The Missing Link in Osmundites.

BY

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With Plate II and one Figure in the Text.

IN their classic series of memoirs on the fossil Osmundaceae, Kidston and Gwynne-Vaughan say (Part II, 1908, pp. 229, 230): '*the vascular anatomy of the Osmundaceae must be derived from a protostele with a solid central homogeneous xylem mass*,' and (in Part IV, 1910, p. 466): 'We regard the Osmundaceae, as a whole, as an ascending series of forms whose vascular system is to be derived from a primitive protostele with a solid homogeneous xylem.'

The missing link in the chain of practical evidence—that is to say, the actual species of *Osmundites*, possessing a solid stele and normal, simple Osmundaceous meristeles in the leaf-bases—was not known to them. The species about to be described from Australia fortunately shows this interesting conjunction of features; and, writing to me about photographs of the new specimen I sent to him, Dr. Robert Kidston, F.R.S., said: 'Your specimen seems to be the missing link we required.'

The specimen came to my hands, in the Geological Department of the British Museum of Natural History, some years ago, having been most kindly sent to us, with other material, by Dr. Walcott, Director of the National Museum, Melbourne, Australia. At that time the British Museum was planning, not only to describe the British Cretaceous fossil plants (see Stopes, 1913, 1915), but to prepare a complete comparative memoir on the Cretaceous plants of the whole world. As the war has rendered this project impracticable for many years to come, the present specimen seemed of sufficient interest to describe individually.

I am much indebted to Dr. Walcott, of Melbourne, for permission to cut the specimen, and to Dr. Smith Woodward, F.R.S., Keeper of the Geological Department, for his unfailing help and courtesy in arranging for the section-cutting and other facilities for utilizing the material in his unique department.

The specimen came with some others, all waterworn fossil woods, from Wollumbilla Creek, Queensland, described as 'probably Cretaceous'. The

Osmundites consisted of a portion of a rhizome and surrounding leaf-bases, together appearing to have been roughly circular when complete, but of which only a portion like a sloping quarter cut out of a round cake was preserved. On the waterworn surface, part of which remains, the weathered and somewhat abraded leaf-bases are clearly visible. They vary, but measure roughly 4 mm. in long diameter of the surface face, representing cross-sections of the petioles. The specimen as a whole comprised a curved piece measuring about $3 \times 2.5 \times 1.5$ cm.

One portion of the specimen (V. 12640) and part of the slides (V. 12641 *a, b, c, d, e, f, g, h, i, and j*) are in the Geological Department, Natural History Museum, kindly presented by Dr. Walcott in exchange for the sections cut and sent to his museum; the other portion of the specimen and the other slides have been sent back to the National Museum, Melbourne, Australia. If desired by later workers, further sections could be obtained from the block in the British Museum, but this contains only leaf-bases and rootlets. A very short segment of the axial portion was preserved, and this was all cut up, yielding four slides and then running out of the specimen. Of these four sections the top and bottom (S 1 and S 4) each show good sections of the complete stele, surrounded by its single celled layer of 'sheath' cells. The two middle of these four sections each suffered partial demolition in the grinding down, so that in them the central axis, though in place, is incomplete.

GENERAL CHARACTER OF THE PLANT.

The new *Osmundites* consists of a slender central solid axis surrounded by a crowd of leaf-bases of which the meristele is a simple curved arc bent with the bow outwards and the horns inwards in the usual Osmundaceous way. There is nothing in the leaf-bases or the leaf-traces (so far as I can detect) which is not absolutely typical and characteristic of the genus. The presence of the sclerized patches within each curve of the meristele, the thickened oval round the meristele, and the lateral patches in the ground tissue on either side of it are comparable with those described by Kidston and Gwynne-Vaughan for *Osmundites* leaf-bases. In particular, the diagram of the leaf base given by them in their Part V, 1914, p. 478, Text-fig. 4, of '*Osmundites* sp. from Queensland', might almost have been drawn from my specimen. Compare my Text-fig with this. This feature can also be clearly seen in the middle of the Photo 6, Pl. II. Kidston's specimen, however, appeared to possess an ordinary Osmundaceous xylem in its main axis.

Interspersed with the leaf-bases in the usual way also, are numerous small diarch roots. The new specimen, therefore, is a quite typical and characteristic *Osmundites*, but for its remarkable and interesting main axis.

DETAILED DESCRIPTION OF SPECIMEN.

The *main axis* is a solid mass of wood. Photographs of the two good sections of this stele are shown on Pl. II, Photos 2 and 3; in Photos 4 and 5 are shown lower magnifications of the whole sections in which they lie. These make clear the relation and relative sizes of the leaf-bases surrounding it and of the main axis. The total diameter of the *xylem* of the main stele is roughly 1 mm., and the whole is irregularly circular with a slight tendency to a stellate shape. (This is of historic interest in comparison with the palaeozoic forms, such as *Zalesskya*, which Kidston and Gwynne-Vaughan link on to the group; see their memoirs quoted above.)

The whole of the central axial tissue appears to me to be tracheal, but about this I cannot be absolutely sure, owing to the absence of longitudinal sections. In the actual slides the solid nature of this central mass is very much more evident than in the photographs, particularly in the slide (V. 12641 *h*) from which Photo 3 is photographed. In this, when the high

Diagram of leaf-base of *Osmundites Kidstoni*, sp. nov., showing the position of the meristele and sclerotic tissues; the latter are dotted. $\times 15$.

power is used with a much reduced orifice in the iris diaphragm, it reveals cell structure right across the space which, in the photograph, looks like a gap. The preservation of the cell-walls here is not optically sharply defined from the mineral matrix, while the cell-walls which show up clearly in the photographs have a strongly-marked contrast with the matrix, due to their black colour. So far as I can judge, this appears to be due to the chances of petrification, and not to any inherent differences in the natures of the cells. This interpretation is confirmed by the presence of a single cell or two which has one half of its walls black and strong, and the other half faint and translucent, and therefore, in the photograph, invisible.

Whether all the central cells were tracheides, or whether dispersed among them were some parenchyma cells, absence of longitudinal sections of this axis makes it impossible to say with certainty, but the appearance in transverse section shows a certain amount of the pitting, and there is no conclusive evidence against the view that the mass consisted almost entirely of tracheides.

The *protoxylems* are not clearly evident, but seem to lie somewhat

within each point of the seven-horned central mass. It is much to be hoped that further specimens of this interesting species may come to light and yield longitudinal sections to settle this and other points about the stele structure.

When one mentally subtracts the seven bays of *secondary* tissue, the star-like form of the primary wood becomes very evident, as is seen clearly in Photo 3. This is so remarkably like the central axial tissue of some of the palaeozoic Botryopterideae that one feels that Kidston and Gwynne-Vaughan's statement that they believe the Osmundaceous and the Botryopteridean series to have had a common ancestor (Part IV, p. 468) has, in this new plant, a strong piece of confirmatory evidence. They say: 'An Osmundaceous stele with a continuous ring of xylem and a mixed pith corresponding exactly to that of *Zygopteris Grayi* has not yet been found; if it did exist, the difference between it and the stele of *Zygopteris Grayi* would lie mainly in the star-like outline of the latter.' The present species has a star-like outline much like the latter. But it appears to be more primitive in having apparently a *solid* xylem and not a mixed pith. The presence of secondary tissue is, of course, a very unusual feature in the ferns of any age, and may, particularly when the primary wood is small, be considered a primitive feature.

The *secondary wood* forms seven compact bays which, together with the somewhat stellate primary wood, complete the roughly spherical shape of the stele (see Photo 3). The secondary and primary tracheides are not sharply distinguished, and, where they are adjacent, it is hard to say which is which. In the outward direction, however, they appear in fairly definite radial series, with a maximum of about seven tracheides in each radius. The greatest diameter of these secondary tracheides is somewhat less ($1.5-2\ \mu$) than the central primary elements of the wood, which vary between $2\ \mu$ and $3\ \mu$.

The pitting of these tracheides also, so far as can be judged from hints revealed in the transverse sections, seems to be that usual in the Osmundaceae. The phloem and outer tissues are not preserved, and the space they must have occupied is filled with crystallized matrix. Surrounding the stele, and evidently outside the phloem, is a layer of large strongly-marked cells. These cells appear very comparable with those described as endodermis in *Osmundites Carnieri* (see Kidston and Gwynne-Vaughan, 1914, Pl. XLIV, Figs. 37 and 40). Outside this layer is again another space of crystallized matrix, in which must have lain the small, recently detached meristemes. At a short distance, about $2.5-3\ \text{mm.}$ (see Photos 4 and 5), the surrounding leaf bases are preserved; those nearer the axis are considerably crushed and distorted, probably owing to their delicacy. Those lying rather farther from the axis are less distorted, and some of the larger ones seem but little crushed (see Photo 1 and Photo 6).

The *leaf-base* is, as has already been mentioned, quite normal and typical for the Osmundaceae. An enlarged photo of the portions within the sclerized ring and the complete meristele are shown in Photo 6, and a diagram of the whole, showing the position of the *sclerotic nests*, is given in the Text-fig. In the detailed cellular structure of the leaf-bases of the new plant no feature meriting special description occurs. The xylem, phloem, and other tissues are apparently entirely usual for the leaf-bases of this family.

The *roots*, of which many are to be seen cut in a variety of directions in among the leaf-bases, are also typical for the family. Their stele is *diarch*, with a group of about a dozen tracheides and a well-marked sheath. See Photo 7, Pl. II. In longitudinal oblique sections, which are numerous, the tracheides appear to be provided with series of irregular rows of narrow pits. They appear to answer to the following description: 'The tracheae are of the typical Osmundaceous type; that is to say, the pits are actual perforations, and several vertical series of them occur on each wall' (Kidston and Gwynne-Vaughan, 1910, p. 456).

DIAGNOSIS.

As strict comparative diagnoses have not been given for the various species of the group, even in the Kidston and Gwynne-Vaughan Memoirs, it is more difficult than it inevitably need be to diagnose a new species from a single and incomplete specimen. Whether or not its small size is characteristic is hard to say; as the secondary wood of the axis was already forming, this may be a specific feature worth including in the diagnosis. The plant described above is named in honour of Dr. R. Kidston, F.R.S., of Stirling, who has done such unique work in Palaeobotany, and has specially interested himself in this group:

Osmundites Kidstoni, sp. nov.

General type of the vegetative body characteristic of the genus; leaf-bases and roots typical, but main axis a protostele with secondary wood. Roots diarch, adventitious among leaf-bases. Leaf-bases with a simple bow-shaped meristele, embracing a sclerenchyma patch in each curved end, and surrounded by a ring of sclerenchyma; irregular lateral sclerenchyma patches in the lateral wings of the leaf-base. Main axis apparently solid, roughly circular, made up of somewhat stellate, seven-rayed protostele filled in with bays of secondary wood. Tracheid diameter varying between $1.5\ \mu$ and $3\ \mu$. Stele surrounded by a sheath of dark cells. The whole plant very small, measuring less than 2 cm. from the centre of the stele to the largest and outermost leaf-base. The largest leaf-bases measure approximately only 3–4 mm. across the ring of circumstellar sclerenchyma.

Locality. Wollumbilla Creek, Queensland.

Horizon. 'Probably Cretaceous.'

Type (and only specimen). One wedge-shaped piece cut into slides: S 1, 2, 3, 4 include the main axis, of which no more remains; slides L 1, 2, and 3 cut longitudinally through the leaf-bases, and slides T 1 to T 12 cut transversely through the leaf-bases. Two pieces of the block remain, V. 12640 in the British Museum of Natural History, and a small piece returned to the National Museum, Melbourne. The slides are shared between the British Museum of Natural History (there numbered V. 12641 *a* to *j*) and the National Museum, Melbourne.

DISCUSSION.

The group has aroused so much interest and has already been so much discussed that it would be easy to enter into a lengthy statement of views about this new member. Its obviously interesting place in the *Osmundites* series will be apparent to all who know Kidston and Gwynne-Vaughan's Memoirs. It fits attractively into their theories, as I pointed out at the beginning, and its place is rendered all the more interesting from its comparatively late geological age. On *a priori* grounds, from the main axis it would have, probably, been judged to be of Early Mesozoic if not Coal Measure age, while the petioles are of Upper Mesozoic and recent type. Comparative accounts of the main genera associated with the group have already been made by others, so that I will confine myself to drawing attention to one plant now of interest which has not so far been much considered in comparison with the group, viz. *Botrychioxylon paradoxum*, Scott (1912). Secondary wood in ferns is rare; the two plants do not, at first sight, much resemble each other, owing to the very much greater extent of the secondary wood in *Botrychioxylon*, but if one imagines the secondary wood only partly formed, as can readily be done by shutting off the outer zones of it in the Fig. 7, Pl. XXXVIII, of Scott's paper, and comparing this with the Photo 3, Pl. II, a suggestive likeness can be seen which is rather more evident on comparing Scott's drawing, his Pl. XLI, Fig. 20. This comparison indicates one more link connecting the characteristics of the early Botryopterideae with primitive features in the Osmundaceae.

The weft of forms representing the Botryopterideae (from some early representatives of which the consensus of opinion allows that the Osmundaceae were derived) shows a various shuffling, permutation, and combination of their features. It is interesting that we now have in this new species the actual combination of a solid somewhat stellate protostele together with secondary wood and an absolutely typical Osmundaceous leaf-base. Whatever its geological horizon, its phylogenetic value is, therefore, high, and it is still more intriguing if the form really lingered into the Cretaceous life of the Antipodes as this fossil makes probable.

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DESCRIPTION OF PLATE II.

Illustrating Dr. M. C. Stopes's paper on the Missing Link in *Osmundites*.

All photographs are enlargements of sections of *Osmundites Kidstoni*, sp. nov., and were taken by Mr. P. Dollman.

Photo 1. Transverse section showing the packed leaf-bases. The meristemes, sclerotic zones, and also adventitious roots can be seen. $\times 3$ (from Slide V. 12641e = T. 9).

Photo 2. Transverse section of the protostele of axis, showing the solid tissue. The apparent gaps and breaks are due to vagaries of fossilization which darkened some walls and left others translucent. Note the seven small bays of secondary wood, the large-celled sheath. $\times 80$ (from Slide V. 12641g = S. 1). This corresponds to A in Photo 5.

Photo 3. Transverse section of the same axis as above with an interval of two slides between. The seven bays of secondary wood and the somewhat stellate shape of the protostele show more clearly. $\times 80$ (from Slide V. 12641h = S. 4). This corresponds to A in Photo 4.

Photo 4. Transverse section of leaf-bases surrounding axis, A. The latter is that shown in Photo 3. $\times 3$.

Photo 5. Transverse section of leaf-bases surrounding axis, A. The latter is that shown in Photo 2. $\times 3$.

Photo 6. Single leaf-base enlarged, showing the simple curved meristeme embracing two patches of sclerenchyma and surrounded by the sclerized ring. $\times 20$ (from Slide V. 12641b = T. 4).

Photo 7. Slightly oblique transverse section of adventitious rootlet, showing its diarch nature. $\times 20$ (from Slide V. 12641c = T. 6).

STOPES-OSMUNDITES.

Huth coll.

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