhat contracted in the upper part, the average length being about 9^{mm}, while the width, varying from 2 to 6^{mm} or 7^{mm}, averages about $4\frac{1}{2}^{mm}$. The nerves fork usually twice, arching to the border, where they average about twenty-six to the centimeter in the larger pinnules, eighteen to twenty per centimeter in the smaller. The cyclopterid pinnules have been seen as long as 8^{cm} and as wide as 10^{cm}. Sometimes they are orbicular, clasping the rachis more or less, or cordate, while in other cases they are lateral, varying in outline, frequently appearing more or less cuneate at the base, and rounded above, as illustrated by Prof. Lesquereux.[1] Of the cyclopterid pinnules that I have figured, that represented in Pl. v, Fig. 7, seems to me to be referable to this species. It is incomplete on the left and above. The lower portion approaching the point of attachment is arched outward, the surface still partly covered with the thick coriaceous substance of the leaf, on which the coarse nerves appear as double lines, as represented in the figures published by Lesquereux. It occurs in association with the pinnæ of this species.

Zeiller[2] and Kidston[3] refer *Neuropteris coriacea* of Lesquereux (non Ettingshausen) to *N. rarinervis*. It is true that the same form of pinnules and arched secondary nerves which were among the distinguishing characters of *N. coriacea*, according to Lesquereux's description, are seen in the Museum specimens of *N. rarinervis* as well as in those examined or figured by the European authors. Also some of the larger leaves of *N. rarinervis* show a thick texture and marked impression in the rock. But I have not yet seen specimens of our species with terminal pinnules twice as broad, and deeply lobed above the middle like that described under *N. coriacea*, as a differentiating character. Some of the terminal pinnules figured by Bunbury[4] would seem to approach it more closely. The union of these two species, which was first suggested by Zeiller, should not be effected without comparing examples of the less known species. Mr. Kidston also combines *N. Desorii* with *N. rarinervis*, having found fine specimens of the latter in Wales, "in which," he says[5] "all the forms of pinnules which Lesquereux has men-

[1] Rept. Geol. Surv. Ill., IV, 1870, Pl. VIII, Fig. 5. Coal Flora, Pl. XV, Figs. 3, 4, 5.
[2] Op. cit., p. 269.
[3] Cat. Pal pl. Brit. Mus., p. 91.
[4] Quart. Jour. Geol. Soc. London, III, 1847, Pl. XXII, Fig. 1a.
[5] Op. cit., p. 92.

tioned as occurring in his *N. coriacea* and *N. Desorii* can be seen." An examination of specimens in the collections of the Museum seems to confirm the action of Lesquereux in separating *N. Desorii* from *N. rarinervis*. Aside from the peculiar deeply lobed, irregularly divided, and lacerated cyclopterid pinnules, much more closely nerved than the rachial pinnules of *N. rarinervis*, and the broadly triangular undulate or lobate rachial pinnules descibed and illustrated as proper to *N. Desorii*, there exist several other more or less conspicuous characters distinctive of the latter species. In *N. Desorii* the pinnules of the longer pinnæ are more often opposite or subopposite, those in the lower part of the pinnæ being at a considerable distance from each other, while those higher up approach one another gradually until they become partly, then wholly united, forming a lobate or undulate tip of the pinnæ, without any distinction of a terminal pinnule.[1] The small lateral pinnæ are nearly like the tips of the larger pinnæ, only less deeply lobed. As a rule the large pinnules of this species are more tapering, more pointed, and undulate to the tip, the thin midnerve also waving in accord with the marginal undulations. The small pinnules are generally more rounded, with a more gradual transition through the deep lobation of the pinnæ to the tip. The nerves of the larger pinnules are strong at the base, becoming thin and round in passing to the margin where they count from thirty-six to forty-two to the centimeter, while in the smaller pinnules there is no distinct midrib, or, if present, it soon disappears, the nerves at the margin numbering thirty to thirty-five per centimeter. In both the large and small pinnules the nervation is somewhat irregularly lax, as is well illustrated in Pl. XIV, Fig. 7, of the Coal Flora.

Relations.—The relations of *Neuropteris rarinervis* to *N. coriacea* are somewhat in doubt, but the latter is described as differing by its much broader and shorter terminal pinnules. Its difference from *N. Desorii* is pointed out above. It is dissimilar to *N. heterophylla* in having its pinnules usually smaller, the nerves much thicker, fewer, and less dichotomized. *N. Smithsii* has much smaller pinnæ and pinnules, the latter distant, oval, or round, with sharply defined midrib, and lateral nerves much closer, usually forking but once and meeting the border at right angles.

Locality.—McClelland's shaft.

NEUROPTERIS CAUDATA n. sp.

Pl. IV, Figs. 1–9.

Fronds tripinnate, rachis coarsely striated, primary pinnæ broad, rapidly tapering toward the apex to a rather acute tip; secondary pinnæ alternate, sometimes subopposite, linear-lanceolate, 2–20^{cm} long, 1–5^{cm} wide, at right angles to the primary rachis or oblique, straight or curved irregularly, the sides nearly parallel in the middle, converging

[1] See Coal Flora, Pl. XIV, Figs. 4, 7, Pl. XV, Fig. 1.

gradually near the top to a lanceolate, obtusely-pointed tip, sometimes contracting toward the base, which often bears a pair of elongated pinnules; secondary rachis distinctly striate; secondary pinnæ succeeded near the apex of the primary pinnæ by large, narrow, rather elongate-triangulate, lanceolate, acute, or acuminate pinnules, 9mm–4cm long, 2mm–2cm wide, the lower ones attached by a narrow portion of their bases, the upper becoming attached by their whole bases or even decurrent; pinnules somewhat coriaceous, alternate, at right angles and generally close or overlapping below, becoming oblique, touching and usually more distant in the middle and upper parts; those of the secondary pinnæ rather oblong, 7mm–4cm long, 2–18mm wide, but in both the secondary and primary pinnæ rounded or round-auriculate at the base above the point of attachment, which is about 1½mm wide toward the base of the pinnæ, attenuate-auriculate below the attachment, the lower angle prolonged downward in a rather flexible, acuminate, spur-like appendage extending down beneath or over the preceding pinnule, frequently crossing the median nerve of the latter; margins of the pinnules of the secondary pinnæ parallel in the middle, the upper border straight or slightly concave, the lower curving in the last half to meet it at the more or less upward turned tip of the pinnules which are obtuse, rounded, or somewhat angular or even becoming obovate near the tip of the pinna, the upper pinnules of the pinnæ attached to the rachis by a wider portion of the base, becoming decurrent near the top, somewhat constricted at the base, the auricles diminishing or even disappearing in those nearest the apex; rachial pinnules large, generally of the same form as the middle ones of the secondary pinnæ but proportionately larger, the auricular appendages usually present and corresponding in proportions; terminal pinnules rhomboidal, narrow, spatulate, more or less obtusely pointed, with one or two lobes in the lower part; nervation nephropteroid, the secondary nerves springing from a number of rather larger vascular bundles entering the base of the pinnule and dissolving into distinct rounded nervils, diverging somewhat flabellately, equally close in all parts of the pinnule, dichotomizing from four to six times at a very narrow angle, arching gradually to the border, where they number 45–65 to the centimeter; the upper surface of the more mature pinnules longitudinally creased along the middle in the lower part over the thicker portion of the entering ribbon of nerves, the under side being correspondingly raised.

This singular species is, next to *N. Jenneyi*, the most abundant fern in the collection. Although the pinnæ are somewhat fragile or caducous, a few entire ones are present. The fern appears to have been large and bushy, the pinnation rather graceful and sometimes delicate. From the asymmetrical character of some portions of the fronds, with secondary pinnæ on one side opposed to rachial pinnules on the other, I am disposed to regard the fronds as dichotomous in the lower part, like *N. heterophylla*, to which, through *N. Loshii*, it is closely related. This view is strengthened by a distinct dichotomy seen in some of the fragments of rachis found mingled with the pinnæ of this species. These rachial fragments are a centimeter or more in width and are distinctly, rather coarsely, striated. The pinnæ are at right angles or oblique, 1½–3cm apart, usually distant, but sometimes slightly overlapping, the secondary pinnæ being succeeded in the upper part of the primary pinnæ by simple pinnules.

These pinnules at the top of the primary pinnæ are long, 9^{mm}–$3\frac{1}{2}^{cm}$ or more in length, 2–20^{mm} or more in width, open or close, more or less triangular, tapering to a more or less slender acute or slightly obtuse point. The larger ones have the auricular appendages well developed below, those higher up become attached by the whole base, and finally decurrent, similar in outline to the corresponding upper pinnules of *Odontopteris neuropteroides* Newberry[1] (non Marrat, nec Grand'Eury, nec Roem.) from the lower coal, Mill Creek, Ohio. In the latter the nervation also is in general like that of *Odontopteris*. Some of the larger and broader pinnules have a certain resemblance in outline to several of Heer's figures of *N. Leberti*,[2] though in our species they are almost invariably acute, with the auricles attenuated so as to suggest spines. The nervation of Heer's species, judging by the figures, is but half as close, however.

The pinnules of the secondary pinnæ have the base rounded above the point of attachment to the rachis, and, except near the tips of the pinnæ, are attenuate, auricled below like the mature large primary pinnules just described. The general outline is oblong, the borders parallel in the lower middle of the pinnule, often concave above, convex below, and rounded in the distal half to meet in a somewhat angular or obtusely rounded apex, which is generally higher than the medial furrow seen towards the base of the pinnule, often occurring so high that the upper margin is nearly straight. These pinnules, which show a fair degree of uniformity in proportions, are illustrated in Pl. IV., Fig. 9. In the upper portions of the secondary pinnæ the auricular appendages become shortened, as seen in the figures, the outline more oval or obovate, as seen in Figs. 1 and 3, the attachment broader, and even decurrent, and the nervation more odontopteroid, as in Newberry's *O. neuropteroides*,[3] or in some specimens of the American *N. Loshii*. Frequently the pair of pinnules at the base of the pinnæ are elongated, as shown in Figs. 6, 8, and 9, that above being rather triangular, narrower, and more acute than the succeeding pinnules, while that below is lanceolate and acute, sometimes nearly three times as long as the next pinnule. These basal pinnules are comparable to the upper primary pinnules, but the caudal prolongation is not so fully developed. The terminal pinnules of the secondary fronds are spatulate or rhomboidal, somewhat lanceolate in some cases, rounded at the tip, generally united with one or two of the undeveloped pinnules preceding them, so as to appear more or less sublobate, resembling those of *N. Loshii*, though generally more slender. The terminal pinnules of the primary pinnæ are similar to those of the secondary pinnæ, though generally more acute and more distinctly sublobate. The pinnules below them of the lanceolate type (Pl. IV, Fig. 5) may be quite distant or crowded together in

[1] Geol. Surv. Ohio, Pal. I, 1873, p. 382, Pl. XLVII, Fig. 2.
[2] Fl. foss. Helv., Pl. II, Fig. 8, 10*b*.
[3] Op. cit., Pl. XLVII, p. 3.

much the same manner as in Lesquereux's *N. aspera*, at an acute angle to the rachis, or oblique, straight, reflexed, or incurved.

The most striking characteristic of this species is the attenuated auricle at the lower side of the base of all the mature pinnules. In the upper part of the pinnæ it first appears as a rounded lobe, gradually elongating in the preceding pinnules until in the more mature leaflets it reaches a length of 11^{mm} or more, generally terminating in an awn-like point. This auricle may curve outward somewhat, presenting a concave side to the rachis, rounding up to the attachment of the pinnule, or it may descend parallel and close to the rachis, or frequently it turns inward, crossing the rachis and passing underneath the opposite pinnules. When the pinnules are contiguous or overlapping, as is usually the case, the lower part of the pinnule and its appendage is covered by the preceding pinnule, as shown in Pl. IV, Fig. 8, in which case the point seldom appears unless its form shows through the somewhat coriaceous texture of the pinnules, or the pinna is dislocated, or the rachis splits, as frequently happens. A similar tendency toward an elongation of the lower auricle is often seen in certain species of *Neuropteris*, especially in *N. Loshii*.[1]

The nervation of the species is nephropteroid. The midrib is represented by a band of vascular bundles forking and diverging, arching, to the margin, in the manner illustrated by Lesquereux for *N. Loshii*, in the Coal Flora. The secondary nerves, often obscure in the rather thick texture of the pinnules, are round, close, forking five or six or even seven times at a narrow angle, and are hardly larger at their origin than at the margin, equally close together in all parts of the pinnule, and measuring an average of about fifty-five per centimeter. The vascular bundles at the base of the leaf are slightly enlarged where they pass from the rachis into the pinnule, but they soon dissolve into nervils of uniform size. The pinnules are slightly creased along the middle for a distance over the thick vascular bundles in the axis, a similar secondary crease marking the position of the smaller band of nerves starting to supply the auricle.

Relations.—In its general habit, pinnation, secondary, basal, and rachial pinnules, and its nervation *Neuropteris caudata* resembles *N. Loshii* more than any other species. However, it differs from this, as from others, by its nervation, which is closer, there being no distinct midrib as in *N. heterophylla*, by its awn-like prolongation of the lower auricle, and the linear acuminate forms of pinnule. *N. Leberti*, some of whose pinnules resemble the larger primary pinnules of this species in form, is described as having its pinnules more distant, the midrib more distinct, and its secondary nerves fewer and forking at a very

[1] See Coal Flora, atlas, Pl. XI. See also *N. heterophylla* Brongn., in Zeiller, Fl. foss. Autun et Épinac, pt. 1, p. 142, Pl. XII, Fig. 1.

These two species are considered as identical by Kidston and Zeiller. While this may be true so far as the European specimens are concerned, it does not appear to be so with the American forms referred to *N. Loshii*, which seem to have several characters not present in the European species.

much wider angle. From *Odontopteris neuropteroides* of Newberry the upper pinnules of *Neuropteris caudata* differ by their closer nervation, the development of the auricle, and the constriction of the mature pinnules at the base. The pinnules of the Ohio plant are decurrent, except the basal pair on the pinna.

Locality.—McClelland's shaft; Hannam shaft.

NEUROPTERIS FLEXUOSA Sternb.

Pl. v, Figs. 1–5.

1826. *Neuropteris flexuosa* Sternberg, Versuch, I, 4, Tent., p. XVI, II, 5, p. 71, Pl. XXXII, Fig. 2. 1847: Bunbury, Quart. Jour. Geol. Soc. London, III, p. 425. 1849: Bunbury, Quart. Jour. Geol. Soc. London, V, p. 141. 1858: Lesquereux, Geol. Penn., II, p. 858. 1860: F. A. Roemer, Palæontgr., IX, p. 27, Pl. VIII, Fig. 6. 1866: Lesquereux, Geol. Surv. Ill., II, Palæont., p. 428. 1869: Schimper, Traité, I, p. 434, Pl. XXX, Figs. 12, 13. 1869: v. Roehl, Foss. Fl. Steink. Westphalens, p. 35, Pl. XII, Fig. 3a, Pl. XV, Fig. 10. 1870: Unger, Sitzb. k.-k. Akad. Naturw. Wien, math.-nat. Cl., LX, p. 783, Pl. II, Fig. 1. 1872: Dawson, Rept. Prog. Geol. Surv. Can. 1870–'71, p. 215. 1876: Ferd. Roemer, Lethaea geognost., I, Pl. LI, Figs. 5a, b, text (1880), p. 183. 1876: O. Feistmantel, Verst. böhm. Ablag., III, p. 64, Pl. XVI, Figs, 5, 6. 1880: Rothpletz, Steink. Ostseite d. Tödi, p. 5, Pl. I, Figs. 8, 9. 1881: Weiss, Aus d. Fl. d. Steink., p. 14, Pl. XV, Fig. 90. 1883: Schenk, in Richthofen's China, IV, p. 217 (pars.). 1886: Kidston, Cat. Pal. Pl. Brit. Mus., p. 93. 1887: Kidston, Radstock Ser., p. 359.

1828. *Nevropteris flexuosa* Sternb., Brongniart, Prodrome, p. 46. 1830: Brongniart, Hist., p. 239, Pl. LXV, Figs. 2, 3, 3a, b; Pl. LXVIII, Figs. 2, 2a. 1879: Zeiller, Vég. foss. terr. houill., p. 51. 1883: Renault, Cours bot. foss., III, p. 169, Pl. XXIX, Figs. 10, 11. 1886: Zeiller, Fl. foss. Valenciennes, atlas, Pl. XLVI, Figs. 2, 2a; text (1888), p. 277.

1835. *Neuropteris flexuosa* Sternb., var. α Gutbier, Abdrücke, p. 56, Pl. VII, Figs. 1, 2, 5.

Fronds large bi- or tripinnate, with large rachis, finely but distinctly striated, secondary pinnæ caducous, at right angles to the rachis, or oblique, alternate, linear, tapering, obtusely pointed; pinnules caducous, alternate, open or oblique, straight or curving slightly upwards, flat, usually contiguous or overlapping, sometimes more distant, sessile, attached at a single point, oblong, cordate at the base, the lower angle sometimes more or less extended, 8–25^{mm} long, 5–10^{mm} wide, the borders parallel, sometimes contracted toward the base, rounded at the summit, those nearer the apex becoming shorter; terminal pinnule much larger than those below it, ovate-lanceolate, generally cuneate toward the base, which is often united with one or two rounded pinnules, the lateral borders undulate; median nerve distinct, dissolving about midway but marked by a furrow up to two-thirds the length of the pinnule; secondary nerves numerous, very slender, originating at a very narrow angle, and forking many times in fine, quite distinct veins.

A number of forms in the collection are specifically inseparable, but they include variations that are so nearly identical with certain forms seen in several of the old-world species that it is alike difficult to assign them all to any one of the European species or to find a boundary line between those types that should be placed in one group

belonging to one species and those in another group belonging to another species. This difficulty is complicated by the number of old-world species to which they are closely related, including *Neuropteris heterophylla*, *N. tenuifolia*, and *N. flexuosa*, to all of which different specimens are perhaps referable, though each identification with one species not only involves specifically identical variations not described from the European strata, but also involves a series of intermediate forms representing the steps in the transition to those types apparently referable to another of the old established species. Were it not for the minuteness of the generally accepted old-world differentiation, by which forms so closely related and so commonly found together as some of the forms described under the above names, are retained distinct, the circumstances would perhaps justify the separation of some of the American forms as a distinct species. Rather than increase the number of species having so much in common, I have followed Lesquereux, referring them to the old species, though, as a whole, they illy fit the European descriptions, and at the same time I shall try to point out the principal differences peculiar to the American plants.

Pinnæ and pinnules of the form represented by Brongniart[1] and others, with overlapping, rather oblong pinnules asymetrically cordate at the base, are found only among the rarer specimens. The rachis, which is often remarkably flexuous, is generally distinctly striated. Usually the pinnules hardly touch, but stand about $\frac{1}{2}^{mm}$ apart, though the distance in rare instances reaches 2^{mm}. Pl. LXV, Fig. 2, in the Histoire, closely represents the prevailing form among the larger pinnules. The average length of these larger pinnules is about 2^{cm}, the width 1^{cm}. All are more or less distinctly cordate at the base, the lower angle sometimes elongated. The specimens show every form in transition, from those in which the sides are nearly parallel, the end round, to those more or less wedge shaped, approaching the forms figured by Lesquereux as *N. tenuifolia* in the Arkansas Report.[2] The terminal pinnule is more or less sublobate or united to the preceding pinnules, as shown by Lesquereux in the Coal Flora, Pl. XII, Fig. 2; by Gutbier, Abdrücke, Pl. VII, Figs. 1, 1a; and my Pl. V, Figs. 1, 2, 4. The number of the nerves at the margin of the pinnules is thirty to fifty per centimeter. The specimens figured appear to be so directly connected with typical specimens of *N. flexuosa* that I have placed them, not without doubt, under this species. Figs. 1 and 2 may represent portions near the end of the primary pinnæ. In the obtuseness of the terminal pinnules of the smaller secondary pinnæ they are unlike any that I have seen figured under this name, but strongly resemble the *N. missouriensis* in the Coal Flora, Pl. VII, Figs. 5, 6, with which they may be identical, or some of those pinnæ figured by Zeiller in the Valenciennes flora, Pl. XLIV, as *N. heterophylla*. They are probably

[1] Hist., Pl. LXVIII, Figs. 2, 2a.
[2] Vol. I, 1860, Pl. V, Fig. 2.

identical with the specimen figured as *N. tenuifolia* by Lesquereux in the Coal Flora, Pl. XII, Fig. 5, and, being unable to separate the forms represented, I am disposed to regard Figs. 1, 2, and 3 on the latter plate as also belonging to *N. flexuosa*, although so large a united portion of a frond as Fig. 1 would be remarkable in that species. Fig. 4 of the same plate can hardly belong to the same species, while the Cyclopteris pinnules, Figs. 8, 9, were subsequently[1] referred by Lesquereux to *N. Loshii*.

The concavity of the lateral margins, illustrated by Lesquereux and seen frequently in the Missouri specimens, is, I believe, peculiar to the American representatives of this species.

Among the fragments of pinnæ of *N. flexuosa* in the collection are a few examples in which elongated rounded portions, including most of the leaf substance between the nervils, have been removed, leaving only a thin brown membranous covering on the stone, while the intact portions of the leaf are black. Corresponding to these thin portions in the petrifaction raised wormlike troughs bordered and mingled with more or less carbonaceous matter appear on the counterpart. At first I was disposed to regard these appearances, so similar to the supposed *Neuropteris* fructifications illustrated by Fontaine and I. C. White, Heer, Lesquereux, and others, as indicating a fructification comparable, especially in form and position, to that of *Scolopendrium*. The evidence is, however, insufficient, especially in view of the altogether different nature of fruiting of the genus as described by Kidston and discovered, though not published, by Lesquereux.

Many authors, among them Schimper, Heer, and Schenk, have combined *N. flexuosa* with *N. tenuifolia*, while Kidston[2] regards *N. plicata*, as figured by Lesquereux,[3] as belonging to *N. flexuosa*. My present distinction between the groups is tentative, especially so far as it concerns the forms of the type illustrated.

Relations.—*Neuropteris flexuosa* differs from *N. tenuifolia* by its proportionately broader pinnules, more decidedly cordate at the base, its nerves more dichotomized and closer at the margin, and its terminal pinnule usually broader, larger, and more flexuous. The pinnules of *N. heterophylla* are usually smaller, rather less densely nerved, the terminal one usually smaller and more elongated. *N. gigantea*, as described in Europe, has its nerves finer and more crowded, the pinnules less often overlapping, usually curved upward, the rachis often provided with small cyclopterid pinnules, and the terminal pinnule smaller than the lateral ones. Our species differs from *N. vermicularis* by the thickened nerves and the union of the terminal with the upper pinnules in the latter, while *N. capitata* differs by its pinnules pedicellate, rounded, the terminal deltoid, acuminate, the nerves flabellate.

Locality.—McClelland's shaft.

[1] 13th Rept. Geol. Surv. Ind., pt. 2, p. 52.

[2] Cat. Palæozoic Plants, p. 93; Trans. Roy. Soc. Edinb., XXXV, pt. 1, p. 314.

[3] Coal Flora, Pl. X, Figs. 1–4.

NEUROPTERIS TENUIFOLIA (Schloth.) Sternb.

1820. *Filicites tenuifolius* Schlotheim, Petrefactenkunde, p. 405, Pl. XXII, Fig. 1.

1826. *Neuropteris tenuifolia* (Schloth.) Sternberg, Versuch, I, 4, Tent., p. xvii; II, 5, 6, p. 72. 1846: Bunbury, Amer. Jour. Sci., 2d ser., p. 231. 1855: Geinitz, Verst. Steink. Sachsens, p. 22, Pl. XXVII, Fig. 3. 1857: Lesquereux, Rept. Geol. Surv. Ky., III, p. 537. 1858: Lesquereux, Geol. Penn., II, p. 879. 1860: Lesquereux, Geol. Surv. Ark., II, p. 312, Pl. V, Figs. 2–6. 1866: Lesquereux, Geol. Surv. Ill., II, Palæont., p. 428. 1869: Schimper, Traité, I, p. 438. 1879: Lesquereux, Coal Flora, text (1880), I, p. 100; atlas, Pl. XII, Figs. 6, 7. 1884: Lesquereux, Am. Nat., XVIII, p. 922.

1830. *Nevropteris tenuifolia* (Schloth.) Sternb., Brongniart, Hist., p. 241, Pl. LXXII, Fig. 3. 1886: Zeiller, Fl. foss. Valenciennes, atlas, Pl. XLVI, Figs. 1, 1a, b; text (1888), p. 273.

Fronds large, tripinnate; rachis striate; secondary pinnæ alternate or subopposite, often short, linear-lanceolate, tapering slowly from near the base to the obtusely pointed summit, at right angles or oblique, somewhat caducous, often touching or overlapping; pinnules varying much in size, alternate or subopposite, at right angles or oblique, straight or slightly curving upwards, usually contiguous or slightly overlapping, but often distant, attached at a single point, sessile or short pediceled, 5^{mm}–3^{cm} long, 1–7^{mm} wide, flat or slightly arched upward, more or less distinctly cordate at the base, oblong and obtuse, with borders parallel or possibly laterally concave, or somewhat triangular, the sides tapering to an obtuse apex; terminal pinnule larger than the lateral ones, lanceolate, sublobate, with somewhat wedge-shaped base, tapering to a round point at the top, the borders sometimes undulate; midrib very distinct, quite strong at the base, passing two-thirds of the way up or more, marked by a furrow on the upper side of the pinnule; secondary nerves distinct though thin, originating at a narrow angle and forking two or three times into fine nervils.

To *Neuropteris tenuifolia* I have referred a series agreeing with specimens in the Museum collection identified by Lesquereux as belonging to that species. Some of the variations agree with the European descriptions and figures, and, although I have seen no foreign specimens for comparison, the identification seems to be more satisfactory than in the case of the preceding species, and fewer forms are left apparently undescribed and unaccounted for. This species, like the preceding, is represented by fragments of fronds and pinnæ and detached pinnules. Forms identical in proportions and nervation with those figured by Brongniart,[1] with tapering pinnæ, contiguous or slightly separated pinnules, the latter cordate at the base, and gradually contracting towards the tip, which is rounded, are the most frequent, while transition forms lead to a few with the elongated pinnules having the margins more nearly parallel, such as those figured by Lesquereux[2] or Zeiller.[3] The forms with more triangular pinnules prevail generally, the pinnules seldom overlapping, and often becoming rather broadly triangular. In these phases it approaches the type figured by Lesquereux

[1] Hist., Pl. LXXII, Fig. 3.

[2] Coal Flora, Pl. XII, Fig. 6. Geol. Surv. Ark., Vol. II, 1860, Pl. V, Figs. 3, 4, 5.

[3] Fl. foss. houill. Valenciennes, Pl. XLVI, Figs. 1, 1*a*, 1*b*.

in the Arkansas report.[1] The intermediate variations between the specimens referred to *N. flexuosa* and these forms are so many that it is in many cases, especially when the matrix is coarse and the nervation obscure, difficult to decide to which species the specimen should be assigned.

As indicated above, the American specimens referred to *N. flexuosa* and *N. tenuifolia* seem not only far from being completely identical with the European species in all their forms, but these variations very strongly indicate a specific unity of the American specimens in a single species, perhaps including *N. missouriensis*, and perhaps distinct from the European, but combining characters differentiated in and common to both of the old-world forms. The same difficulty in differentiating our types, or finding them in complete accord with either or both of the European species, was mentioned by Bunbury in his descriptions of the plants from Cape Breton,[2] and by Lesquereux in the Coal Flora.[3] Although I can find no satisfactory dividing line separating our specimens into two species, I have followed my distinguished predecessor in assigning to the best of my ability, though undoubtedly with errors, the various forms to the old-world species to which they appear to approach the most closely. While many of my specimens agree perfectly with specimens in the U. S. National Museum collections, identified by Lesquereux as *N. tenuifolia*, I am inclined to regard some of those figured by him[4] under that name as standing nearer the forms referable to *N. flexuosa*, though others[5] seem to represent the former. The reference of Fig. 4, Pl. XII, of the Coal Flora with the triangular cyclopterid pinnules to either of these species seems to me very doubtful. Some of the phases shown in the species approach *N. gigantea*, as figured by Sternberg, Brongniart, and Weiss, in habit, form, and distance of pinnules, but the terminal pinnules are larger, the nervation much more distinct, and the small rachial pinnules observed by Sternberg and Zeiller are wanting in our specimens.

Relations.—The distinctions between *N. tenuifolia* and *N. gigantea* have just been mentioned. The former is said to differ from *N. flexuosa* by its smaller pinnules, more tapering, narrower in proportion to the length, and the nervation less crowded, while the pinnules are proportionately longer, with secondary nerves finer and less crowded than those of *N. heterophylla*.

Locality.—McClelland's shaft; Hannam's shaft.

NEUROPTERIS cf. TRICHOMANOIDES (Brongn.) Lx.

Pl. IV, Fig. 10.

To *Neuropteris trichomanoides* I have compared three specimens of *Cyclopteris*, whose preserved portions agree well with Brongniart's orig-

[1] Vol. II, 1860, Pl. V, Fig. 2.
[2] Quart. Jour. Geol. Soc., London, III, 1847, p. 425.
[3] Vol. I, p. 101.
[4] Coal Flora, Pl. XII, Figs. 1, 2, 3, 5.
[5] Loc. cit., Figs. 6, 7. Report Geol. Surv. Ark., Vol. II, 1860. pl. V., Figs. 3–6.

inal description and illustration[1] as well as with those of several other European authors.[2] While the Missouri fragments have the thin texture, the outline orbicular or oval, and the nerves rather thin, distinct, distant in the lower part, dichotomizing several times, to about eighteen to the centimeter at the border, I still hesitate to refer them definitely to that species, for the reason that in none of them are the basal lobes and attachment shown. The specimen figured is possibly only a small representative belonging to the same plants as those described below as *N. dilatata* (L. and H.) Lx., the specimens of both being found mingled with the remains of *N. flexuosa* and *N. tenuifolia.* They differ markedly from the specimen figured by Lesquereux in the Coal Flora,[3] as well as with the specimens from Cannelton, Pennsylvania, identified by him as *N. trichomanoides* in the Museum collection, in which the nerves are much closer in all parts, numbering forty-eight to fifty-five per centimeter at the border.[4] The latter are much finer veined than anything elsewhere described under that name. Von Roehl[5] and Kidston[6] having found *Cyclopteris* pinnules, which they accept as *C. trichomanoides*, attached to *Neuropteris heterophylla* (*N. Loshii* in part), regard them as the rachial pinnules of true *Neuropteris*, but Grand 'Eury[7] and Zeiller[8] prefer to consider the pinnules identified by themselves as *N. trichomanoides* to be odontopteroid on account of their association with *Odontopteris minor* and *O. Reichiana.* I have placed these and all the following *Cyclopteroid* pinnules in the genus *Neuropteris*, because among all the specimens and blocks broken up in the collection, comprising fourteen boxes of material, I have not yet seen a fragment of any species of *Odontopteris.*

Locality.—McClelland's shaft.

NEUROPTERIS DILATATA (L. & H.) LX.

1833. *Cyclopteris dilatata* Lindley and Hutton [non (L. & H.) Sternb.], Fossil Flora, II, Pl. XCIB.

1849. *Nephropteris dilatata* (L. & H.) Brongniart, Tableau, p. 16 (65). 1869: Schimper, Traité, I, p. 430.

1880. *Neuropteris dilatata* (L. & H.) Lesquereux, Coal Flora, I, p. 78.

Pinnules very large, transversely oblong or oval-orbicular, asymmetrical, very deeply auriculate, the lobes often overlapping, the basilar sinus subcentral; margin more or less undulate; texture rather thick; nerves of moderate size, quite distinct, though often dissociated and spread out, radiating flabellate from the base, about 6–10 to the cen-

[1] Hist. Vég. foss., I, (1830), p. 217, Pl. LXI bis, Fig. 4.

[2] Geinitz, Verst. Steink. Sachsens, 1855, p. 23, Pl. XXVIII, Figs. 2, 3. Heer, Fl. foss. Helv., 1874, p. 17, Pl. VI, Fig. 16. Breton, Étude géol. Dourges, 1873, p. 61, Pl. VI, Fig. 3 (not 1, 2). Renault, Cours bot. foss., III, 1883, p. 184, Pl. XXX, Fig. 5.

[3] Pl. IV, Fig. 4, p. 79.

[4] Mr. Lacoe informs me that these Cannelton specimens were afterwards removed from *N. trichomanoides* by Lesquereux, whose unfinished MS. contains the note that it belongs to a new species, although it was not named.

[5] Foss. Fl. Steink. Westphalens, 1869, Pl. XVII.

[6] Cat. Pal. Pl. Brit. Mus., 1886, p. 90.

[7] Fl. Carb. Loire, 1877, p. 113.

[8] Fl. foss. houill. Commentry, I, 1888, p. 266.

timeter at one-third of the distance to the border, dichotomizing 5–7 times in passing, slightly arcuate, to the margin, where they number about 22–28 or more per centimeter.

The great variation in the form and peripheral characters, as well as in size, that has been observed among the pinnules of the same species of *Cyclopteris*, even when attached to the same rachis, has cast much doubt on the prevailing discrimination of the forms in species. Pinnules belonging to the same species may be more or less cuneate, or they may have overlapping auricles. Size is of but little specific value. However, while it may well be that the pinnules of the same kind of *Neuropteris* or *Odontopteris* have been described under different names, it does not seem quite probable that *Cyclopteris dilatata*, *C. orbicularis*, *C. oblata*, and *C. trichomanoides* all are parts of *Neuropteris heterophylla*. The large number of species of *Neuropteris*, a portion of which are known to have borne cyclopterid pinnules, and of *Odontopteris*, whose rachial pinnules are sometimes cyclopterid, furnishes in itself some reason for the attempt to distinguish specific characters among the many cyclopterid forms. It appears probable that the classification of those whose actual pinnate relations are not definitely known will ultimately be based chiefly on the characters of nervation and texture. The only illustration of *Neuropteris dilatata* L. & H. of which I am aware is that given in the Fossil Flora. Of the original specimen, Mr. Kidston, in his valuable Notes on the Palæozoic Species mentioned in the Fossil Flora, says,[1] "The nervation is not sufficiently indicated to determine the species. I believe, however, that it is referable to *Neuropteris heterophylla*, Brongn." The enumeration and brief description of this species made subsequently by Goeppert, Unger, and Schimper, seem to have been based wholly upon Lindley and Hutton's figure and brief characterization. It appears, therefore, somewhat doubtful whether the American species is identical with that represented by the British specimen. I have, however, thought best to retain, for the present, the name employed by Prof. Lesquereux for this form of pinnule. The identification of my specimens with those described by Lesquereux under that name, is based upon a comparison with the specimens originally described in the Coal Flora, p. 78, placed in my hands through the courtesy of Dr. J. H. Britts of Clinton, Missouri, of whose collection they form a part. The pinnules, some of which must have been as much as 25^{cm} in longer diameter, are of rather thick texture, and irregularly sinuate at the margin. Some of the fragments show evidence of a more or less longitudinally oval form similar to that seen in *C. orbicularis*, with which Zeiller[2] unites *Cyclopteris dilatata* L. & H. The nerves, as described above, are generally distinct, sometimes appearing narrow and rounded, but usually they are spread out, similar to the nervation shown by Goeppert[3] in

[1] Proc. Roy. Phys. Soc. Edinb., vol. x, 1890-91, p. 366.
[2] Fl. foss. houill. Valenciennes, p. 298.
[3] Gättungen, Lief. 5 u. 6, p. 91, Pl. IV u. V, Fig. 2.

Cyclopteris crassinervis, which is perhaps referable to our species, or they are separated into two close parallel bundles. Occasionally they are dissociated into filaments. It is hoped that these original American forms may eventually be illustrated.

Relations.—The relations of *Neuropteris dilatata* to other Cyclopterid species is undefined. The American specimens appear to conform more closely to the description and characters of *N. trichomanoides*, from which they differ perhaps by their rather thicker texture and coarser nerves. The size, which was formerly one of the distinguishing features of *N. dilatata*, is not much greater than that of the *N. trichomanoides* figured by Zeiller in the Commentry Flora,[1] the general character of which, excepting the very thin nerves, more distant at the margin, is very much like that of our specimens. As stated above, it is quite possible that the specimen, Pl. IV, Fig. 10, compared to *N. trichomanoides*, is really a small specimen of this species. *N. dilatata* seems to differ from *Cyclopteris orbicularis* by its nervation, proportionally closer at the base, branching more irregularly and at a narrower angle, and less dense at the margin.

Locality.—McClelland's shaft; Hannam's shaft.

NEUROPTERIS, SPECIES.

Pl. v, Fig. 6.

Two other forms of cyclopterid pinnules occur in the collection, whose specific characters seem hardly sufficient to warrant either their reference to any of the well-defined species or the foundation of a new one. The first, Pl. v, Fig. 6, is a large fragment representing the greater part of the right half of an oval-orbicular pinnule, somewhat cuneate, apparently without a distinct auricle, with a sinuate margin, nerves rather closer than in the last species, forking five or six times, generally at a rather wider angle than in the former, and arching considerably to the margins. A conspicuous feature is the nearly uniform dichotomizing of the nerves at about 8^{mm} from the margin, forming a well-defined marginal zone, in which the nervation is almost twice as close, thirty to thirty-six per centimeter, as it is just central of the line of dichotomy. In nearly all respects the specimen agrees well with the one figured by von Roehl[2] as *Cyclopteris orbicularis*.

Another pinnule is subsemicircular below, its top round-truncate, 3$\frac{3}{4}^{cm}$ wide, 16^{mm} long, with thin nerves, sometimes dilated at the base, radiating from the long basilar attachment, and forking three or four times in passing to the border, where they number about thirty-four per centimeter. While its specific relations are unknown, the indentification of the same form in other localities can not be without some homotaxial value. I have not therefore attempted to place it in any

[1] Pt. I, Pl. XXIII, Fig. 3.

[2] Foss. Fl. Steink. Westphalens, p. 43, Pl. XXI, Fig. 3.

species. It is slightly suggestive of the rachial pinnules of *Odontopteris alata* Lx.,[1] the *Cyclopteris semiflabelliformis* of Morris,[2] and *C. densa* Ren. and Zeill.[3] It is probably a *Nevropteris* pinnule, there being no fragment of *Odontopteris* in the collection.

Locality.—McClelland's shaft.

DICTYOPTERIS Gutbier. 1835.

DICTYOPTERIS SQUARROSA Ett. sp.

1852. *Neuropteris squarrosa* Ettingshausen, Abhandl. K.-k. geol. Reichsanst., I, 3, No. 4, p. 10, Pl. VI, Fig. 3.

1855. *Dictyopteris neuropteroides* Gutb. in litt., Geinitz, Verst. Steink. Sachsens, p. 23, Pl. XXV, Fig. 6,°6a. 1864: R. Andree, N. Jahrb. f. Min., p. 170. 1866: Bureau, Bull. Soc. géol. France, [2] XXIII, p. 848, Pl. XIV, Figs. 3, 4. 1868: Weiss, Verh. naturh. Ver. pr. Rheinl. u. Westphal., XXV, p. 83. 1869: Karl Feistmantel, Steink. Klein-Přilep, etc., pp. 34, 61, 94. 1869: v. Roehl, Foss. Fl. Steink. Westphalens, p. 49, Pl. XVI, Fig. 6. 1869: Schimper, Traité, I, p. 618. 1873: O. Feistmantel, Zeitschr. d. deutsch. geol. Gesell., XXV, p. 598. 1873: O. Feistmantel, Jahrb. K.-k. geol. Reichsanst., XXIII, p. 277 (29). 1874: O. Feistmantel, Abh. k. böhm. Gesell. Wiss., [6] VI, p. 81. 1874: O. Feistmantel, Abh. k. böhm. Gesell. Wiss. [6], VII, p. 24. 1874: Areitio, Anales Soc. esp. Hist. nat., III, p. 250. 1876: Heer, Fl. foss. Helv., p. 36, Pl. VII, Fig. 9. 1877: Grand 'Eury, Fl. Carb. Loire, p. 120. 1881: Weiss, Aus d. Fl. Steink., Pl. XV, Figs. 93, 93a. 1882: Schütze, Abh. geol. Specialk. Preussen, III, 4, pp. 77, 226. 1883: Karl Feistmantel, Mittelböhm. Steinköhlen-Ablag., p. 61. 1883: Kušta, Sitzb. math.-nat. Cl. k. böhm. Gesell. Wiss., pp. 160, 172, 178. 1884: Lesquereux, Coal Flora, III, p. 833.

Fronds bipinnate, pinnæ opposite or subopposite; pinnules opposite or subopposite, at right angles to the rachis, sessile, close, contiguous or slightly overlapping, entire, 2–3½^{cm} long and 9–12^{mm} in width, the shorter ones oval, those of average length, or longer, somewhat falcate, nearly truncate or truncate-cordate, often unequal at the base, oblong-lanceolate, tapering towards the end, obtuse; terminal pinnules long, rather linear-lanceolate, obtusely pointed; median nerve dissolved quickly into slender secondary nerves, at first close and nearly parallel, diverging gradually and forking four or five times, and anastomosing in passing very obliquely to the border; secondary nerves near the base flabellate from the point of attachment; meshes very narrow, acute at each end, greatly elongated near the median line, becoming shorter near its borders.

The most prominent characters of this species of *Dictyopteris*, fragments of which are scattered all through the shales sent from Aurora, are the rather narrow pinnules, sometimes slightly dilated at the base, but hardly auriculate, the larger ones falcate towards the tip, which is obtuse; the rather weak median nerve dissolving at about one-third or one-half the distance up the pinnule into fine, nearly parallel secondary nerves, curving gradually towards the margin, which they meet quite obliquely; and the areolation, elongated and narrow proportionately,

[1] Coal Flora, I, p. 131, Pl. XXI, Fig. 1.

[2] Trans. Geol. Soc. London [2], V, 1840, p. 448, Pl. XXXVIII, Fig. 7.

[3] Fl. foss. houill. Commentry, pt. 1, p. 267, Pl. XXIII, Fig. 4.

even at the margin. The slender secondary nerves hardly anastomose until they have passed some distance from the median line, the meshes becoming shorter, but continuing narrow nearer the margin. The areolæ are bounded by irregularly curved nervils and are acute at the ends. The general characters of the pinnules are fairly well shown by Ettingshausen[1] in his original figure of *Neuropteris squarrosa*, although the tips of the pinnules are broken, only indicating the falcate upward curve towards the end. This is better shown by von Roehl[2], pinnules of whose specimen are proportionately considerably wider at the base, the lateral borders converging more rapidly. The figure of *Dictyopteris neuropteroides* given by Geinitz,[3] and copied by several authors, indicates a rather more pronounced curvature in the middle of the pinnule, and an apex rather more acute than that seen either in Ettingshausen's figure or my specimens. The pedicel seen in Dr. Geinitz's figure seems somewhat doubtful. The shorter and broader pinnules of this species are oval and truncate-rounded at the base, similar to the pinnules on the main rachis of Gutbier's *Dictyopteris Brongniartii*.[4]

In 1855 Dr. Geinitz, when describing the *Dictyopteris neuropteroides* Gutb. in litt., inscribed the name *Neuropteris squarrosa* Ett. in the synonymy only with doubt, having only Ettingshausen's figure before him. Their identity was verified, however, by R. Andree[5] in the examination of a collection of fossil plants from the same source as those studied by Ettingshausen, viz, Stradonitz, and his verification has been accepted, I believe, by all European paleontologists except Kidston, who referred[6] *Neuropteris squarrosa* to *Neuropteris cordata* L. & H., apparently on account of the original figure and Ettingshausen's comparison of it with *N. macrophylla*.

Among the fossil plants in the collection of the U. S. National Museum are two specimens (No. 1463) from Stradonitz, Bohemia, labeled *Neuropteris squarrosa* Ett., apparently in Ettingshausen's own handwriting. These specimens comprise several pinnules whose agreement with my specimens, as well as with the original figures, is clearly identical. In all the characters of form, size, texture, and nervation the American and the Bohemian species agree.[7] Certainly the *Neuropteris squarrosa* is a *Dictyopteris*. I can find no reason for disagreeing with the European authors in uniting it with *Dictyopteris neuropteroides*. But, such being the case, it appears that conformity with the laws of nomenclature demands that Ettingshausen's specific name, published, described, and illustrated in 1852, should have priority over Gutbier's name *Dictyopteris neuropteroides*, first published by Geinitz in 1855, as "1850 v. Gutbier in litt." Gutbier's manuscript name of 1850 should

[1] Steinkohlenfl. Stradonitz, Pl. VI, Fig. 3.
[2] Foss. Pfl. Steink. Westphalens, Pl. XIV, Fig. 6.
[3] Verst. Steink. Sachsens, Pl. XXVIII, Figs. 6, 6a.
[4] Abdrücke, Pl. XI, Fig. 7.
[5] Die Versteinerungen d. Steinkohlenformation v. Stradonitz in Böhmen, N. Jahrb. f. Min., 1864, p. 170.
[6] Cat. Pal. Pl. Brit. Mus., p. 98.
[7] It is hoped that examples of these pinnules may be hereafter illustrated.

not obtain when, before its publication, the species had been fully described and figured under another designation. I have, therefore, recognized Ettingshausen's species, both as identical with the American fern, and also, granting it to be identical with *Dictyopteris neuropteroides*, as having priority over the other name.

Relations.—This species is most nearly related to *Dictyopteris Brongniartii*, from which it differs by its insignificant median nerve and its secondary nerves, which are much finer and clearer, forming larger and narrower meshes. The areolæ of *Dictyopteris Brongniartii* are very much shorter near the middle of the pinnæ, without so much variation in the length between the meshes near the median line and those near the border. The form of the pinnules, including the short oval ones of *D. neuropteroides*, is largely similar to that of the *Dictyopteris Brongniartii* represented by Gutbier.

Dictyopteris Schützei has a strong midrib, the secondary nerves arching to the border, and its areoles much smaller. *Dictyopteris Scheuchzeri* has cordate-acute pinnules, with distinct midrib and nerves arch in strongly, forming very fine, irregular meshes, while *Dictyopteris obliqua* has a rather pronounced midrib, the nerves curving to the border, and the areolation nearly alike in all parts of the pinnule, somewhat polygonal and often hexagonal.

Locality.—Aurora; also at Hannams' shaft.

ANOMALOUS FORMS.

APHLEBIA Presl. 1838.

The real nature of these interesting remains, which have been described at different times in the genera *Fucoides*, by Gutbier; *Aphlebia*, by Presl, *Schizopteris*, by Brongniart, *Hymenophyllites*, by Goeppert, *Pachyphyllum*, by Lesquereux, *Rhacophyllum*, by Schimper, *Filicites*, by Germer, and in *Palmacites*, *Algacites*, *Rhodea*, *Trichomanites*, and *Laminarites*, by various authors, is not yet perfectly clear. They are considered by various botanists as primordial fern fronds, undeveloped stipal fronds, or anomalous laciniate pinnules sometimes occurring at the base of the primary pinnæ. They were considered by Lesquereux as including types related to several ranks of vegetation, some having affinities with *Neuropteris*, *Hymenophyllum*, and other ferns, others as being parasitic on fern stems, or as derived from thalli, of primary rhizomatic tufts of leaves, while others might be fucoidal.

The discovery in recent years of *Aphlebiæ* attached to the rachis of many species of *Pecopteris* and *Sphenopteris*, such as *P. dentata*, *P. Biotii*, *P. abbreviata*, and *Sphenopteris crenata* strengthens the view now generally entertained, that most of the species of *Aphlebia* are stipal abortive pinnæ growing from the bases of primary or secondary rachises, similar to the foliar growth seen in *Hemitelia capensis* Br., or

Gleichenia gigantea Wall. However, Kidston's claim to having found both sterile and fruiting fronds of *Alicornopteris convoluta*,[1] a frond apparently closely related to some forms of *Aphlebia*, indicates that the above hypothesis may account for only a portion of the species. It is not improbable that more than one group may be represented among these anomalous remains. Zeiller points out with justice, when restoring Presl's genus, that the type to which Brongniart applied the name *Schizopteris* does not belong to the genus *Aphlebia* or *Rhacophyllum*, and that *Aphlebia* has priority and should be retained in spite of its derivative signification, the name of a genus or species being in effect a designation rather than a description. A similar misnomer is familiar as *Calamites*.

APHLEBIA ARBORESCENS Lx. sp.

1870. *Hymenophyllites arborescens* Lesquereux, Geol. Surv. Ill., vol. IV, p. 415, Pl. XVII.

1874. *Rachophyllum arborescens* (Lx.) Schimper, Traité, III, p. 525. 1880: Lesquereux, Coal Flora, I, p. 314.

Primary pinnæ large, linear, acute (?) sympodially dichotomous, the axis straight or slightly flexuous; secondary pinnæ alternate, oblique, rather strong, decurrent, curving outward, not constricted at the base, divided into alternate oblique, more or less regularly and deeply lobed segments; lobes or pinnules, alternate simple, linear-lanceolate, or bi- or trifid, the ultimate divisions shorter and more broadly lanceolate; nervation usually very obscure, the main axis flat, marked by obscure vascular bundles, giving off other thin bundles which pass, mingled with cellular tissue, into the secondary divisions.

This fine form of *Aphlebia* is well illustrated in the Illinois report referred to above. The most prominent features of the species are the long frond with its axis rather broad and flat; the obscure nervation in the cellular tissue; the branches or secondary pinnæ, moderately broad, ramose, the borders close or slightly overlapping; the divisions deeply dissected into broadly diverging lobes; and the lobes broadly lanceolate, of varying length, and generally acute.

Aphlebia arborescens is very similar to some of the forms referred to *A. filiciformis* Gutb. The one figured in Gutbier's Abdrücke, Pl. I, Fig. 13, is very similar to some of the upper secondary pinnæ in my specimen, though the former are rather less distinctly dissected. It does not seem probable that the large number of forms included by Geinitz, Kidston, and some other authors under *A. filiciformis* are all representations of a single species. In view of the fact that a large number of species of ferns belonging to several genera have been discovered to bear *Aphlebia* pinnæ, it becomes probable that the number of species of the latter genus must be considerable, and that in *Aphlebia*, as well as in *Cyclopteris*, a more careful and critical examination and differentiation of the forms will better serve the interests of both geology and biology.

[1] Trans. Roy. Soc. Edinb., vol. XXXIII, 1889, p. 152, Pl. VIII, Figs. 11–15.

Relations.—Among the described species of this genus *Aphlebia arborescens* is most nearly related to *A. filiciformis* and *A. elongata* Zeill. From the former it differs by its broad, flat, rather thin axis and branches, with the vascular tissue obscure or invisible, and the well-developed ultimate divisions broader, often longer, and more acute. The ramification is also more robust. *Aphlebia elongata*, as described by Zeiller, is, on the contrary, more ovate-lanceolate in the contour, its primary divisions preserving the same form, the division very much more oblique, and deeply dissected, the lobes much closer, more fasciculate in appearance and elongated, the sinuses being narrow and acute. The Commentry species differs further by the presence of a large median nerve.

Locality.—McClelland's shaft.

LYCOPODINEÆ.

SIGILLARIÆ.

SIGILLARIA Brongn., 1822.

With the exception of some macrospores which may perhaps belong to some of the Carboniferous lycopods, but which are not so preserved as to appear identifiable, the only remains of this great order that I have observed in the entire collection consist of numerous fragments of long leaves which belong probably to the genus *Sigillaria.* These leaves are broad and rather thin, but seldom flattened, the circumstances of preservation having been such as to keep them in nearly their original form. Some of the fragments are 20^{cm} or more in length, from $5–11^{mm}$ in width, quite rigid, and tapering very gradually. From the fact that the decrease in width is hardly perceptible in specimens of $10–15^{cm}$ long it is probable that the larger ones may have attained a length of $40–50^{cm}$ or more. The surface is covered with a thin, black, quite smooth, coaly covering in most of the specimens. The upper surface is characterized by a strongly marked, rather broad furrow $2–2\frac{1}{2}^{mm}$ wide, the sides of which curve slightly downward to a rounded angle in the center or to a quite distinct fine rounded medial crease in most fragments where the coaly covering is removed. Under the lens the surface in the groove is rather distantly striated. Bordering the groove are two slender raised lines, one on each side, apparent on most of the specimens. These may be nerve bundles or ducts originating in the lateral cicatrices of the scar. From these lines to the margin the surface of the leaves is nearly flat or slightly curved upward, the only interruption being a fine line in slight relief from the parenchyma at a distance of about $\frac{1}{2}–\frac{2}{3}^{mm}$ from and parallel to the border. The lower surface of the leaves is marked by a carene about 2^{mm} wide, the edge thin and rounded, though not raised very high. On either side of the carene is a well-defined crease, probably the stomatiferous crease de-

scribed by Renault. A faint secondary crease is seen in some specimens situated just within the line near the border noted in the description of the upper surface. The latter, which is also quite distinct in a specimen belonging to the same species in the museum collection from Murphysboro, Illinois, would seem to indicate the presence of a pair of nerves near the border. Such a condition would, however, be contrary to the conclusions reached by Renault from his researches in the internal structure of the lycopodiaceous leaves of the Coal Measures, as well as to the results of Kidston's examination of the group represented by *Cyperites bicarinata* L. & H.,[1] which he regards[2] as uninerved, and belonging to *Sigillaria* or *Lepidodendron*. Enough is not yet known or described of the leaves of this group to make them of much assistance in the identification of species; and considering the known variation of proportions of the leaves in the different parts of the same tree it is not probable that great assistance can be expected from a special study of them. However, comparatively few have ever been illustrated or described. Of these, one of the specimens figured by Ettingshausen[3] as *Flabellaria Sternbergii*, subsequently refigured by O. Feistmantel as belonging probably to *Lepidophyllum*,[4] is much like our specimens. The general aspect of the leaves is much that of the one figured and referred to *Lepidodendron* by Lesquereux[5] or the *Lomatophloios macrolepidotum* illustrated by Renault in the Atlas to the Commentry flora[6].

Several specimens from the Preston colliery, in Schuylkill county, Pennsylvania, and from Murphysboro, Illinois, containing leaves between which and my specimens I can see no difference, are in the fossil-plant collection of the U. S. National Museum, but I have no satisfactory information as to their floral association on which to base more than a supposition as to the identified trunks to which they may have belonged.

Locality.—Abundant at McClelland's shaft; rare in the shales from Carterville.

---

[1] Fossil Flora, I, Pl. XLIII, Figs. 1, 2.
[2] Proc. Roy. Phys. Soc. Edinb., X, 1890-'91, p. 359.
[3] Steinkohlenfl. Radnitz, Pl. XXIV, Fig. 2.
[4] Verst. böhm. Ablag.. II, Pl. XX, Fig. 3, p. 43 (217).
[5] Geol. Surv. Ill., II, Palæont., p. 455, Pl. XLV, Fig. 6.
[6] Pl. LVIII, Fig. 1.

II. PHANEROGAMS.

GYMNOSPERMÆ.

CORDAITEÆ.

CORDAITES, Unger. 1850.

CORDAITES COMMUNIS Lx.

1878. *Cordaites communis* Lesquereux, Proc. Am. Phil. Soc., XVII, p. 320. 1880: Lesquereux, Coal Flora, I, p. 534. 1880: Fontaine and I. C. White, Permian Flora, p. 18. 1890: G. Hambach, Bull. Geol. Surv. Mo., I, p. 85.

Leaves rather large, oblique at the stem, somewhat imbricated, varying in size, the largest reaching a length of 25^{cm} or more and a breadth of 4^{cm} or more, quite rapidly narrowed to the base, the borders generally slightly recurved; primary nerves, twenty-four to twenty-six per centimeter, distinct, especially on the under surface of the leaf, relatively strong, rounded; intermediate nerves, two to four, rather indistinct; epidermis apparently minutely shagreened.

I am unable to find any difference between the abundant fragments of leaves occurring in the shales of McClelland's shaft and specimens of *Cordaites communis* from Clinton, the locality whence came the types described by Lesquereux in the Coal Flora. I have not seen the leaves attached to the stem nor examples of the peculiar fructification mentioned by Lesquereux. The density of the nervation remains constant, varying only from twenty-two to twenty-four primary nerves per centimeter in the middle portion of the blade, thus apparently constituting a definite character for the species in this region, although but little weight has generally been given by paleontologists to the density of the nervation of the leaves in determining the species of *Cordaites*. The same species is also represented by specimens from Van Buren, Arkansas, in the National Museum collection.

Relations.—*Cordaites communis* appears to be closely related to *C. borassifolius* (Sternb.) Ung., from which it was distinguished by Lesquereux by its smaller leaves, more rapidly narrowed to the base. Its nervation appears to be less dense. Small fragments of the leaves are suggestive of the foliage of *C. principalis* (Germ.) Goepp., as figured by Heer[1] and Sterzel.[2] The leaves of *C. principalis* as generally described are rather smaller, with the primary nerves usually farther apart. The distinction between many of the American species and those of the old world will remain uncertain until foreign specimens are in hand for comparison. For stratigraphic purposes it will suffice to be content for the present with identifying the new material so far as possible with the types examined and identified by Lesquereux, Newberry, and Andrews.

[1] Fl. foss. Helv., Pl. I, Figs. 12–16.

[2] Fl. Rothl. nordwestl. Sachsen, p. 32, Pl. IV (XXIV), Figs. 1, 2.

Fragments of the leaves of *C. serpens* Lesq. are also similar to our species, but the primary nerves of the former are farther apart, while one of the secondary or intermediate nerves is stronger than the others.

Locality.—McClelland's shaft; Aurora.

CORDAITES cf. COSTATUS Lx.

A few fragments of leaves are present which agree fairly well with the corresponding portions of Museum specimens of *C. costatus* described and illustrated by Lesquereux.[1] The leaves are narrow occasionally appearing somewhat palmately divided. The primary nerves, eighteen to twenty per centimeter, are sharp, with four thin intermediate nerves. While my fragments appear to belong to the same species as the specimens in the Museum collection, I hesitate, in the absence of the characteristic stems with narrow carinate interrupted ridges decurring from the attachments of the leaves, to refer them definitely to that species.

Locality.—McClelland's shaft.

CORDAIANTHUS Grand 'Eury. 1877.

CORDAIANTHUS, species.

Ten specimens of the fruiting spikes of *Cordaites*, all belonging probably to the same species, are found in the material from Belleville. These are included in Grand 'Eury's division, *baccifer*, having ovules in the axils of foliaceous bracts along the raceme. The condition of preservation is not such as to allow a satisfactory specific identification or description. The spikes are long and slender, one of the specimens, both ends of which are broken away, still measuring 18^{cm} in length. In width they are 12–15^{mm}. The axis, 2–3^{mm} in diameter, is fibrous, slightly striate and somewhat zigzag, corresponding to the attachments of the ovules, and concave in the intervals, similar to the form of the axis in "heads" of wheat or rye. The fruit capsules are sessile, close, oblique to the axis, and arranged spirally. The bracts are short, slightly exceeding the ovule in the younger state, and apparently falling away when the fruit is more mature. The ovules are ovate-cordate about 5^{mm} or 6^{mm} in length, and 3^{mm} or 4^{mm} in width, and minutely striated. In form they resemble the *Cordaianthus subgermarianus* figured by Grand 'Eury[2] or the *Antholithus* illustrated by Newberry,[3] from Youngstown, Ohio, but in size and arrangement they must both have been nearer Grand 'Eury's Fig. 11, of *Cordaianthus*, on Pl. XXVI, of the Loire flora. When broken longitudinally the appearance is much like the spikes seen in the *Cordaicladus selenoides*, Fig. 1, Pl. XXV, of the latter work. Although I have not yet seen any specimens nor figures

[1] See Proc. Am. Phil. Soc., XVII, 1878, p. 323, Pl. LI, Figs. 1–3, and XVIII, 1879, p. 222, Pl. III, Figs. 1, 2; Coal Flora, vol. II, p. 540, Pl. LXXX, Figs. 1–3, Pl. LXXXVI, Figs. 1, 2.

[2] Fl. Carb. Loire, p. 232, Pl. XXVI, Fig. 10.

[3] Annals of Science, II, Cleveland, 1854, No. 1, p. 3, Fig. 2; Geol. Surv. Ohio, vol. I, pt. 2, Paleont., p. 363, Pl. XLI, Fig. 2.

anywhere agreeing with these very long, slender spikes with crowded ovules and short bracts, the latter often apparently absent, I have thought best not to describe them under a new name until seen in more abundant material or compared with other collections.

Locality.—McClelland's shaft.

CORDAICARPUS Geinitz. 1862.

CORDAICARPUS LINEATUS Lx.

1884. *Cordaicarpus lineatus* Lesquereux, Coal Flora, III, p. 805, Pl. CXI, Fig. 16.

Endotesta exactly cordate, about $8\frac{1}{2}^{mm}$ long and $6\frac{1}{2}^{mm}$ wide in the broadest portion, 4^{mm} thick, finely striated, the apex slightly elongated to form an acute or mucronate point, the edges rounded, the sides somewhat convex, the basal sinus distinct, marking the sides for a short distance in the lower portion by a shallow vanishing groove; sarcotesta of nearly the same form as the endotesta, except at the apices of the lobes, where it is somewhat dilated or enlarged downward, about 2^{mm} thick at the edges of the endotesta at the middle, and 3^{mm} or $3\frac{1}{2}^{mm}$ thick at the base of the lobes, the medial sinus reaching nearly or quite to the base of the endotesta, which appears to be provided with a short pedicel passing into the chalaza.

Remains of several fruits are found, mingled with fragments of the leaves of *Cordaites*, in a specimen of dark laminated sandy shale from near Joplin. The more delicate vegetable tissue is carbonized. The fruits are replaced by marcasite. The best preserved fruit on the block represents the nucleus or endotesta, in marcasite, of a *Cardiocarpus* with its semi-carbonized envelope or sarcotesta. The former is exactly cordate, acute or mucronate at the apex with the surface longitudinally striate. The structure of the coverings of the nucleus is not clear.

Although my specimen is somewhat smaller than the figure of *Cordaicarpus lineatus* Lx., given in the Coal Flora,[1] the nucleus or endotesta has the same form and character as in that species whose description was based entirely on the nucleus, and it is most probably identical with that, whether or not *C. lineatus* is a good species.

The outline of the nucleus itself is somewhat like *Cardiocarpus pachytesta* Lx., as illustrated in Fig. 15, Pl. CIX of the Coal Flora, though not so broad in the upper part; or like *C. zonulatus* Lx., Pl. CX, Figs. 14, 15.

The profile in a lateral view in the endotesta is suggestive of several forms of fruits, such as the *Cordaicarpus major*, *C. ovatus*, and *C. congruens*, figured by Grand 'Eury,[2] Newberry's *Cardiocarpon latum*,[3] *Cardiocarpum cornutum* Daws,[4] *Cardiocarpus Ottonis* Gutb.,[5] *C. Gutbieri*

[1] Vol. III, Pl. CXI, Fig. 16, p. 805.

[2] Fl. Carb. Loire, Pl. XXVI, Figs. 16, 20, 21.

[3] Annals of Science, I, Cleveland, 1853, No. 13, p. 153, Fig. 3; Geol. Surv. Ohio, I, Pt. 2, Paleont., p. 372, Pl. XLIII, Fig. 3.

[4] Foss. Pl. Dev. and Upp. Sil. Can., 1871, p. 60, Pl. XIX, Fig. 214.

[5] Verst. Rothl. Sachsen, 1849, p. 27, Pl. IX, Fig. 7.

Gein.,[1] *Cordaicarpus acuminatus* R. and Z.,[2] and *C. sclerotesta* Brongn.[3] It is most similar, however, to *Cardiocarpum australe* Carr.,[4] and the *C. emarginatum* Brongn. figured by O. Feistmantel from the Coal Measures of Bohemia.[5]

The relative proportions of the envelope are somewhat like those seen in *Cardiocarpon ingens* Lx.,[6] or the *C. latum* of Newberry, except that the sarcotesta of our species is thinner near the apex, where it is apparently traversed for some distance at least by the elongated apex of the endotesta, while its lower portion is emarginate at the base, as in *C. ingens*, in Newberry's *C. samaræforme*[7] or Dawson's *C. cornutum*, and the *C. emarginatum* above referred to. The thickening of the envelope in the lobes is comparable to that seen in *C. Baileyi* Daws.,[8] *C. Harveyi* Lx.,[9] or the *C. sclerotesta minor* figured by Brongniart in his beautiful work on the Silicified Fruits.[10]

Cordaites is now one of the best known of the Paleozoic plants, its trunk, including the pith *Artisia* and *Sternbergia*, having been recognized and studied histologically as *Dadoxylon* Endl. (*Araucarites* Goepp.) and *Cordaioxylon* Gr. 'E., the branches as *Cordaicladus* Gr. 'E., the leaves as *Cordaites* (*Pyncnophyllum* Brongn.), *Dory-Cordaites* Gr. 'E., *Poa-Cordaites* Gr.'E., *Dictyo-Cordaites* Dn., and *Scuto-Cordaites* R. and Z., the inflorescences as *Cordaianthus* (*Antholithus* L. & H.) and *Cordaistrobus* Lesq., and the fruits *Cordaicarpus* Gr. 'E. (*Cyclocarpus* and *Jordania* Goepp. and Fiedler), and *Cordaispermum* Gr. 'E. To this type most authors now refer the whole or the greater part of the genus *Cardiocarpon* Brongn. The argument for the relationship of *Cardiocarpon* to the *Cycadaceæ* was forcibly presented by Dr. Newberry in his Report on the Fossil Plants in the Paleontology of Ohio.[11] The combined researches of several authors have made known the structure of both the male and female flowers of *Cordaites*, the pollen, the fertilization of the ovules, and the developmental stages of the *Cordaicarpus* (or *Cardiocarpon*), specimens of which have been found still attached to stems with leaves.

Relations.—*Cordaicarpus lineatus* Lx. most closely resembles *C. acuminatus* R. and Z., *C. australe* Carr. sp., and probably *C. emarginatus* Brongn. It is possible that it may belong to the first of these species, the faint striation being only the result of abrasion or erosion of the ligneous endotest. The latter is described as having the lateral borders straight.

---

[1] Geinitz: Verst. Steink. Sachsens, Pl. XXI, Fig. 23 (not 24, 25); Von Roehl, Foss. Fl. Steink. Westphalens, p. 153, Pl. XXII, Fig. 12; Kidston, Foss. Fl. Radstock Ser., p. 403, Pl. XXIII, Fig. 5.

[2] Fl. foss. Commentry, atlas, Pl. LXXII, Fig. 8.

[3] Ad. Brongniart, Graines foss. silicif., 1881, Pl. II, Fig. 1; Renault and Zeiller, l, c., Fig. 3.

[4] Quart. Jour. Geol. Soc. London, XXVIII, 1872, p. 356, Pl. XXVII, Fig. 4.

[5] Verst. böhm. Kohlenablag., II, 1875, p. 46 (221), Pl. XX, Figs. 4–6.

[6] Geol. Surv. Ark., II, 1860, Pl. IV, Figs. 4, 4a; Coal Flora, Atlas, 1879, Pl. LXXXV, Figs. 34, 35.

[7] Newberry, op. cit., p. 375, Pl. XLIII, Figs. 11, 11a.

[8] Dawson, op. cit., p. 60, Pl. XIX, Fig. 219.

[9] Coal Flora, III, Pl. CIX, Fig. 22.

[10] Pl. A, Fig. 6.

[11] Geol. Surv. Ohio, vol. I, pt. 2, 1873, p. 370.

It appears rather broader and smooth. The envelope or sarcotest is unknown in this and Carruther's species, which is described as having "a ridge running along one side of the fruit within and parallel to the edge." *C. emarginatum* Brongn. has the nucleus more ovate and the sarcotesta much thicker, especially above, while *C. Gutbieri* Gein. is much broader, thinner, with the endotest less acute, not so distinctly cordate at the base, the sarcotest being thin and rounded. *C. latum* Newb. sp. and *C. major* Gr. 'E. have their endotestæ broader, that of the former being less distinctly mucronate, with a line from the lower part to the summit, while the endotesta of the latter is less deeply cordate. *C. zonulatus* Lx. often has a central depression on the smooth nucleus, the sarcotest thickened above and prolonged downward at the base, and *C. pachytesta* Lx. has the envelope rounded and connivent above and prolonged below, the endotesta being larger, with a long slender pedicel. None of these are described as having a thinly striated nucleus or endotesta like that of *C. lineatus*.

Locality.—North end of the Bay state lease, Oswego, Joplin, Jasper county.

RESULTS.

DIFFICULTIES IN CORRELATION OF WESTERN TERRANES WITH EASTERN SERIES BY MEANS OF FOSSIL PLANTS.

Two obstacles are most important in preventing a satisfactory determination of the age of the plants and the correlation of their containing terranes with others whose stratigraphical position has been determined. The first one is the want of even a single paleobotanical section of the trans-Mississippi deposits with which to compare our flora. With the exceptions of the flora from near the base of the Lower Coal-measures in Henry county, Missouri, and a supposed subconglomerate flora from Washington county, Arkansas, the floras of the entire Carboniferous series in the great western regions are essentially unknown. Although plant-bearing horizons have been reported in the different state publications as occurring at various localities in the Lower, Middle, and Upper Coal-measures of the trans-Mississippi states, no one has ever examined them, I believe, nor have we so much as a published list of the species from any fixed horizon.[1] Considering these circumstances it is very earnestly hoped that geologists in these states will cooperate in procuring and identifying plants from as many fixed horizons, and localities in those horizons, as possible, in order to work out the floral associations and characteristics of the various stages in the different ascertained sections of the Coal-measures, with a view to their final

[1] Two apparent exceptions to this are the two small collections identified by Lesquereux from Ottawa and Osage city, Kansas, whose stratigraphic position is only indefinitely indicated; and a few plants described by the same author in 1860 from Jenny Lind and James Fork, Arkansas, considered by him to be subconglomerate, but which appear on a careful analysis to belong to the true Coal-measures. However, it is evident that these two isolated fragments, whose position and relation to the entire series is hardly approximately fixed, can at best be of very slight correlative value.

utilization in constructing standard paleobotanical sections of the Carboniferous in those areas.[1]

The second difficulty lies in the unreliability of the recorded geographical distribution of the species and of the geological position assigned to some of the localities, seriously impairing the homotaxial trustworthiness of our Carboniferous flora except within broad limits. This has already been suggested in the discussion of several species.

No close or accurate correlation, by means of paleobotany, of Carboniferous plant beds in the eastern or western areas can be accomplished until a close study of the plants shall have been made on the basis of their exact stratigraphical occurrence as well as from the standpoint of systematic botany, and it will always be useless to attempt to employ the fossil floras of any region in determining precise stages until they shall have been collected and studied by horizons in the same sedimentary basin or general region. It is not enough to collect and label fossil plants merely by localities; the flora of each horizon in the section should be collected and studied by itself. The methods so often followed by the paleobotanist must be exchanged for the minute and exact method of the best paleozoologist if the paleobotany of the Carboniferous or any other series is to fulfill its capacity for usefulness and receive the recognition that the paleontology of so comprehensive, highly differentiated and sensitive a class of organic life deserves.

Lack of confidence in the recorded distribution and range of the species, in view of known errors in geological and geographical distribution, as well as the want of actual knowledge of the floras of more horizons, whose stratigraphical relations to the series in a given region has been ascertained, makes it too often impossible to determine the age of any undetermined horizon in the eastern region with more precision than to indicate the group to which it belongs. The inaccuracy and liability to error involved in attempting definitely to correlate isolated horizons at so remote distances as Missouri, Arkansas, or Texas, with eastern paleontological sections, even when the latter are good, is a common experience among paleontologists.

DISTRIBUTION OF THE SPECIES.

Being in the present case dependent almost wholly on such data as have been published on the floras of the Carboniferous in the eastern states, I have attempted to reach only some general conclusion as to the probable age of the outliers by consulting the recorded distribution of the species. The following list, compiled chiefly from the Coal Flora, gives their geographical and geological range as stated by various authors. I have not attempted to revise the geological assignment of the localities according to more recent geological researches, except in a

[1] The incompleteness of the botanical record, even in the eastern areas, will be roughly indicated in the discussion of the distribution of the species.

few cases, deeming such errors as remain to be relatively unimportant when seeking, as in the present case, only the series to which the terranes belong, rather than their approximate horizon.[1]

CALAMITES RAMOSUS Artis.

XI. *Subconglomerate,* Helena, Ala. [Lesq.], (XII?); Centerville, Tenn. [Lesq.], (XII?); Ark. [Lesq.] (XII? or XIII?).

XII. *Conglomerate Series,* Campbell's Ledge, near Pittston, Pa. [I. C. W.—Lesq.]; Cuyahoga Falls, Ohio [Lesq.—Newby.].

XIII. *Lower Coal Measures,* B. Mazon creek, Morris, Colchester, Murphysboro, Ill. [Lesq.], C. Darlington bed, Cannelton, Pa. [I. C. W.—Lesq.]; D. Duquoin, Ill. [Lesq.], D. or E. Ky. [Lesq.], (?) 500 feet above Millstone Grit, near Gadsden, Ala. [Russell—Lesq.],(?) Osage City,Lawrence,Ottawa,Kans. [Lesq.](XV?), R. I. [Lesq.].

Anthracite Series, D. or E. Brown's coll., near Pittston, Pa. [Lesq.]; E. Butter mine, Pittston, Pa. [Lesq.]; E. or F. Wilkesbarre, Pa. [Lesq.]; F.? Orchard-mine vein [Lesq.]; M. Gate and Salem vein, Pottsville, Pa. [Lesq.].

Middle Coal Measures, Nova Scotia [Daws.].

ANNULARIA STELLATA (Schloth.) H. C. Wood.

X. *Pocono,* Berea, Ohio [Lesley].

XII. *Conglomerate Series,* Campbell's ledge, Pittston, Pa. [I. C. W.—Lesq.].

XIII. *Lower Coal Measures,* B. Murphysboro, Mazon creek, Colchester, Ill, [Lesq.]; Ky. [Lesq.]; C. Darlington bed, Cannelton, Pa. [I. C. W.—Lesq.]; Clinton, Mo. [Lesq.]; D. Duquoin, Ill. [Lesq.].

XIV. *Lower Barren Measures,* 20 feet below Pittsburg coal, Wheeling, W. Va. [F. & W.].

XV. *Upper Coal Measures,* St. Clairsville, Ohio [Lesq.].

XVI. *Permo-Carboniferous,* roof shales of Waynesburg coal, Cassville, W. Va. [I. C. W.—F. & W.].

Anthracite Series, C. Shamokin, Butler dam, Pittston, Pa. [Lesq.]; E. or F. Port Griffith R. R. cut, Pittston, Pa. [Lesq.]; F. Oakwood coll., Pittston, Pa. [Lesq.]; G. Olyphant, Pa. [Lesq.].

ANNULARIA SPHENOPHYLLOIDES (Zenk.) Gutb.

XII. *Conglomerate Series,* Campbell's ledge, Pittston, Pa. [I. C. W.—Lesq.].

XIII. *Lower Coal Measures,* B. Murphysboro, Mazon creek, Morris, Colchester, Ill. [Lesq.]; C. Darlington beds, Cannelton, Pa. [I. C. W.—Lesq.]; Clinton, Mo. [Lesq.]; (?) Jenny Lind, James Fork, Ark. [D. W.—Lesq.]; Centerville, Tenn. [Lesq.]; R. I. [Lesq.]; Ind. [C. A. W.[; Pa. [Lesq.]; Lawrence, Kans. [Lesq.].

XIV. *Lower Barren Measures,* 20 feet below Pittsburg coal, Wheeling, W. Va. [F. & W.].

XV. *Upper Coal Measures,* Pomeroy, O. ["G" of Lesq.].

XVI. *Permo-Carboniferous,* Roof shales of Waynesburg coal, Cassville, W. Va. [I. C. W.—F. & W.].

[1] In the following catalogue of distribution, when the names of two authors, separated by a dash, occur within the brackets, it will be understood that the last named is authority for the identification of the species in that particular locality, while the first named is responsible for the age assigned to the deposit. The Roman numbers are those used by the Geological Survey of Pennsylvania. In each division or group the localities which have been referred to some horizon are given first. The interrogation points in parentheses indicate that the stages or horizons of the following localities are unknown. They do not imply doubt as to the occurrence of the species at a given point. The Roman numbers in parentheses with interrogations are used to suggest a different group, as apparently indicated by published flora. Errors will doubtless be found by geologists in the field, and such corrections or criticisms as they may give will in the end, I trust, be conducive to a better understanding of the Carboniferous flora.

Anthracite Series, A. Shamokin [Lesq.]; E. or F. Port Griffith [Lesq.]; G. Plainsville [Lesq.]; M. Pottsville, Tremont [Lesq.].

Upper and Middle Coals, Nova Scotia [Daws.].

SPHENOPHYLLUM CUNEIFOLIUM (Sternb.) Zeill. (= *S. erosum.*)

XII. *Conglomerate Series*, Cuyahoga Falls, O. [Lesq.]; Talmadge, O. [Lesq.—Newby.]; Centerville, Tenn. [Lesq.] (XIII ?).

XIII. *Lower Coal Measures*, C. Clinton, Mo. [Lesq.].

XV. *Upper Coal Measures*, Pittsburg coal at St. Clairsville, O. [Lesq.].

Middle Coal Formation, Nova Scotia [Daws.].

SPHENOPHYLLUM MAJUS Bronn.

XIII. *Lower Coal Measures*, B. Spring Creek, Ind. [Lesq.]; Mazon Creek, Ill. [Lesq.]; C. Clinton, Mo. [Lesq.]; Darlington bed, Cannelton, Pa. [Lesq.]; (?) James Fork, Ark. [D. W.—Lesq.]; R. I. [Lesq.].

XV. *Upper Coal Measures*, G. Barnesville, O. [Lesq.].

XVI. *Permo-Carboniferous*, Roof shales, Waynesburg coal, Cassville and West Union, W. Va. [F. and W.].

Anthracite Series, E. or F. Port Griffith; Wilkesbarre, Pa. [Lesq.].

Upper and Middle Coal Measures, Nova Scotia [Daws.].

PINNULARIA sp.

Not characteristic of any horizon or group.

DIPLOTHMEMA GENICULATUM (Germ. & Kaulf.) Stur.

Middle Carboniferous and transition to Upper Carboniferous of England, Saxony, and Bohemia.

MARIOPTERIS (PSEUDOPECOPTERIS) MAZONIANA Lesq. sp.

XIII. *Lower Coal Measures*, B. Mazon Creek, Ill. [Lesq.].

MARIOPTERIS (PSEUDOPECOPTERIS) DECIPIENS Lesq. sp.

XI. *Subconglomerate*, Dade Co., Ga. [Lesq.] (XII?); Helena Coal Mines, Ala. [Lesq.] (XII?).

XIII. *Lower Coal Measures*. James Fork, Jenny Lind, Ark. [D. W.—Lesq.]; Van Buren, Ark. [D. W.]. D. or E. Sullivan Co., Ind. [Lesq.].

Anthracite Series, A. Shamokin, [Lesq.]; F. ? Oakwood Colliery, Wilkesbarre, [Lesq.].

Middle Coal Formation, Nova Scotia [Daws.].

SPHENOPTERIS OBTUSILOBA Brongn.

X. *Pocono*, New River, W. Va. [Lesq.].

XI. *Subconglomerate*, West Va. [Lesq.].

XII. *Conglomerate Series*, Cuyahoga Falls, O. [Lesq.]; Campbell's Ledge, Pittston, Pa. [Lesq.].

XIII. *Lower Coal Measures*, B. Colchester, Ill. [Lesq.]; C. Clinton, Mo. [Lesq.]; (?) Jenny Lind, Ark. [D. W.—Lesq.].

Anthracite Series, F. ? Oakwood coll., Wilkesbarre, Pa. [Lesq.].

Middle Coal Formation, Nova Scotia [Daws.].

SPHENOPTERIS MACILENTA L. & H.

XI (?). Black Lick seam, Jefferson Co., Ala., along the Black Creek, near Gadsden, Ala. [Lesq.] (XII?); (?) Ark. [Lesq.] (XIII?).

XII. *Conglomerate Series,* W. Va. [F. & W.].

XIII. *Lower Coal Measures,* C. Clinton, Mo. [Lesq.]; Cannelton, Pa. [Lesq.].

SPHENOPTERIS LACOEI D. White.

XIII. *Lower Coal Measures,* Clinton, Mo. [D. W.]; Cannelton, Pa. [D. W.].

SPHENOPTERIS HILDRETI Lesq.

XIII. *Lower Coal Measures,* Union, Greenup, and Carter Cos., Ky. [Lesq.].

SPHENOPTERIS, species.

This form appears to be related to *S. nummularia.*

PECOPTERIS DENTATA Brongn.

XII. *Conglomerate Series,* Campbell's Ledge, Pittston, Pa. [Lesq.]; Cuyahoga Falls, O. [Lesq.—Newby.].

XIII. *Lower Coal Measures,* B. Morris, Mazon Creek, Colchester, Ill. [Lesq.]; C. Clinton, Mo. [Lesq.]; Darlington, Pa. [I. C. W.—Lesq.]; D. Duquoin, Ill. [Lesq.]; (?) R. I. [Lesq.].

XIV. *Lower Barren Measures,* 20 feet below Pittsburg coal, near Wheeling, W. Va. [F. & W.].

XV. *Upper Coal Measures,* G. Pomeroy, O. [Lesq.].

XVI. *Permo-Carboniferous,* Roof shales of Waynesburg coal at Cassville, W. Va. [F. & W.].

Anthracite Series, D. or E. Brown's coll., Pittston [Lesq.]; G. Olyphant [Lesq.].

Middle Coal Formation, Nova Scotia [Daws.].

(?) PECOPTERIS UNITA Brongn.

The species to which our specimens are most closely related, perhaps being identical, has a record of distribution as follows:

XIII. *Lower Coal Measures,* B. Mazon Creek, Colchester, Grape Creek, Ill. [Lesq.]. Union Co., Ky. [Lesq.]; C. Darlington bed, Cannelton, Pa. [Lesq.]; D. Duquoin, Ill. [Lesq.] E. Buchtel, O. [Lesq.]; (?) R. I. [Lesq.].

Anthracite Series, D. or E. Brown's coll., Pittston [Lesq.]; E. or F. Stanton and Empire mines, Wilkesbarre [Lesq.]; Port Griffith [Lesq.]; F.? Wilkesbarre [Lesq.]; G. Olyphant [Lesq.]; M. Gate and Salem veins, Pottsville [Lesq.].

Middle and Upper Carboniferous, Nova Scotia [Daws.].

PECOPTERIS LESQUEREUXII D. White.

Perhaps identical with forms indentified as *P. aspidioides* from Rhode Island (XIII). It belongs to the group including *P. arborescens, P. cyathea,* etc.

NEUROPTERIS FIMBRIATA Lesq.

XIII. *Lower Coal Measures,* B. Mazon Creek, Murphysboro, Morris, Ill. [Lesq.]; C. Darlington bed, Cannelton, Pa. [Lesq.]; E. Buchtel, O. [Lesq.]; (?) Jenny Lind, Ark. [D. W.—Lesq.].

XV. *Upper Coal Measures,* G. St. Clairsville, Athens, O. [Lesq.]; (?) Marietta, O. [Lesq.].

XVI. *Permo-Carboniferous,* Roof shales of Waynesburg coal, Carmichael's, Pa. [F. &. W.]; W. Va. [I. C. W.—F. & W.].

Anthracite Series, D. or E. Brown's colliery, Pittston [Lesq.]; E. Butler mine, Pittston [Lesq.]; F. ? Oakwood coll., Wilkesbarre [Lesq.]; G. Olyphant [Lesq]; M. Gate vein, New Philadelphia [Lesq.]; Pottsville [Lesley].

NEUROPTERIS SCHEUCHZERI Hoffm.

XIII. *Lower Coal Measures,* B. Morris, Murphysboro, Mazon Creek, Colchester, Ill. [Lesq.]; Spring Creek, Ind. [Lesq.]; Union Co., Ky. [Lesq.]; C. Darlington bed, Cannelton, Pa. [Lesq.]; Clinton, Mo. [Lesq.]; D. or E. Sullivan Co., Ind. [Lesq.]; (?) Shirley Knob, Cass township, Pa. [I. C. W.]; R. I. [Lesq.]; Ottawa, Ill. [Lesq.]; Jenny Lind, James Fork, Ark. [D. W.—Lesq.]; Ottawa, Osage City, Kans. [Lesq.]; Mansfield, Mass. [Marcou].

XIV. *Lower Barren Measures,* 20 feet below Pittsburg coal, near Wheeling, W.Va. [F. & W.]; ? Bellaire, O., 20 feet below Pittsburg coal [F. & W.].

XV. *Upper Coal Measures,* G. St. Clairsville, Pomeroy, O. [Lesq.]; Pittsburg coal, near mouth Redstone Creek, Pa. [Lesley].

XVI. *Permo-Carboniferous,* W. Va. [F. & W.].

Anthracite Series, A. Shamokin; C. Ontario coll., Pittston; D. Carbon Hill tunnel; D. or E. Brown's coll., Pittston; E. Yatesville; F. Wilkesbarre; G. Olyphant, M. Gate Vein, Pottsville, Pa. [all Lesq.].

NEUROPTERIS JENNEYI D. White.

Nearest related to *N. Scheuchzeri,* but with a facies somewhat Odontopteroid, comparable to *O. Wortheni.*

NEUROPTERIS RARINERVIS Bunb.

XIII. *Lower Coal Measures,* B. Murphysboro, Mazon Creek, Morris, Grape Creek, Ill. [Lesq.]; Union Co., Ky. [Lesq.]; C. Cannelton, Pa. [Lesq.]; Clinton, Mo. [Lesq.]; Kittanning coal, W. Va. [F. & W.]; D. Duquoin, Ill. [Lesq.].

XIV. *Lower Barren Measures,* 20 feet below the Pittsburg coal, near Wheeling, W. Va. [F. & W.].

Anthracite Series, E. Yatesville; E. or F. Wilkesbarre; F. Wilkesbarre; G. Olyphant, Pa. [Lesq.].

Middle Carboniferous, Cape Breton [Bunb.]; Nova Scotia [Daws.].

NEUROPTERIS CAUDATA D. White.

Nearest related to *N. Loshii,* as seen in specimens from the Kittanning.

NEUROPTERIS FLEXUOSA Sternb.

X. *Pocono,* Lewis tunnel, W. Va. [Lesq.—Font.].

XI. ? *Subconglomerate,* New river, W. Va. [Font.] (XII?).

XIII. *Lower Coal Measures,* B. Murphysboro, Mazon Creek, Morris, Ill. [Lesq.]; C. Cannelton, Pa. [I. C. W.—Lesq.]; Kittanning coal, W. Va. [F. & W.]; (?) near base of series at Dudley, Pa.; Shirley Knob, Pa. [I. C. W.].

XIV. *Lower Barren Measures,* 20 feet below the Pittsburg coal, near Wheeling, W. Va. [F. & W.].

XVI. *Permo-Carboniferous,* Roof shales of Waynesburg coal, West Union, W. Va. [F. & W.]; Carmichael's, Pa. [F. & W.].

NEUROPTERIS TENUIFOLIA (Schloth.) Sternb.

XI. *Subconglomerate,* W. Va. [Lesq.]; Chester group, Ill. [Lesq.]; Tracy City and Lower Sewanee, Tenn. (Lesq.]; Male's Coal, Ark. [Lesq.] (XII?).

XII. *Conglomerate Series,* Tipton Run, Pa. [I. C. W.].

XIII. *Lower Coal Measures*, B. Murphysboro, Mazon Creek, Morris, Colchester, Ill. [Lesq.]; C. Cannelton, Pa. [Lesq.]; Clinton, Mo. [Lesq.]; D. or E. Ky. [Lesq.] (?) Jenny Lind, James Fork, Ark. [D. W.—Lesq.]; R. I. [Lesq.]; Tuscaloosa, Ala. [Bunb.].

XV. *Upper Coal Measures*, G. St. Clairsville, O. [Lesq.].

Anthracite Series, A. Shamokin; E. or F. Wilkesbarre; G. Olyphant, Pa. [all Lesq.].

NEUROPTERIS cf. TRICHOMANOIDES Brongt.

Quite different from specimens of *N. trichomanoides* Lesq. from Cannelton, though corresponding closely to the figures and descriptions of foreign specimens under that name.

NEUROPTERIS DILATATA (L. &. H.) Lesq.

XIII. *Lower Coal Measures*, Clinton, Mo. [D. W.].

XV. *Upper Coal Measures*, Pomeroy, O. [Lesq.—Lyell].

NEUROPTERIS, species.

Related to *N. trichomanoides*, and possibly representing cyclopterid pinnules of *N. flexuosa* or *N. tenuifolia*.

DICTYOPTERIS SQUARROSA Ett. sp.

Middle Carboniferous of Europe.

APHLEBIA ARBORESCENS Lesq. sp.

XIII. *Lower Coal Measures*, B. Morris, Ill. [Lesq.]; (?) Mo. [Hambach].

SIGILLARIA, species.

Apparently identical with specimens from Murphysboro, Ill., and Preston coll., Schuylkill Co., Pa.

CORDAITES COMMUNIS Lesq.

XI. *Waverly Sandstone*, Rushville, O. [Lesq.].

XIII. *Lower Coal Measures*, Darlington beds, Pa. [Lesq.]; C. Clinton, Mo. [Lesq.].

CORDAITES cf. COSTATUS Lesq.

C. costatus has as yet been identified, I believe, only from the Kittanning (Lower Coal Measures) at Cannelton.

CORDAIANTHUS, species.

Of no correlative value.

CORDAICARPUS LINEATUS Lesq.

XI. *Subconglomerate*, Ark. [Lesq.]. (XII ? or XIII?).

XIII. *Lower Coal Measures*, C. Cannelton, Pa. [Lesq.].

Summary of distribution of species in the United States.

Species.	Pocono. X.	Subconglomerate. XI. ?=XII	Conglomerate series. XII.	Lower Coal Measures. ?=horizon unknown.	Barren. XIV.	Upper Coal Measures. XV.	Permocarboniferous. XVI.	Anthracite of Pennsylvania.				British provinces.		
								A, B, C.	D, E, F.	G.	M.	Lower Coal Measures.	Middle Coal Measures.	Upper Coal Measures.
Calamites ramosus		Tenn.?, Ala.,? Ark.?	Pa., O...	(B) Ill., (C) Pa., (D or E) Ky., (?) Ala., Kans., R. I., Ark.					D or E, E or F, F. ?		M...		×	
Annularia stellata	O		Pa	(B) Ill., Ky., (C) Pa., (D) Ill., Ark.	W. Va	O	W. Va	C	D or E, E or F, F.	G				
Annularia sphenophylloides			Pa	(B) Ill., (C) Pa., Mo., (?) O., Ark., Tenn., R. I., Ind., Kans.	W. Va	O	W. Va	A	E or F	G	M...		×	×
Sphenophyllum cuneifolium			O., Tenn.	(C) Mo		O							×	
Sphenophyllum majus				(B) Ind., Ill., (C) Pa., Mo., (?) Ark.		O	W. Va		E or F				×	×
Mariopteris mazoniana				(B) Ill										
Mariopteris decipiens		Ga?Ala?Ark?		(D or E), Ind., (?) Ark.				A	F?				×	
Sphenopteris obtusiloba	W. Va	W. Va	Pa., O?..	(B) Ill., (C) Mo., (?) Ark.					F?				×	
Sphenopteris macilenta		Ala., ? Ark.?.	W. Va	(C) Mo., Pa., (?) Ala...										
Sphenopteris Lacoei				(C) Pa., Mo										
Sphenopteris Hildreti				Ky										
Pecopteris dentata			Pa., O...	(B) Ill., (C) Pa., Mo., (D) Ill., (?) R. I., Ark.	W. Va	O	W. Va		D or E	G			×	
(?) Pecopteris unita				(B) Ill., Ky., (C) Pa., (D) Ill., (E) O., (?) R. I.					D or E, E or F, F. ?	G	M...		×	×
Neuropteris fimbriata				(B) Ill., (C) Pa., (E) O., (?) Ark.		O	Pa., W. Va		D or E, E, F. ?	G	M...			
Neuropteris Scheuchzeri				(B) Ill., Ind., Ky., (C) Pa., Mo., (D. E.?) Ind., (?) Pa., R. I., Ill., Ark., Kans.	O., W. Va	O., Pa..	W. Va...	A, C ..	D, D or E, E, F.	G	M...			
Neuropteris rarinervis				(B) Ill., Ky., (C) Pa., W. Va., Mo., (D) Ill.	W. Va				E, E or F, F.	G			×	
Neuropteris flexuosa	W. Va. (?)	W. Va. ?	W. Va	(B) Ill., (C) Pa., (?) Pa	W. Va		Pa., Va							
Neuropteris tenuifolia		Ill., Tenn., ? Ark., ? W. Va. ?	Pa	(B) Ill., (C) Pa., Mo., (D) Ky., (?) R. I., Ala., Ark.		O		A	E or F	G				
Neuropteris dilatata				(C) Mo		O								
Aphlebia arborescens				(B) Ill., (?) Mo										
Cordaites communis		O		(C) Pa., Mo										
Cordaicarpus lineatus		Ark. ?		(C) Pa										

AGE OF THE OUTLIERS AS DETERMINED BY THE DISTRIBUTION AND FACIES OF THE FLORA.

A brief inspection of the tabulated summary of the twenty-two species recorded from other regions shows the occurrence in the Lower Coal-measures of all the old species of our flora, though only four, less than one-fifth, are confined thereto. Three are said to occur in the Pocono or Waverly and eight, or a little more than one-third, in the Subconglomerate. Only nine, including five of the above, are recorded in the Conglomerate series, or Interconglomerate, though there is probably confusion between XI and XII, some geologists believing several of the plant beds referred to in the Coal Flora under XI to belong in reality to XII. However this may be, it is clear that, so far as known, less than one-half of our species occur below the Lower Productive Measures. Six only are reported from the Lower Barren Measures, a singularity doubtless due to ignorance of the flora of that series, as will be explained later. But nine species have been described from the Upper Coal-measures or Monongahela river series, and seven species, all but one the same as in the preceding column, are also reported from the Permo-Carboniferous, above the Waynesburg coal. However, six of the plants which appear in the Upper or Permo-Carboniferous, having survived the deposition of the Barren Measures, are also included among those occurring below the Lower Productive Measures (XIII). These species, of great vertical distribution, can therefore be of little assistance in correlation. The remaining six species which have been found below the Lower Coal-measures have all a distribution also within XIII. This ancient element is, however, fully counterbalanced by that occurring in XV and XVI, of which four species have not been found below XIII, while eight, perhaps more, do not go below the Conglomerate series (XII), and this without taking into consideration the time interval and the almost unknown flora represented by the Barren Measures (XIV). Judging, therefore, by the recorded distribution in the bituminous regions, the identity of our flora is evidently with that of the Lower Coal-measures (XIII).

Passing now to the anthracite region, we find five represented in the lower coals, eight in coal G of the Olyphant section, and five in the Gate and Salem veins of the upper anthracite. The largest representation, twelve species, is, however, in coals D, E, and F of this series, and taking this into account, together with the affinity of the flora of the Olyphant horizon (G), the age of our flora, judged by the recorded anthracite distribution, would be apparently synchronous with E or F of the anthracite series, a horizon higher than that indicated strictly by the recorded distribution in the bituminous series.

Returning again to the distribution in the Lower Coal-measures of the bituminous fields, it is of some interest to see in what horizon the greater number of species appear to be represented, though the con-

clusions that may be drawn from such a comparison are of little actual value. We find fourteen species in the coal B at Mazon creek, Morris, etc., in Illinois, eighteen in the Middle Kittanning (C) at Cannelton, Pennsylvania, or its supposed chronologic equivalent at Clinton, according to Lesquereux, while nine come from coal D or E in Illinois and Kentucky. The percentage of identity with the Cannelton-Clinton flora is very striking, comprising eighteen out of twenty-two old species, and furnishes a strong argument for considering our flora as of nearly the same age, i. e., about the middle of the Lower Coal-measures.

But the materials for the distribution of our coal flora are as yet too scanty to warrant great faith in mere percentages and numerical identities. Until the floras of all the stages of all the Coal-measures shall have been worked out systematically from a greater range of localities proofs by numerical comparisons will always be liable to mislead. Other things being equal, a flora from a horizon but little known paleobotanically will, in correlating on the numerical basis, be attracted towards the nearest allied flora that is relatively well known, though the horizon may be quite different. Fragmental floras derived more or less remotely from the same horizon may seem to have more in common with the developed flora of an entirely different stage than with each other. It may even happen that none of the small collections contain or represent the floral associations really more characteristic of that horizon. As yet the flora of no horizon or series in the bituminous coal fields, except, perhaps, the Permo-carboniferous, has been systematically studied and published. Only a few horizons have been specially worked, and these have been examined only in single localities or restricted vicinities. The collections of Mr. Lacoe from Campbell's ledge (XII) in the anthracite area, of Mr. I. F. Mansfield from the Darlington bed, just above the Middle Kittanning, at Cannelton, Pennsylvania, the collection from the Mazon creek horizon (B) at that place and at Colchester, Murphysboro, and Morris, Illinois, and the collections made by Dr. Britts from the Lower Coal Measures in the neighborhood of Clinton, Missouri, developing these respective floras in isolated regions, are loadstones toward which the new floras of unexplored horizons or of remote regions, when developed in a different environment, are inevitably attracted, for want of a relatively equal elaboration of a more closely allied flora, coming either from the same horizon or one stratigraphically nearer. No paleozoologist of good standing will insist that collections made from one or two strata in a single locality, or even a narrow area, represent the fauna existing under various conditions throughout a complex group of great geographical extent. Owing to the greater bulk of the specimens and the greater labor of collecting them, it is seldom that a collection of fossil plants includes more than a portion of the flora of the locality where they are obtained.

Without stopping to discuss the meager materials, representing local floras, from various regions in the Conglomerate (XII) and subjacent

series, the stratigraphical relations of whose habitats are not yet understood or agreed upon, a brief review of the work done on the paleobotanically more important portion of the series is sufficient to indicate in the most general way the fragmentary condition of our knowledge of the floras of the various stages and regions of the American Coal-measures. In Pennsylvania, whose Carboniferous paleobotany is best known, the only flora that has been published from any horizon in the whole bituminous measures above the Conglomerate series is that of the shales just below the Middle Kittanning, and this is known only from collections made at Cannelton, though the horizon is said to be nearly always well filled with good plant remains. A few plants from the Permo-Carboniferous (XVI) of this state are described in Fontaine and I. C. White's Permian Flora. In West Virginia only a few species from the Kittaning and Upper Freeport (XIII), mostly without localities, mentioned in the above work, are known between the Conglomerate series (XII) and a horizon twenty feet below the Pittsburg coal. The list of plants, about thirty in number, from the latter stage at a single locality, Wheeling, constitutes essentially all that is published of the entire flora of the Barren Measures (XIV) throughout their extent. A few unimportant fragmentary lists from the Lower Coal-measures and the Upper Coal-measures represent all the species known from any stage between the Subcarboniferous and the Permo-Carboniferous of that state. Nothing is known of the plants above XIII in Indiana or Kentucky, although higher horizons are present here as well as in Tennessee, whose Paleozoic flora above the Conglomerate series is supposed to be wholly unknown. Nothing better can be said of Georgia or Alabama, except to mention a few plants which are definitely stated to belong to a horizon above the Millstone Grit, in the latter state, near Gadsden. The exploited flora of Illinois is practically limited to that of the Lower Coal-measures (XIII), only about twenty species having been described among four localities of uncertain position in the Upper Coal-measures. Passing westward and southward, we find that essentially nothing is known of the floras of the entire thickness of the Carboniferous in Iowa, Missouri, Arkansas, Indian Territory, and Texas, with the exception of a flora, mostly without definite localities, recorded as Subconglomerate in Arkansas, and the plants collected in the vicinity of Clinton, in the Lower Coal-measures of Missouri.

It thus becomes quite probable that correlations made now on a basis of percentages may require serious revision when the floras of the respective stages, many of which are yet wholly unexplored, shall have been made known, by means of collections gathered from many and more widely distributed stations. We shall probably continue to find in the flora of any new region or horizon corresponding to a stage in XIII or XIV the highest percentage of species identical or allied with

the flora listed from Cannelton in Pennsylvania or that from the Morris horizon of Illinois, until the floras of the Freeport horizons, the Barren Measures (XIV), and the stages of the Upper Coal-measures (XV) are at least as well known, relatively, as those represented at Cannelton or Morris. Even the more ancient or more recent types can not have their proper weight until the presence or absence of those types in the intermediate or adjacent stages is more satisfactorily indicated by searching at various localities in those stages and studying the plants.

The occurrence of more ancient or modern types in a local flora is as liable, when used as coordinative evidence within too narrow limits, to lead to error as is correlation by percentages, and from the same remote cause. The best relative results should be obtained by employing both methods.

While on the basis of numerical affinities our flora is largely identical with that from Clinton, it appears when considered as to its facies to present a rather more recent aspect. Although the round-pinnuled sphenopterids are present the lycopods are almost wholly absent. This may be due to the upland character of the flora, a condition that may otherwise disturb any arguments based on the aspect, or facies, of the flora. The number of neuropterids, comprising over one third of the flora, is very remarkable and may perhaps be due to the above circumstance. But the occurrence among them of several thick-nerved species would seem to indicate a younger flora. No forms peculiar to the Lower Carboniferous are present, while the affinities of the new *Pecopteris* and *Sphenopteris* species are also among more recent forms. Finally, as a negative argument, may be mentioned the considerable number of forms which are either new species or which differ somewhat from anything described from the Lower Coal-measures, or found among the great quantities of material from the coals near Clinton, Henry County, now in my hands. It is not improbable that an exploration of the measures above the horizons at Clinton, all as yet wholly unknown, may reveal there new forms among the interesting but unstudied Middle and Upper Carboniferous floras of the trans-Mississippi regions.

CONCLUSIONS.

The flora of the outliers in southern Missouri, so far as exhibited in these collections, is, as is indicated above, comprised chiefly of ferns, a number of which are new, while others have not been identified in this continent before. It is characterized by a preponderance of neuropterids, the presence of several thick-pinnuled spenopterids, the scarcity of calamarian remains (unless we include *Spenophyllum*), and the almost entire absence of the *Lycopodineæ* the only vestiges of the latter being the leaves of a single species.

From this examination of the identities and affinities of its species and their distribution, as well as from the facies and elements of the

flora, the conclusion is reached that the plant-bearing terranes in question belong to the Lower Coal-measures, while the horizon indicated, though not proved by the flora as a whole, appears to be rather younger than that which has furnished the Clinton plants. If such be the case the lead and zinc ores of the region must have been deposited at some period subsequent to the formation of a stage probably about the middle of or in the upper half of the Lower Coal-measures.

PLATES.

PLATE I.

PLATE I.

DIPLOTHMEMA GENICULATUM (Germ. & Kaulf.) Stur. (pp. 44–46).

Fig. 1. Fragment of compound pinna, natural size.
1*a*. Pinnule, enlarged two diameters.
2. Segment from lower in the frond, better indicating the subpalmate division of the pinnules, natural size.
2*a* Typical pinnule, enlarged two diameters.

SPHENOPTERIS, species (pp. 59, 60).

Fig. 3. Small pinnæ, showing acorn-shaped pinnules.

SPHENOPTERIS (PSEUDOPECOPTERIS) MACILENTA L. & H. (pp. 55, 56).

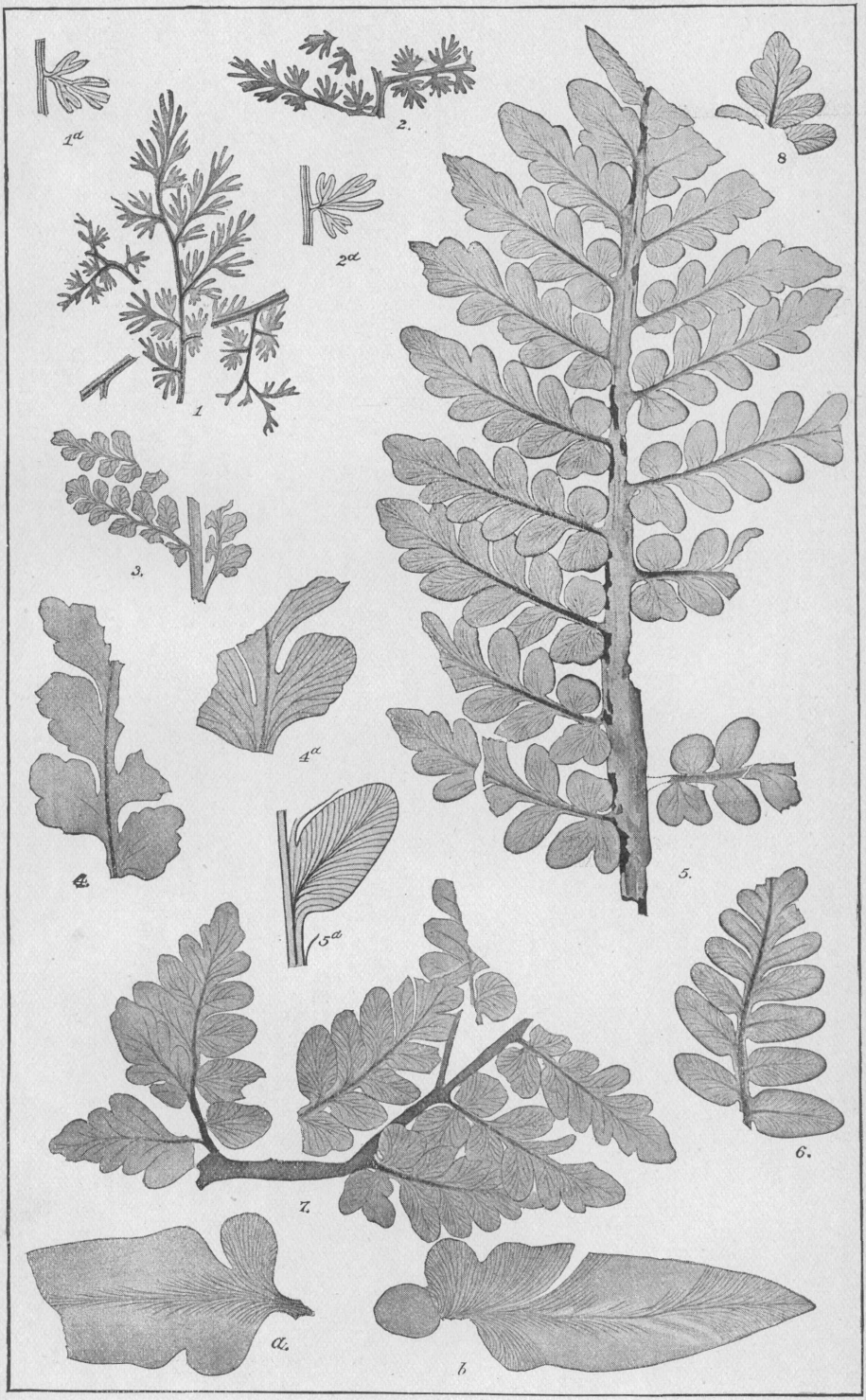
Fig. 4. Fragment of pinna, natural size.
4*a*. Similar fragment with detail of nervation, slightly enlarged.

MARIOPTERIS (PSEUDOPECOPTERIS) DECIPIENS Lx. sp. (pp. 47–52).

Fig. 5. Portion of secondary (?) pinna, natural size.
5*a*. Detail of ordinary pinnule, enlarged two diameters.
6. Pinna, with marginal wing, natural size.
7. Fragment of compound pinna, probably adjacent to a dichotomy, natural size.
8. Apex of secondary pinna, natural size.

NEUROPTERIS JENNEYI n. sp. (pp. 82–84).

Fig. 7*a b*. Fragments of two pinnules, on same rock with *Mariopteris decipiens*, Fig. 7, natural size.



DIPLOTHMEMA, MARIOPTERIS, SPHENOPTERIS, NEUROPTERIS.

PLATE II.

PLATE II.

MARIOPTERIS (PSEUDOPECOPTERIS) DECIPIENS LX. sp. (pp. 47–52).

Fig. 1. Small pinnæ, natural size.
2. Fragment from compound pinna, with nervation, natural size.
3. Segment of compound pinna, natural size.
3*a*. Pinnules, enlarged two diameters.

PECOPTERIS (ASTEROTHECA) LESQUEREUXII n. sp. (pp. 65–67).

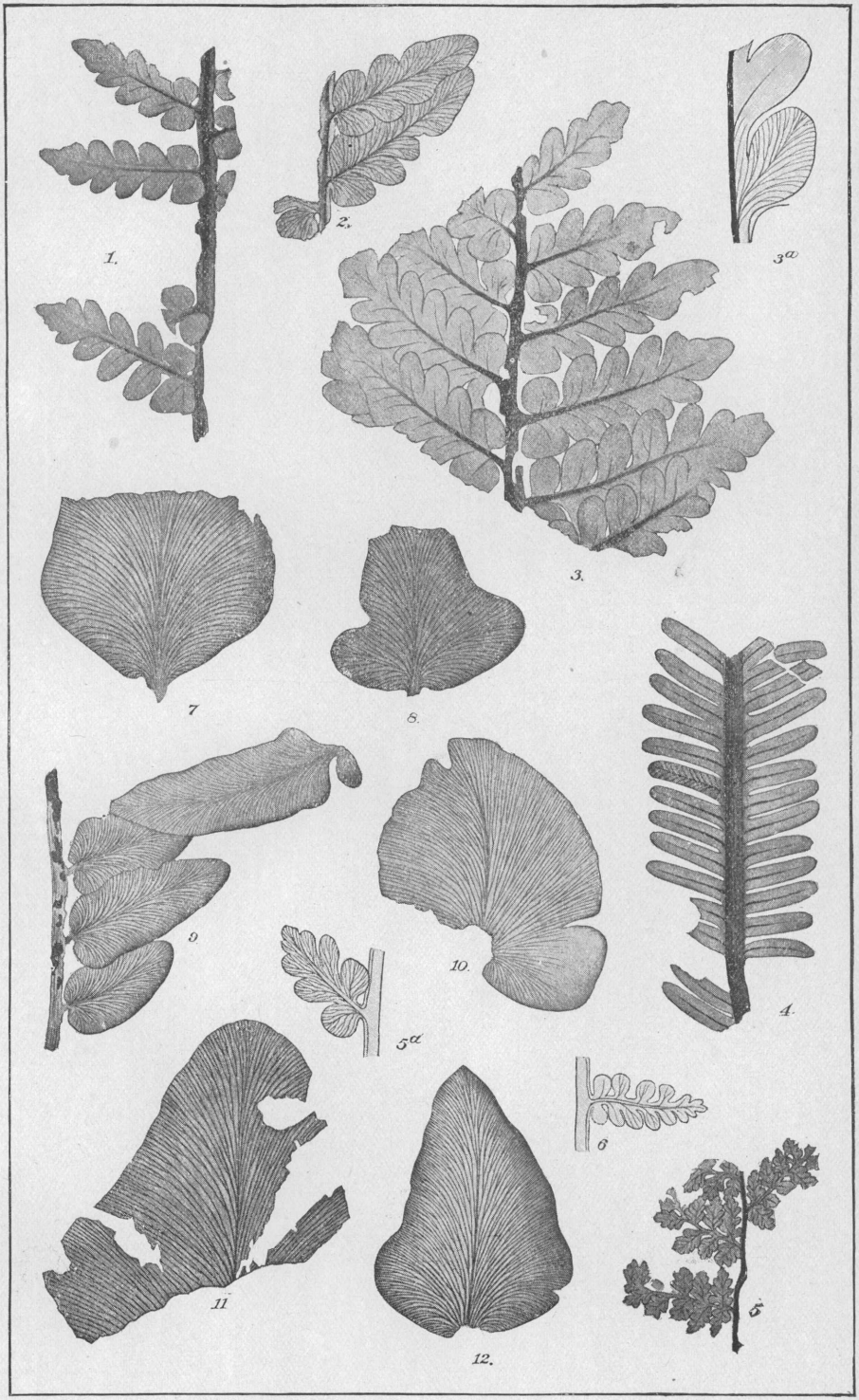
Fig. 4. Portion of pinna, natural size.

SPHENOPTERIS LACOEI n. sp. (pp. 56–58).

Fig. 5. Fragment of compound pinna, natural size.
5*a*. Pinnule, enlarged two diameters.
6. Another pinnule, enlarged two diameters.

NEUROPTERIS JENNEYI n. sp. (pp. 82–84).

Fig. 7. Pinnule from low in the frond, natural size.
8. Small rachial pinnule, natural size.
9. Pinnules on penultimate rachis between the ultimate pinnæ, natural size.
10. Cyclopterid pinnule, natural size.
11. Large rachial pinnule, natural size.
12. Rachial pinnule, natural size.



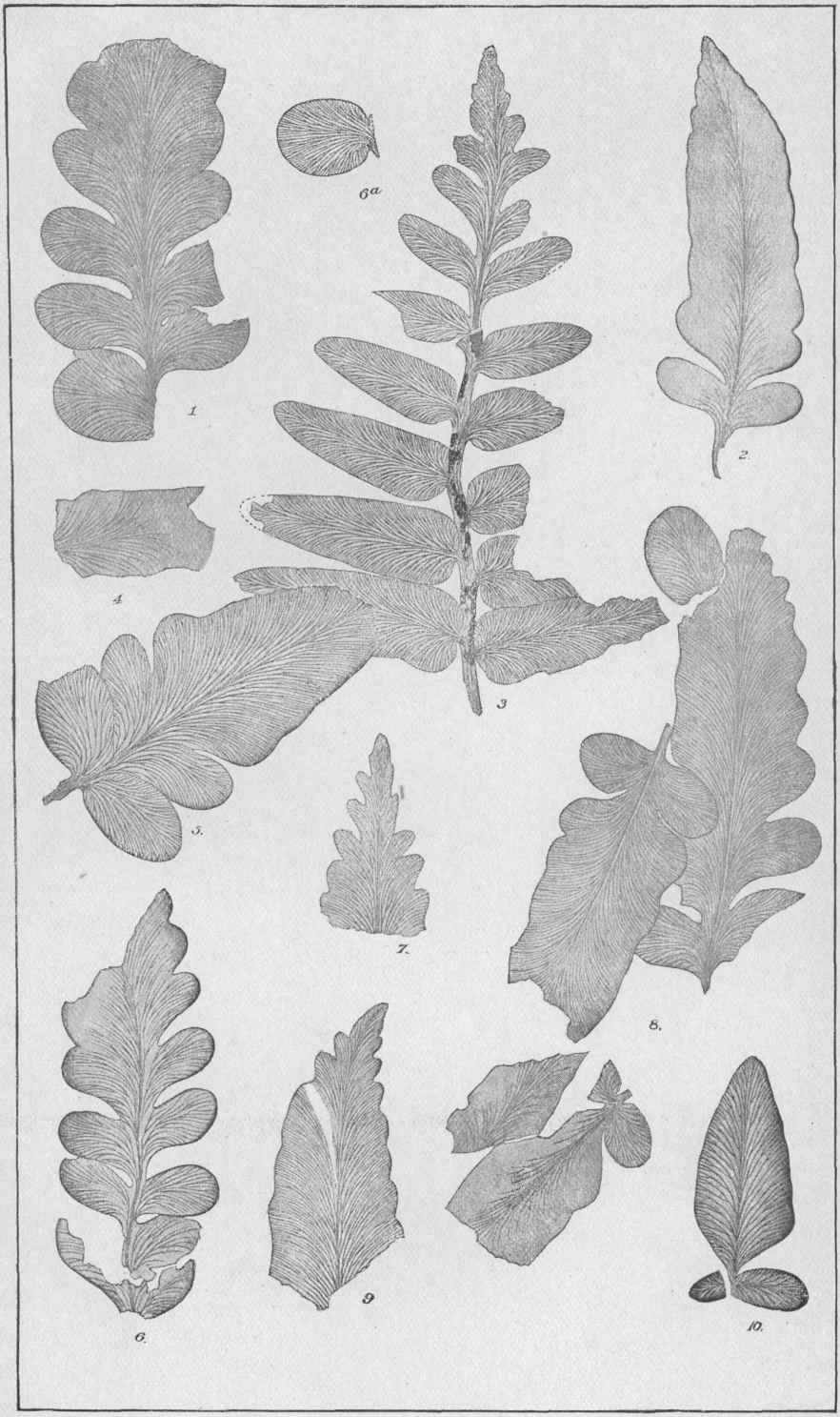
MARIOPTERIS, SPHENOPTERIS, PECOPTERIS, NEUROPTERIS.

PLATE III.

PLATE III.

NEUROPTERIS JENNEYI n. sp. (pp. 82–84).

Fig. 1. Portion of lobed pinnule, or ultimate pinna.
2. Upper part of a similar pinnule.
3. Top of secondary pinna.
4. Fragment on rock with Figs. 3 and 5.
5. Broad pinnule, showing the development of the basal lobes or pinnules.
6. Fragment from lower part of pinnule.
6*a*. Pinnule slightly enlarged.
7. Dentate-crenulate tip of pinnule.
8. Pinnules from which the basal lobes or pinnules have fallen.
9. Top of average pinnule.
10. Small rachial (?) trilobate pinnule.
All natural size.



NEUROPTERIS.

PLATE IV.

PLATE IV.

NEUROPTERIS CAUDATA, n. sp. (pp. 87–91).

Fig. 1. Pinna.
2. Typical pinnule.
3. Small pinna.
4. Base of pinnule.
5. Fragment from upper pinna.
6. Base of pinna, with elongated inferior pinnule.
7. Broad pinnules.
8. Basal portion of pinna.
9. Portion of middle secondary pinna.

NEUROPTERIS cf. TRICHOMANOIDES (Brongn.) Lx. (pp. 95, 96).

Fig. 10. Fragmentary pinnule.
All natural size.

NEUROPTERIS.

PLATE V.

PLATE V.

NEUROPTERIS FLEXUOSA Sternb. (pp. 91–93).

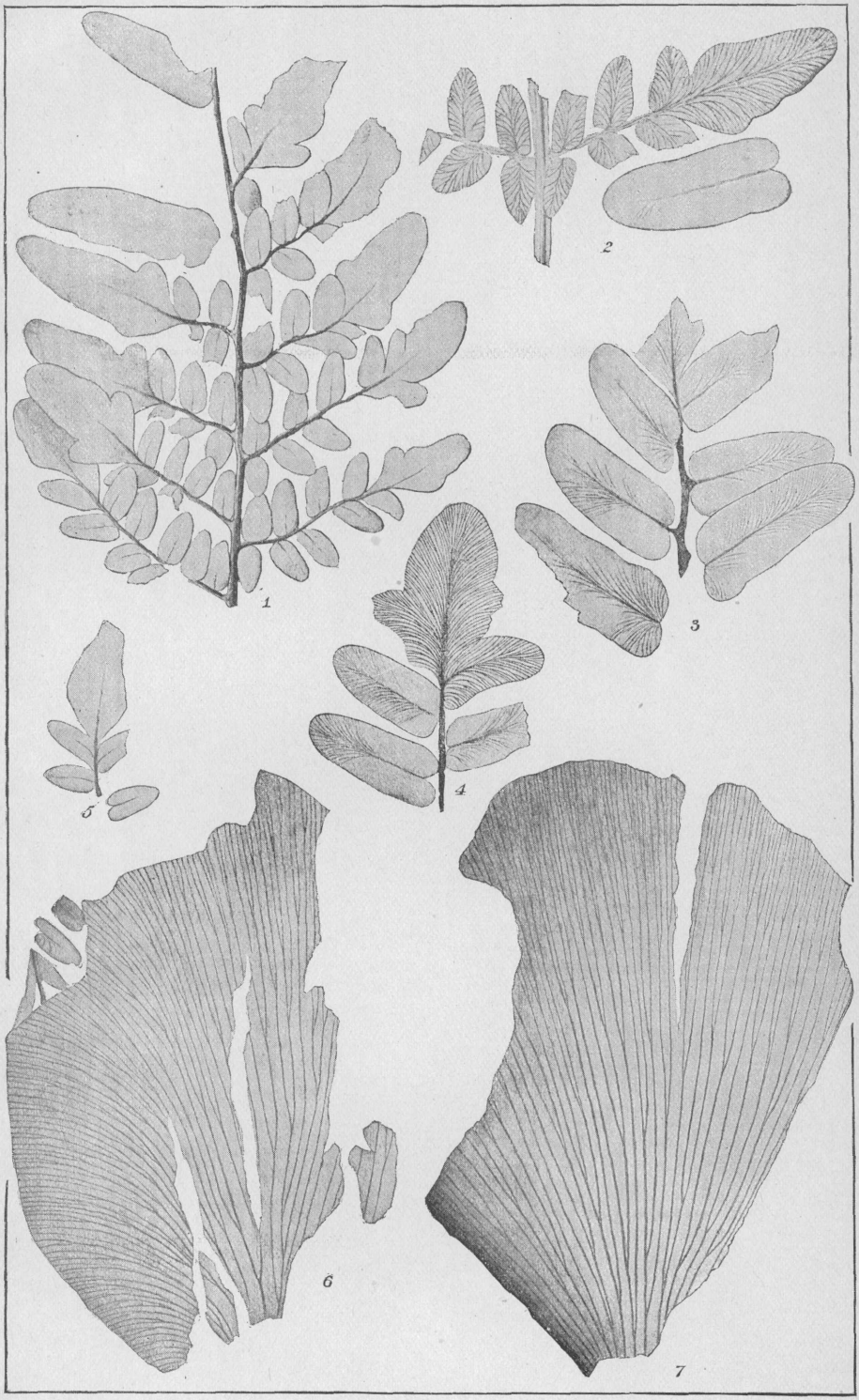
Fig. 1. Upper part of secondary pinna.
2. Short pinna, resembling N. missouriensis.
3. Tip of pinna.
4. Similar tip.
5. Tip of small pinna.

NEUROPTERIS, species (pp. 98, 99).

Fig. 6. Cyclopterid pinnule, possibly belonging to the preceding species, associated with pinnules of the latter. It may represent the following species.

NEUROPTERIS RARINERVIS, Bunb. (pp. 85–87).

Fig. 7. Cyclopterid pinnule, apparently belonging to this species.
All natural size.



NEUROPTERIS.

INDEX.

[Pages on which descriptions of species occur are printed in black-faced type.]