# FOSSIL PLANTS FROM THE UPPER PALAEOZOIC ROCKS OF NEW SOUTH WALES.

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(Plates xxi-xxiii; one Text-figure.)

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This paper contains descriptions of a number of fossils which had been submitted to Professor A. C. Seward at Cambridge by Professor Sir T. W. Edgeworth David. During 1927, while holding an International Education Board Fellowship in Science I spent about nine months working at Cambridge under Professor Seward, and he suggested the examination and description of these specimens as part of my work. During the progress of the work he maintained a close interest in it and helped very materially by suggestions and notes on many points that arose. I desire to acknowledge freely my indebtedness to Professor Seward, not only for his assistance in this particular piece of work, but also for his kindly interest in all that I was able to do whilst working with him and for the inspiration afforded by the privilege of close association with him and his work. To the International Education Board of New York and the Council of the Linnean Society of New South Wales I am deeply indebted for the opportunity to work at Cambridge and other places abroad.

The species described are *Lepidodendron Osbornei*, n. sp., *Ulodendron minus* L. and H., and *Pitys* (?) *Sussmilchi*, n. sp., from the Volcanic Stage of the Kuttung Series; *Stigmaria ficoides* Brongn., from both Volcanic and Basal Stages of the Kuttung Series; *Dadoxylon farleyense*, n. sp., from the Ravensfield Sandstone at the base of the Farley Stage of the Lower Marine Series; and *Dadoxylon Arberi* Seward from the Newcastle Coal Measures at Lake Macquarie.

The relative positions of the horizons from which the fossils were obtained are shown on the following vertical sections of the Carboniferous and Permo-Carboniferous succession in New South Wales, compiled from information kindly supplied by Professor Sir Edgeworth David, and Mr. G. D. Osborne, B.Sc., of the Geology Department of the University of Sydney, who has done much detailed field work on the Carboniferous rocks of the district.

| | | Feet. |
|---|---|---|
| Newcastle Series | Upper Stage | 600 |
| | Lower Stage | 800 - 1,000 |
| Tomago Series | | 500 - 1,800 |
| Upper Marine Series | Chaenomya Beds | 100 - 150 |
| | Crinoidal Shales | 1,500 - 3,000 |
| | Muree Beds | 400 |
| | Branxton Beds | 2,000 - 3,000 |
| Greta Series | | 300 |
| Lower Marine Series | Farley Stage | 1,000 |
| | Rutherford Shales | 1,070 |
| | Lochinvar Stage | 2,635 |

| | | Feet. |
|---|---|---|
| Kuttung Series .. .. .. | Glacial Stage .. .. .. .. .. .. .. | 4,200 |
| | Volcanic Stage .. .. .. .. .. .. | 3,000 |
| | Basal Stage .. .. .. .. .. .. .. | 2,300 |

Burindi Series.

The above section shows the complete succession from the base of the Carboniferous to the top of the Permian. Where to place the junction between the two systems is a much-debated question amongst Australian geologists. Formerly the dividing line was placed between the Kuttung Series and the Lower Marine Series, but in view of the fact that the flora of the Kuttung Series is typically Lower Carboniferous, as judged by the standard of European fossil floras, it is possible that the Lower Marine Series represents the Upper Carboniferous in Australia.

Further detail of the succession in the Kuttung Series (kindly supplied by Mr. Osborne) is as follows:

| | |
|---|---|
| Glacial Stage, 4,200 feet .. | Upper part: main glacial beds, 1,900 feet. |
| | Paterson toscanite, 300 feet. |
| | Lower part: sandstone, tuffs, etc., about 2,000 feet. |
| Volcanic Stage, 3,000 feet .. | Chiefly lavas, tuffs and conglomerates. |
| | Martin's Creek hornblende-andesite at base. |
| Basal Stage, 2,300 feet .. | Upper part: tuffs and sandstones. |
| | Lower part: essentially conglomerates. |

The horizons in the Kuttung Series from which fossil plants have been obtained are:

(1) About 50 feet below the top of the Basal Stage, where *Lepidodendron* and *Stigmaria* occur.

(2) At the top of the Basal Stage, just underlying the Martin's Creek andesite, where silicified specimens, probably of (?) *Pitys*, have been obtained.

(3) In the Volcanic Stage about 800 feet above the Martin's Creek andesite is the Welshman's Creek Horizon from which abundant plant fossils have been obtained.

(4) *Rhacopteris* occurs on a horizon about 100 feet above the Welshman's Creek horizon.

(5) In the Glacial Stage, about 1,700 feet above the Volcanic Stage, *Lepidodendron* and *Rhacopteris* have both been recorded.

The Ravensfield Sandstone is a band some 20 to 30 feet thick forming the base of the Farley Stage; the beds at Lake Macquarie from which the specimen of *Dadoxylon Arberi* was obtained are about 140 feet below the top of the Upper Stage of the Newcastle Coal Measures.

Although the number of species described from the Welshman's Creek horizon is small, they indicate without doubt that the age of the beds is Lower Carboniferous. The species from the Ravensfield Sandstone shows close resemblance to species from rocks of "Permo-Carboniferous" age in other parts of the world.

### (*a*) *Plants from the Kuttung Series.*

LEPIDODENDRON OSBORNEI, n. sp. Plate xxi, figs. 1, 2.

A specimen from the Volcanic Stage of the Kuttung Series at Welshman's Creek has on one side an example of *Ulodendron* (described below) and on the other a flat impression, about 15 cm. × 3·5 cm., of a Lepidodendroid stem. The general surface of this Lepidodendroid impression is marked by numerous more or less parallel vertical wrinklings, and the most striking feature is the presence of very elongated spirally-disposed, kite-shaped leaf cushions (Pl. xxi, fig. 2). Both above and below, the elongate leaf cushions are continued in the form of a narrow groove; they are 3·5-4 cm. long, and only 4 mm. wide at the widest part, which is somewhat above the middle, 1·2-1·5 cm. from the apex. Situated just above the widest part is a rather small, rounded leaf scar which does not occupy the whole width of the cushion; the leaf scar is about 2 mm. in diameter and in some cases there is a suggestion of a small central scar, and also perhaps of a ligular scar just above the leaf scar.

The leaf cushions are well separated from one another and the general appearance of the impression is very characteristic. It is quite unlike any species previously recorded from Australia, but bears a more or less striking resemblance to species which have been figured from Carboniferous rocks in the Northern Hemisphere. The resemblance is very close indeed to *Lepidodendron spetsbergense* Nathorst from the Lower Carboniferous rocks of Spitzbergen (Nathorst, 1894, p. 37, Pl. 7; 1914, p. 37, Pl. 2, 3, 4, 13, 14). *L. spetsbergense* has similar elongated, kite-shaped leaf cushions which, however, are wider in comparison with their length than in *L. Osbornei*; the leaf scar of *L. spetsbergense*, as in *L. Osbornei*, does not occupy the whole width of the cushion, but in the latter it appears to be situated higher up than in the former. Other species showing considerable degree of resemblance are *L. rimosum* and *L. Glincanum*.

The decorticated stem of *L. rimosum* Sternberg, figured by Zeiller (1886, Pl. lxvii, fig. 4) from the coal basin of Valenciennes, has elongate cushions which resemble those of *L. Osbornei*, but are wider in comparison with their length, and are also much closer together. Zeiller's fig. 5, however, which he also calls *L. rimosum*, shows little resemblance to our specimen and indeed does not appear to be referable to the same species as his fig. 4. White (1899, p. 196) described specimens as *L. rimosum* var. *reticostatum*, one of which (Pl. liv, fig. 3) he described as representing "the impression of the cortex of a stem that seems to be in a Ulodendroid condition". I can see no evidence of this in his figure. The cushions in White's figures 3 and 4 are similar to those of my specimen, and in fig. 4 the vertical wrinkling of the surface between the cushions heightens the resemblance. The leaf scar as seen in the figures of var. *reticostatum* varies in position in that variety, being sometimes at the point where the cushion is widest and sometimes well above this; it does not occupy the whole width of the cushion, a feature in which it also agrees with my specimen. The specimens described by White were obtained from the Lower Coal Measures of Missouri.

Zalessky (1904, p. 88, Pl. 2 and 3) figures several specimens of *L. rimosum* from the Carboniferous basin of Donetz which are undoubtedly of the same general type as *L. Osbornei*. He discusses the differences in the diagnosis of the species by different authors and figures the species under four varietal names; of his examples, those figured as var. α and var. *alternans* (Pl. 2, figs. 7 and 8) are similar to *L. Osbornei*, except that, as in other examples of *L. rimosum*, the cushions are comparatively broader and are closer together. The examples of *L. rimosum* figured by Rydzewski from the Polish coal basin are similar to those figured by Zalessky from Donetz, and Rydzewski considers the varieties as representing different states of preservation. In general, his figures do not show cushions so elongated in their lower half as those of *L. Osbornei*; the scar in the Polish examples is above the widest part of the cushion as in our specimen.

Of the variety of specimens figured by Kidston (1903, Pl. 2-5) from Canonbie as *L. Glincanum* only one (Pl. 5, fig. 41) resembles *L. Osbornei* in the leaf cushions, which are fusiform with long slightly bent extremities and separated by irregularly longitudinally striated cortex. Another species from the Kulm flora of Spitzbergen described by Nathorst as *L. Kidstonii* (1920, Pl. 3, figs. 1-7) shows a close resemblance to our specimen in the narrow fusiform leaf cushions with the scar above the widest part.

It is clear that this specimen from New South Wales is very closely allied to species widely distributed in the Northern Hemisphere in rocks of Carboniferous age, e.g., *L. spetsbergense*, which occurs in Lower Carboniferous rocks in Spitzbergen, *L. rimosum* from Carboniferous rocks in Poland, the Donetz basin, Valenciennes and in the Missouri Coal Measures, and *L. Glincanum* from the Lower Coal Measures of Canonbie. Of these species the resemblance is closest to *L. spetsbergense*—a Lower Carboniferous species.

ULODENDRON MINUS Lindley and Hutton. Plate xxi, fig. 3.

On one surface of an irregularly-oblong specimen, about 22 cm. × 7 cm. × 4 cm. thick, there are two circular areas about 4 cm. in diameter and separated from one another by 2-3 mm. The circular areas have a narrow, flat or slightly concave border, about 4 mm. wide, and in the centre an approximately circular depression about 1 cm. in diameter. Between this central depression and the narrow border the surface is slightly convex, and is smooth in the upper half and covered with rows of small projecting knobs in the lower half.

The specimen is very similar to that of a Ulodendroid scar of *Lepidodendron Veltheimianum* figured by Kidston (1885, Pl. 3), though not so large. In Kidston's figure the scar is more elongate (4½ inches by 2½ inches), while in our specimen it is circular (4 cm. diam.), but the two agree in having the smooth narrow border, a central depression, and the intermediate area smooth in one half and tuberculate in the other half. The specimen figured by Kidston came from the Carboniferous Limestone Series of Midlothian. It is also very similar to the specimen figured by Zeiller (1886, Pl. lxxiii, fig. 2) as *Ulodendron minus* from the Eschweiler Mines, in its general appearance as well as in the size and the close proximity of the two scars to one another. Zeiller's figure shows again the smooth narrow border, central depression, and intermediate raised area, tuberculate in one half and smooth in the other. Similar Ulodendron stems are figured from the Culm supérieur of France by E. Bureau (1913) as *U. majus* (Plates xlvi-xlvii) and *U. minus* (Pl. xlviii).

Another somewhat similar example, to which our specimen does not show so close a resemblance, is that figured by Nathorst from the Culm flora of Spitzbergen (1920, Pl. 4, figs. 1, 2) as *Lepidodendron mirabile*. In this the scars are more elongate, about 3·5 by 2·5 cm.; the nature of the markings on the surface is not quite clear, but appears to be similar to that in our specimen.

The specimen so resembles described examples of *Ulodendron minus* from other parts of the World that it seems justifiable to refer it to that species. In comparing impressions such as these it must be remembered that the characters available are perhaps insufficient for accurate specific determination.

The specimen was obtained from the Volcanic Stage of the Kuttung Series at Welshman's Creek.

STIGMARIA FICOIDES Brongniart. Plate xxi, fig. 4; xxiii, fig. 4.

The specimens from three localities in New South Wales may be referred to this "species" which represents in general the underground rhizome of such plants as *Lepidodendron* and *Sigillaria*. At all three localities the rocks are part of the Carboniferous system of New South Wales, and from two (? three), remains of *Lepidodendron* have been recorded.

(*a*) *Stigmaria* from the Basal Stage of the Kuttung Series at Clarencetown, N.S.W. (Pl. xxi, fig. 4).

A large specimen, one surface of which is an almost flat impression of the surface of a Stigmarian axis preserved in a rather coarse sandstone. The impression is about 22·5 cm. long and has a maximum width of about 8 cm., but is bounded on all sides by broken or incomplete margins. The surface is marked by numerous regularly arranged circular scars in some of which there is a small central umbilicus; the scars are arranged in regular spirals and are as much as 9 mm. in diameter.

Parallel to the length of the impression and a little to one side of the middle there is a shallow groove about 6 mm. wide which extends the whole length of the specimen. This groove is superimposed on the impression of the surface of the rhizome and does not interrupt the regularity of the circular scars, some of which it covers but does not hide from view. It represents the remains of the pith and is marked by a number of parallel, longitudinal, discontinuous wrinkles which may be compared with those shown in a specimen figured by Williamson (1887, Pl. xiv, fig. 68, a).

On one side of the specimen, on a surface perpendicular to the impression just described, there are numerous long narrow flattened impressions of rootlets, in some cases obviously connected to the circular scars on the surface of the rhizome. They are at least 8 cm. long; the flattened impression is as much as 1 cm. wide close to the stem, and tapers gradually, being only 4 or 5 mm. wide at the limit of the specimen, some 8 cm. from the scar.

The form of this specimen closely resembles some previously figured examples of *Stigmaria* with rootlets, among which may be mentioned those figured as *Stigmaria ficoides* by Williamson (1887, Pl. xii, figs. 40, 74), Zeiller (1886, Pl. xci) and Seward (1910, fig. 205). Our specimen is the first example with rootlets attached to be described from Australia. *Stigmaria* does not appear to have been noted in descriptions of the Australian Carboniferous flora, but it is possible that some, at least, of the specimens which have been recorded as *Cyclostigma* may be more correctly referred to *Stigmaria*.

(*b*) *Stigmaria ficoides* from the Volcanic Stage of the Kuttung Series at Welshman's Creek, Wallarobba.

A large specimen consisting of portion of a thick, gradually tapering axis. The specimen is somewhat flattened, being elliptical in cross section; it is 21 cm. long, the maximum and minimum dimensions at one end being 16 cm. and 9 cm., and at the other end the corresponding measurements are 13 cm. and 6 cm. The surface is marked by numerous, spirally-arranged circular scars, each with a raised central portion at the apex of which there is a small central depression. The surface is irregularly wrinkled parallel to its length and in addition to the wrinkles there are a number of narrow elongate ribbon-like depressions on the surface; these represent the impressions of rootlets which have not been detached but which have been pressed flat against the surface of the rhizome.

Embedded in the matrix filling the rhizome there is, at the broader end of the specimen, part of the cast of the medullary cavity, with spirally-arranged elongated superficial ridges which, as figured by Williamson (1887, Pl. xiii, fig. 64) represent "prolongations of the medulla into the inner extremities of the primary medullary rays" of the vascular cylinder. Judging from the size and curvature of the portion of this medulla cast preserved, the pith was nearly 1 cm. in diameter, thus corresponding closely in size with that of the specimen described above from Welshman's Creek.

(*c*) *Stigmaria ficoides* from Rouchel (Plate xxiii, fig. 4; Specimen F1403, Geological Survey of N.S.W.).

Two specimens from this locality are casts of portion of the external surface of Stigmarian axes. They show the spirally-arranged circular scars, each about 7 mm. in diameter, with a raised central ring, the centre of which is occupied by a small depression. The surface between the scars is finely wrinkled and the specimens are indistinguishable from those figured by Williamson (1887, Plate xiv, fig. 75) who also explains their structure by his diagram (Pl. xii, fig. 76). A similar specimen is also figured by Nathorst (1914, Pl. 7, fig. 5) from the Culm flora of the sandstones of the Pyramidenberg and other places in Spitzbergen.

Examples of *Stigmaria ficoides* similar to all three types above described are figured by E. Bureau (1913) from the Upper Culm of the basin of the Loire in France.

### PITYS (?) SUSSMILCHI, n. sp. Plate xxii, figs. 1-3.

A petrified specimen from Welshman's Creek, Wallarobba, N.S.W., on a horizon near the base of the Kuttung Series, has only portion of the secondary wood preserved, without any of the pith or primary wood, or of the cortex.

Transverse section (Pl. xxii, fig. 1) shows the secondary xylem to be made up of regular radial series of four or five sided tracheids, of rather uniform size. The cells are small, the sides being approximately equal and about 0·05 mm. long. The primordial wall is quite distinct and thin; it has been considerably thickened. The pitting of the radial walls rarely shows in transverse section. The medullary rays are numerous, 1- to 4-seriate.

In radial section (fig. 2) the walls of the tracheids are frequently completely occupied by bordered pits; these pits are usually in three vertical rows, alternate, closely crowded and hexagonal in outline, and have an elongate-oval pore. Sometimes there are less than three vertical rows of pits, and when there is a single row the pits are often in contact and slightly flattened above and below; the single row of pits does not cover the whole wall of the tracheid. The medullary rays consist of radially elongated parenchymatous cells whose radial walls are pitted, the number of pits in the field varying from a single large irregularly oval pit to 6 or 7 small circular bordered pits.

The most characteristic appearance of the wood is that in tangential section (fig. 3), where the medullary rays are very characteristic. They are from one to four cells wide and from one to twenty-four cells high and are very abundant. Occasionally the tangential walls of the tracheids are pitted in the same manner as the radial walls.

The characters of the secondary wood of our specimen allow a reference with little hesitation to the Pityeae and probably to the genus *Pitys*.

Of the species already included in *Pitys* three, *P. Withami* (L. & H.), *P. antiqua* Witham and *P. primaeva* Witham (see Scott, 1902) are characterized by having primary xylem strands confined to the peripheral region of the pith; a fourth species, *P. Dayi* Gordon, of which an abbreviated account only has been published (in Scott, 1923, 256-260), is distinct from the three above-mentioned species in having primary xylem strands scattered through the whole of the pith region; in this character it shows close relation to the genus *Archaeopitys*, described from the Waverley shale (Lower Carboniferous) of Kentucky by Scott and Jeffrey (1914, 345), which may ultimately have to be included in *Pitys*.

The three species of *Pitys*, viz.: *Withami*, *antiqua* and *primaeva* may be distinguished from one another by the characters of their secondary wood, particularly by the medullary rays; our specimen shows closest resemblance to *P. Withami* L. & H. In the absence of any knowledge at all of the structure of the pith and primary wood in the New South Wales specimen it would be unsafe to refer it definitely to one of the species already described, more especially since the stratigraphical evidence available indicates that our specimen comes from a higher horizon than the three European species which all occur in the lower division of the Calciferous Sandstone (Lower Carboniferous).

Attention may be called to the similarity to species of *Pitys* exhibited by the tangential section of *Sigillaria* (?) *muralis* from Brazil figured by David White (1908, Pl. xii, fig. 2). In this figure the medullary rays resemble those of *Pitys* very closely, but the South American species is apparently quite distinct from *Pitys* in the general character of the secondary wood, which is described as "soft and spongy" (White, 1908, 467).

### (*b*) *A fossil wood from the Lower Marine Series.*

Dadoxylon farleyense, n. sp. Plate xxii, figs. 4-9; xxiii, 1-3.

The specimen is part of a stem from the horizon of the Ravensfield Sandstone in the Lower Marine Series, near Farley, N.S.W. The Lower Marine Series is the lowest division of what is usually known as the Permo-Carboniferous System in Australia. In New South Wales the *Glossopteris* flora makes its first appearance with the occurrence of *Gangamopteris* in association with a marine fauna on a horizon about 2,000 feet above the base of the Lower Marine Series. The Ravensfield Sandstone is a belt of solid sandstone containing abundant marine fossils, and occasional pieces of fossil wood; it is at the base of the Farley Stage, and about 3,800 feet above the base of the Lower Marine Series. The specimen described below is well preserved and shows pith, primary xylem and an incomplete portion of the secondary xylem. In section it is roughly oval, about 9 × 7 cm.; it is not, however, preserved symmetrically about the pith which is not in the centre of the specimen, the longest radius of secondary xylem from the pith being nearly 4 cm. The pith is comparatively small, about 7·5 × 4·5 mm. Annual rings are present, but the greater part of the secondary xylem has been fractured; the structure of the wood itself has not been greatly disturbed by this fracturing, which appears to have been due to a crushing force possibly after petrifaction had been completed or nearly so.

*The pith.*—The pith is small and broadly oval in transverse section, the longest and shortest diameters being 7·5 and 4·5 mm. respectively; the margin of the pith is a series of almost straight lines giving it the outline of an elongated octagon, from some, at least, of the angles of which, leaf-traces appear to depart. The central portion of the pith is not preserved, a piece about 2 mm. diameter being missing, but the outer part is mostly well preserved (Pl. xxii, figs. 4-6). There is a certain amount of differentiation in the cells of the pith. In the central part the cells are regularly rounded or hexagonal, with rather thick walls, and fairly uniform in size, about 100 μ in diameter. Outside this there is a zone, irregular in width, in which the cells are thin-walled and exhibit great variation in size, from 35 μ to 140 μ in diameter. At the margin of the pith there is perhaps a narrow region, not more than a few cells wide, where the cells are small (30 μ - 35 μ) and not always easy to distinguish from the primary xylem. This region, however, does not form a distinct medullary sheath like that described in such species as *Dadoxylon indicum* Holden (1917), and our specimen may rather be compared with *D. Lafoniense* Halle (1911). In longitudinal section (Pl. xxii, fig. 4) the cells of the pith are short, rectangular, parenchymatous cells, arranged in fairly regular vertical series; the vertical dimension is on the average about the same as the horizontal, varying from about one-half to twice - 70 μ to 100 μ wide, 35 μ to 200 μ high. Occasionally the fusion of two or three cells in a vertical row produces an elongated cell as much as 280 μ high.

Scattered irregularly through the pith are nests of thick-walled cells, filled usually with dark brown contents. In transverse section (Pl. xxii, fig. 4) the cells of these sclerotic nests do not differ in size or shape from the cells of the central zone of the pith, and in longitudinal section (fig. 5) they are observed to form part of the regular vertical series of cells. Generally many of the cells in a single nest are shorter vertically than horizontally, and often the horizontal cell walls are oblique, giving the cells of the nest a pseudo-radial arrangement. Occasionally the vertical row of cells on one or both sides of a nest is made up of shallow cells, perhaps the result of horizontal divisions of pith cells. The walls do not appear to be pitted. These nests are roughly spherical in shape, sometimes ellipsoidal with longest diameter either vertical or horizontal. The number of cells making up a single nest averages about 15 (varying from 6 to 23) as seen in transverse section; in longitudinal section the nests spread over a number of vertical rows of cells, ranging from 2 to 9, averaging about 6, while the average height of a nest is also about 6 cells. Sometimes adjacent nests are continuous, either vertically or horizontally, connection being made by a few thick-walled cells similar to those forming the nest. The number of such nests observed in the portion of the pith preserved in transverse section was about 20, and as about half of the actual pith is preserved the number in a complete transverse section would be about 40.

Sclerenchymatous groups of cells, giving the pith a very characteristic appearance, have been described in a number of genera, including *Calamopitys* (Scott, 1902, 342), *Mesopitys* (see Scott, 1923, 283), *Rhexoxylon* (Walton, 1925, 11) and *Lyginopteris* (Williamson and Scott, 1895, 717; Seward, 1917, 41), and they are probably not of special importance. No lacunae have been observed near the margin of the pith of *D. farleyense* such as those described by Halle (1911) as mucilage canals in *D. Lafoniense* from the Falkland Is., and which also occur in *Poroxylon*.

Scattered irregularly through the pith there are numerous small, oval, brownish-coloured spots (Pl. xxii, fig. 4) usually about 150 μ by 100 μ, but sometimes considerably smaller, 80 μ by 60 μ.

*The primary xylem.*—The primary xylem forms a zone (Pl. xxii, fig. 6), about 6-8 cells wide, not distinctly marked off from the secondary xylem, nor indeed from the small parenchymatous cells of the outer pith. There are some definite bundles of primary xylem, but they are not distinctly defined as in the genera *Mesoxylon*, *Calamopitys*, *Mesopitys*, etc. On the whole the tracheids of the primary xylem are roughly hexagonal in section and tend to be somewhat larger (up to 48 $\mu$ by 36 $\mu$) than those of the secondary xylem (40 $\mu$ by 32 $\mu$ or less); they are not regularly arranged in radial rows like those of the secondary xylem, but there is quite a noticeable degree of regularity in the arrangement of many of the tracheids of the primary xylem. Where primary bundles can be recognized, it is chiefly by the fact that the rows at the sides of the bundle converge from the inner boundary of the secondary xylem. In the bundles it is not possible to differentiate any protoxylem elements in transverse section, though this is perhaps possible in longitudinal section by the presence of annular thickening or very extended spirals. It does seem certain that there is no development of centripetal xylem which is an important feature in determining the generic position of the specimen. In some places the primary xylem bundle appears to extend in two narrow strips into the pith region and to enclose one or two fairly large parenchymatous cells, giving somewhat the appearance exhibited in sections figured by Miss Holden in *D. indicum* (Holden, 1917, Pl. xix, figs. 13, 14).

In radial longitudinal section the primary xylem is formed of some six to eight rows, of which the inner one or two may show annular or very extended spiral thickening, three or four rows show close spiral thickening and two or three rows show scalariform and reticulate thickening, these being followed by the reticulately pitted tracheids of the secondary xylem.

The zone of primary wood is not continuous, and in the areas between the indefinite primary bundles the parenchyma of the pith is continuous with the medullary rays.

*The secondary xylem* (Pl. xxii, figs. 7-9).—The secondary xylem shows the usual regular arrangement in radial rows, of more or less equidimensional rectangular cells with uniseriate or biseriate medullary rays. Annual rings are clearly distinguishable, there being a distinct line of demarcation between the summer wood of one ring and the spring wood of the succeeding ring; on account of the shattering of the stem it is not possible to follow the rings right round the stem, but they can be traced for considerable distances and always end abruptly where the wood has been fractured. In radial section also there is a distinct difference between summer wood and that of the succeeding spring. The rings vary from about 5 to 8 mm. in width.

The radial walls of the tracheids have one or two, occasionally three, vertical rows of large, alternate, circular bordered pits (see fig. 8). When there is only a single row the pits are sometimes in contact and flattened, but at other times they are separate from one another and retain their circular outline. When there is more than a single row the pits are in contact but are not so closely packed as to have the hexagonal outline so common in woods of similar type to our specimen. Occasionally the pits in two vertical rows are opposite instead of alternate. The pore in the bordered pits is small and broadly elliptical in outline, generally elongated transversely.

The medullary ray cells are parenchymatous and generally from three to seven times as long (radially) as high. Their radial walls are pitted with small elliptical bordered pits, the number varying up to about seven in the field.

Tangential sections (fig. 9) show the rays generally to be uniseriate, occasionally biseriate, and varying from 2 or 3 to 21 cells in height. No pitting was observed on the tangential walls of the medullary ray cells but occasionally there appeared to be one or two rows of alternate bordered pits on the tangential walls of tracheids of the secondary xylem.

*General Discussion.*

*Dadoxylon farleyense* agrees very closely in many of its characters with *Dadoxylon Lafoniense* described by Halle (1911, 177) from Permo-Carboniferous rocks of the Falkland Is.; the two species resemble one another especially in the absence of marked distinction between primary and secondary xylem and in the absence of centripetal xylem. The presence of annual rings and the pitting of the radial walls of the tracheids add to the resemblance. In the former species the medullary rays are considerably higher than in *D. Lafoniense*, and the presence of an abundance of sclerotic nests in the pith of *D. farleyense* is another point of difference.

The genus *Mesopitys* Zalessky, in which annual rings are well marked, has definite strands of primary xylem described by Zalessky (1911, 28) as being wholly endarch, an observation which has not been entirely borne out by re-examination of his material (see Seward, 1917, 295; Scott, 1923, 283); the leaf-trace is a single strand where it passes through the secondary xylem. Our species differs from *Mesopitys* in having apparently no centripetal xylem and in having only very indefinite primary xylem bundles; it has also much higher medullary rays, but has a similar type of pith with abundant sclerotic nests.

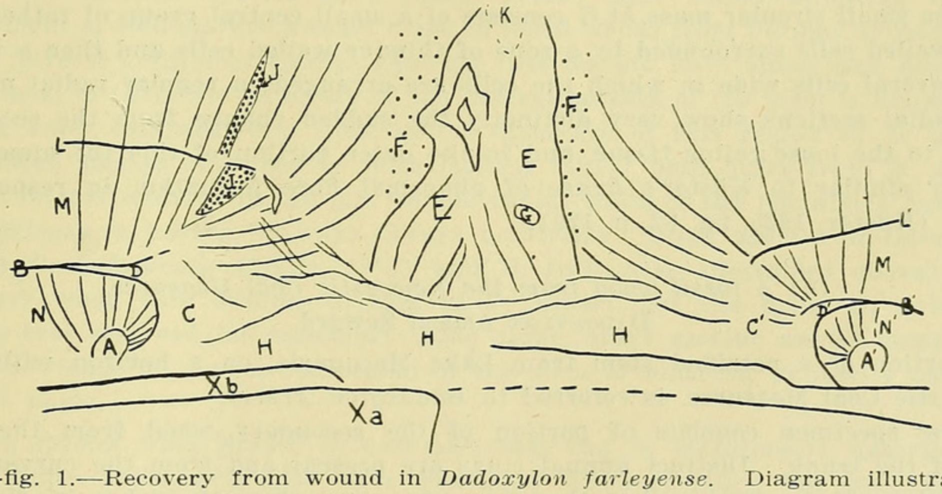
*D. farleyense* is another addition to the species of *Dadoxylon* with structure of the central region preserved, from the Gondwana flora. Although silicified woods are very common on some horizons in rocks of Permian (Permo-Carboniferous) age from the Gondwana region, in very few cases has the structure of the central region of the stem been sufficiently well preserved for description. The cases in which knowledge of the pith and primary wood is available include *Dadoxylon Pedroi* Zeiller (1895) from Brazil, *D. Lafoniense* Halle (1911) and *D. Bakeri* Seward and Walton (1923) from the Falkland Islands, *D. indicum* Holden (1917) from India, *D. sclerosum* Walton (1925) from South Africa and the stem described as *Araucarioxylon Daintreei* from Queensland (Chapman, 1904, 320). Very little is known of the pith or primary xylem of *D. Arberi* Seward (1919, 255), the characters of the species being those of the secondary xylem; Walton (1925, 2) has described a specimen of *D. Arberi* from South Africa in which some crushed remains of pith and primary wood are preserved. *D. farleyense* differs from *D. Arberi* in having numerous sclerotic nests in the pith, and also in the character of the pitting on the radial walls of the tracheids. *D. farleyense* may be closely related to the stem from the Bowen River Coal Measures in Queensland described by Chapman (1904) as *Araucarioxylon Daintreei* but in the latter the medullary rays appear always to be uniseriate and the bordered pits on the radial walls of the tracheids are often in 4 to 6 vertical rows and have an oblique slit-like pore.

*D. Bakeri* Seward and Walton (1923, 325) is a similar type of wood occurring in association with *Glossopteris* in the Falkland Is.; it does not possess secretory reservoirs or canals like *D. Lafoniense* Halle, it has a zone of tissue lining the inner side of the primary bundles such as is present in *D. indicum* Holden, and the pits on the radial walls of the tracheids are often in stellate groups recalling the distribution of pits characteristic of the genus *Callixylon* which occurs in the Upper Devonian of Indiana. In all the features just mentioned *D. Bakeri* is to be distinguished from *D. farleyense*.

*Recovery from wound and development of callus.* Plate xxiii, figs. 1-3; Text-fig. 1.

The sections of this specimen of *D. farleyense* have been cut through portion of the stem where there was a roughly circular projecting scar, about 15 mm. in diameter, with a fairly well defined outer rim about 1 mm. wide and a depressed central area (Pl. xxiii, fig. 3). From these sections it appears that this scar is the result of a wound, perhaps the breaking of a branch, which has been repaired by the development of callus growth and the gradual lateral extension of wood over the wound area. The figures (Pl. xxiii, figs. 1, 2) show close similarity to examples of callus growths (*cf.* Hartig, 1878, Plates v and vi; Küster, 1925, figs. 51, 53, 78, 82, 102, 105), and the specimen is thus of considerable interest as being one of the very few cases so far recorded amongst fossils. It also shows, as of course is to be expected, that the methods of recovery from wounds were the same in bygone ages as they are to-day; both in outward appearance and in sections the fossil is very similar to recent examples of the same phenomenon. Plate xxiii, fig. 2, shows a section near the central portion of the wound; fig. 1 one near the margin.

The general structure is well shown in transverse section (Text-fig. 1). At Xa in the figure is a normal annual ring of the secondary wood. The next succeeding ring, Xb, is abruptly broken off after the spring wood has been developed to a thickness of about 0·7 mm., whereas the annual ring Xa is about 3·7 mm. thick. On the level at which the slide is cut this break of the secondary wood has a lateral extent of nearly 2 cm. Where the wound has been received, and particularly at the outer margins, groups of rather loose parenchymatous cells




Text-fig. 1.—Recovery from wound in *Dadoxylon farleyense*. Diagram illustrating Plate xxiii, fig. 2. Explanation in text.

have been developed (A, A[1], H). These cells have very much the appearance of cortical tissue and their formation has been accompanied by the secretion of a considerable amount of resin as evidenced by numerous cells in the vicinity filled with darkish-brown contents. Such loose parenchymatous tissue is characteristically developed in the formation of callus wood (see Küster, 1925, fig. 48). At A and A[1] it appears that some of the cells of this tissue must have developed cambial activity for, from the outer margins of the two groups, series of regularly arranged rows of tracheids radiate, and by spreading inwards they commence to repair the damage caused by the wound. At the lines marked B and B[1] there is every appearance of the termination of a season's growth, but this radial discontinuity dies out laterally in a very short distance (3 or 4 mm.) and would perhaps seem to have been due to some check in growth round the wound. Along the surface where this check took place there is a narrow wedge

(D, $D^1$) of loose cells, resembling cortical tissue, which expands when it reaches the edge of the wound region into an extensive mass of loose cells forming a callus over the broken edge of the wound (C, $C^1$). In a radial direction this passes gradually into the series of regularly arranged rows of tracheids of the secondary xylem. The narrow wedges (D, $D^1$) just mentioned are also succeeded radially by regular rows of tracheids and a little further out (at L and $L^1$) there is the normal well-defined boundary of an annual ring. The ends of this outer part of the annual ring (M, $M^1$) encroach further on to the wounded region than those of the earlier part (N, $N^1$).

In the central part of the wound area there are confused masses of cells (E) where, for the most part, the structure is not well preserved and it is possible that some of the groups of cells may have belonged to the basal part of a broken branch. On either side there is a zone of loose irregular thin-walled parenchyma (F) (similar to that at C, $C^1$) and merging into the secondary xylem which finally completely encloses the wound zone. At K there is a small group of large, rather thick-walled cells very like those forming the pith, and scattered through the whole of the wound region there are numerous small oval brown spots whose presence in the pith has been noted above. In places, particularly in the vicinity of A and $A^1$ and in the rows of cells radiating therefrom, and also at J, many of the cells are filled with darkish-brown contents, perhaps resinous secretion induced by the wounding.

The small circular mass at G consists of a small central group of rather large thick-walled cells surrounded by a zone of thinner walled cells and then a narrow zone several cells wide in which the cells are arranged in regular radial manner.

Radial sections show very distinctly the sudden change from the secondary xylem to the loose callus tissue, and in the outer portion of this the appearance is very similar to Küster's figure of abnormal fibre formation in response to injury (Küster, 1925, fig. 82, p. 120).

### (c) *A fossil wood from the Newcastle Coal Measures.*

### Dadoxylon Arberi Seward.

Portion of a petrified stem from Lake Macquarie, on a horizon within the Newcastle Coal Measures, is referred to *Dadoxylon Arberi.*

The specimen consists of portion of the secondary wood from the outer part of the trunk. Distinct annual rings are present and from the curvature of these rings it is obvious that the stem was more than 12 inches in diameter. The rings are fairly regular and are from 3 to 6 mm. in width. The radial rows of tracheids and the medullary rays are considerably distorted and do not follow a straight radial direction.

In transverse section the tracheids of the spring wood are small, approximately square, about ·05 × ·05 mm., and are two or three times the dimension of the summer wood tracheids in a radial direction, the latter being approximately ·05 × ·02-·04 mm. The greater part of the annual ring is made up of the spring wood; there are up to 20 rows of thicker-walled tracheids in the summer wood, occupying less than 1 mm. in width, and the rings vary from 3 to 6 mm. in total width.

The preservation of the pitting of the walls of the tracheids is very imperfect and incomplete. The radial walls have large, approximately circular bordered pits with a wide border and a fairly large transversely oval or circular pore. There may be as many as four vertical rows of pits or only a single row. When there are four rows they are alternate and so crowded that they are hexagonal in outline and they cover the whole surface of the radial wall. When there are only one or two rows of pits they are not always in close contact and may be circular or slightly flattened top and bottom by contact with adjacent pits, and may be opposite instead of alternate.

The medullary rays are only poorly preserved and no example was observed of pits communicating with the tracheids. In tangential section the rays are very abundant and almost always uniseriate; occasionally one or two cells near the middle of the ray may be divided into two vertically. The height of the ray varies from 2 cells to 30 cells, the majority being between 6 and 15 cells high, and the cells are almost square, with somewhat rounded corners. The number of rays visible in tangential section is about 20 per square millimetre.

It seems more than probable that the specimen belongs to the species originally described by Arber (1905, 191) as *Dadoxylon australe*, now known as *D. Arberi* (Seward, 1919, 255), with which it agrees fairly closely in most of its characters. Arber's specimens were from the Newcastle Series at Newcastle and Lake Macquarie, and our specimen comes from the latter locality. Walton (1925) has recently described *D. Arberi* in greater detail than the original account. In our specimen the diameter of the pits on the radial walls of the tracheids is about ·01 mm., and that of the tracheids themselves about ·05 mm.

It was in this species that Arber (1905) first called attention to the development of well-marked annual rings in fossil woods from Permo-Carboniferous rocks. Several additional species showing this feature have since been described and in most of them the structure of the central portion of the stem is known, but we still know comparatively little of the structure of this region in *D. Arberi*. Two Indian species described by Miss Holden (1917) both differ from *D. Arberi*, *D. indicum* particularly in the pits on the radial walls of the medullary rays and *D. bengalense* in having the rays always uniseriate. Other species of *Dadoxylon* such as *D. Lafoniense* (Halle, 1911) and *D. farleyense* (described above) have secondary wood very similar to that of *D. Arberi*, but the name *D. Arberi* is perhaps best reserved for secondary wood alone, other specific names being used when knowledge of the central region of the stem is sufficient to justify use of a separate name.

Two species from Brazil, *D. nummularium* and *D. meridionale*, described by David White (1908, 579, 583) have secondary wood of much the same general type as *D. Arberi*, but in neither species is there any evidence of the development of annual rings.

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## EXPLANATION OF PLATES XXI-XXIII.

### Plate xxi.

Figs. 1, 2. *Lepidodendron Osbornei*, n. sp. Welshman's Creek, Wallarobba, N.S.W.

1. Photograph (slightly enlarged) of specimen; 2. Drawing, by Mr. T. A. Brock, of Cambridge, showing the very elongated, kite-shaped leaf cushions (slightly reduced).

Fig. 3. *Ulodendron minus* L. and H. (x ½). Welshman's Creek, Wallarobba, N.S.W.

Fig. 4. *Stigmaria ficoides* Brongniart (x ½). Clarencetown, N.S.W. Showing the remains of the pith and of the numerous flattened rootlets.

### Plate xxii.

Figs. 1-3. *Pitys* (?) *Sussmilchi*, n. sp. Welshman's Creek, Wallarobba, N.S.W. (x 25).

1. Transverse section; 2. Radial longitudinal section, showing the alternate, closely-crowded pits; 3. Tangential section showing the characteristic medullary rays.

Figs. 4-9. *Dadoxylon farleyense*, n. sp. Ravensfield Sandstone, near Farley, N.S.W. (x 25, except fig. 8, which is x 60).

4. Transverse section of portion of the pith, showing three of the "sclerotic nests" and, in the top left hand corner, some of the oval brownish-coloured spots which are of frequent occurrence not only in the pith, but in other parts of the wood. 5. Longitudinal section of the pith. 6. Transverse section showing outer portion of the pith, primary xylem and secondary xylem. 7. Transverse section of secondary wood showing junction between two annual rings. 8. Longitudinal section of the secondary wood showing pitting of radial walls. 9. Tangential section of the secondary wood.

Plate xxiii.

Figs. 1-3. *Dadoxylon farleyense*, n. sp.

1. Transverse section (× 4) near margin of wound caused, probably, by breaking off of a branch. The callus tissue repairing the wound shows in this section as an elongate band of cells, similar in appearance to cortical cells, extending for about two-thirds across the middle of the photograph. 2. Transverse section (× 4) nearer the centre of the wound than Fig. 1. The details shown are explained in the text and in Text-fig. 1. 3. Photograph (approx. nat. size) of the specimen after sections had been cut.

Fig. 4. *Stigmaria ficoides* from Rouchel, showing root scars (approx. nat. size).