

"Note on the Occurrence of a Seed-like Fructification in certain Palæozoic Lycopods." By D. H. SCOTT, M.A., Ph.D., F.R.S., Honorary Keeper of the Jodrell Laboratory, Royal Gardens, Kew. Received August 21, 1900.

It has generally been assumed by palæobotanists that the fossil seeds described by Williamson* under the name of *Cardiocarpon*, even if not necessarily co-generic with the *Cardiocarpus*† of Brongniart, at least belonged to the same group of Gymnospermous plants.‡ Brongniart's specimens, often preserved with marvellous perfection, have proved to be the seeds of members of the extinct Order Cordaiteæ, or of allied plants. The same conclusion applies to certain of the British forms, notably the *Cardiocarpon anomalum* of Carruthers,§ which was certainly Cordaitean, and probably to some of Williamson's examples.

The specimens to be shortly described in the present note show, however, that seed-like bodies, identical with those figured by Williamson under the name of *Cardiocarpon anomalum*,|| were borne on Lepidodendroid cones, otherwise indistinguishable from *Lepidostrobus*. They thus prove that under the genus *Cardiocarpon*, and even under the "species" *C. anomalum*, totally different objects have been confounded, namely, the seeds of Cordaiteæ or Cycads on the one hand, and the integumented megasporangia of certain Palæozoic Lycopods on the other. The latter organs present close analogies with true seeds, but are wholly distinct in detailed structure from the Gymnospermous seeds above mentioned.

The discovery of the specimens of the new cone is due to Messrs. J. Lomax and G. Wild, who recognised it as a *Cardiocarpon*-bearing strobilus, resembling a *Lepidostrobus*.¶

The original specimens, which are calcified and generally well preserved, were derived from the Ganister beds of the Lower Coal-

* "Organisation of the Fossil Plants of the Coal-measures," Part VIII, 'Phil. Trans.,' vol. 167, Part I, 1877, p. 254.

† Founded in Brongniart's 'Prodrome d'une Histoire des Végétaux Fossiles,' 1828. The forms *Cardiocarpon* and *Cardiocarpus* have been used indiscriminately by authors.

‡ See, for example, Solms-Laubach, 'Introduction to Fossil Botany.' English edition, p. 120.

§ "Notes on some Fossil Plants," 'Geol. Mag.,' vol. 9, 1872.

|| *Loc. cit.*, Part VIII, Plate 14, fig. 118, and Plate 16, fig. 119; Part X, 1880, Plate 20, fig. 64. These figures are from specimens which I have certainly identified with the *Lepidostroboïd* fructification. Others figured by Williamson are of doubtful nature.

¶ See the note by Messrs. Wild and Lomax, "On a new *Cardiocarpon*-bearing Strobilus," 'Annals of Botany,' March, 1900.

measures, some from Hough Hill, Stalybridge, others from Moorside, Oldham. Numerous sections were cut by Mr. Lomax and Mr. Wild. A closely similar fructification occurs, at a much lower horizon, in the Burntisland beds of the Calceiferous Sandstone Series.

The strobilus is of the ordinary *Lepidostrobus* type. The cylindrical axis bears numerous spirally disposed sporophylls, each of which consists of a long horizontal pedicel, expanding at the distal end into a rather thick lamina, which turns vertically upwards.

Anatomically, the structure is also that of a *Lepidostrobus*. The stele which traverses the axis has a narrow ring of centripetal wood, and a large pith; the leaf-trace bundles which pass out to the sporophylls are collateral in structure, and agree closely with those described by Mr. Maslen in *Lepidostrobus Oldhamius*.*

The ligule is sometimes well preserved; it is seated in a depression of the upper surface of the sporophyll, at the distal end of the sporangium, and is thus in the normal position.†

With one exception, the specimens of the strobilus are immature, and their tissues not quite fully differentiated. These younger specimens bear sporangia which are essentially those of a *Lepidostrobus*. A single large sporangium is seated on the upper surface of the horizontal pedicel of each sporophyll, to the median line of which it is attached along almost its whole length.

The sporangium narrows out towards the top, and terminates above in a well-marked ridge; in general form it resembles Williamson's *Cardiocarpon anomalum*, but in the immature condition there is no integument. The outer layer of the sporangial wall has the columnar or palisade-like structure characteristic of *Lepidostrobus*; it is lined by a more delicate inner layer, which may be several cells thick.

So far the structure is simply that of a *Lepidostrobus* with rather thick-walled sporangia.

Within the sporangial cavity, the membranes of the megaspores are usually preserved; a single large megaspore almost fills the sporangium, but smaller, abortive spores, with thicker walls, are also present. Some specimens show that three of these abortive spores were present in each sporangium. It appears, then, that a single tetrad was developed in each megasporangium, and that of the four sister-cells one only came to perfection, constituting the functional megaspore.

In one specimen, discovered by Mr. Wild, the strobilus is in a more advanced condition. In its upper part the sporophylls simply bear sporangia, as above described, but lower down in the cone these are replaced by integumented, seed-like structures, identical with the detached bodies called *Cardiocarpon anomalum* by Williamson.

* Maslen, "The Structure of *Lepidostrobus*," 'Trans. Linn. Soc.,' London, Ser. 2, vol. 5, 1899.

† Maslen, "The Ligule in *Lepidostrobus*," 'Annals of Botany,' vol. 12, 1898.

The structure of this strobilus is sufficiently well preserved to show that the anatomy of the axis agrees with that of the less mature specimens, and, as the tissues are more completely formed, exhibits the *Lepidostroboid* characters even more clearly.

Mr. Wild's specimen, then, demonstrates that the *Cardiocarpon anomalum* of Williamson was borne on a cone with all the characters of a *Lepidostrobus*, and that it represents the matured condition of the megasporangium and sporophyll.

The detailed comparison of specimens in the young and the mature condition has shown the nature of the change, which converts the megasporangium, together with its sporophyll, into a seed-like organ. The nucellus of the latter retains almost unaltered the structure of the megasporangial wall, with its columnar layer. In the sporangial cavity the single large megaspore, accompanied by its abortive sister-cells, is present as before. A thick integument has, however, grown up from the sporophyll, completely overarching the megasporangium, except for a narrow crevice left open at the top. When seen in a section tangential to the strobilus as a whole, this crevice is cut across, and presents exactly the appearance of a micropyle; in reality it differs from a micropyle in being a narrow slit, extending almost the whole length of the sporangium, in the radial direction, whereas the micropyle of an ordinary seed is a more or less tubular passage.

The integument springs from the upper surface of the sporophyll-pedicel; it does not consist of the incurved margin of the pedicel, for, in the more distal region, the margin of the latter projects considerably beyond the insertion of the integument.

From the frequency of detached specimens in the *Cardiocarpon* condition, it appears that in nature the sporophyll, bearing the integumented megasporangium, was shed as a whole, though parts of the sporophyll-lamina no doubt perished, only so much being persistent as was necessary to form a complete envelope to the "seed."

In a strobilus associated with the seed-like specimens, and bearing microsporangia, it was found that the latter, like the megasporangia of the female cone, are provided with integuments. This specimen was figured by Mr. Maslen as a variety of *Lepidostrobus Oldhamius*,* though possibly deserving specific rank, a determination with which I agreed at the time. There is every reason, however, to suppose that this strobilus was a male fructification of the same species, the female of which bears the integumented seed-like megasporangia above described. The microsporangial integument is more widely open than that of the megasporangium.

The Burntisland specimens, which from their horizon are presumably of a distinct species, are at present only known in the isolated *Cardiocarpon* condition. They are of interest for two reasons: in one speci-

* Maslen, 'Structure of *Lepidostrobus*,' p. 371, Plate 37, fig. 21.

men the ligule is clearly shown, enclosed by the integument, the only example of this organ, so far observed, in the mature, seed-like stage of the fructification.

Another of the Burntisland specimens is the only one as yet observed in which the prothallus is present.* It fills a great part of the functional megaspore, which is almost co-extensive with the sporangial cavity, and consists of a large-celled tissue, resembling the prothallus of *Isoetes* or *Selaginella*. The peripheral prothallial cells are smaller than the rest, but no archegonia could be detected.

The bodies described in this note resemble true seeds in the possession of a testa or integument, and in the fact that one megaspore or embryo-sac alone came to perfection; the seed-like organ was likewise shed entire, and appears to have been indehiscent. In many points of detail, however, the reproductive bodies in question differ from the seeds of any known Gymnosperms; they afford no proof of the origin of the latter Class from the Lycopods. The newly discovered fructification nevertheless shows that certain Palæozoic Lycopods, with strobili at first indistinguishable from *Lepidostrobus*, crossed the boundary line which we are accustomed to draw between Sporophyta and Spermatophyta.

As these fossils appear worthy of generic rank, I propose to found the genus *Lepidocarpon* for their reception; it may be briefly characterized as follows:—

Lepidocarpon, *gen. nov.*—Strobilus, with the characters of *Lepidostrobus*, but microsporangia and megasporangia each surrounded by an integument, growing up from the upper surface of the sporophyll. Megasporangium completely enclosed in the integument, except for a slit-like micropyle along the top. A single functional megaspore developed in each megasporangium. Sporophyll, together with the integumented megasporangium, detached entire from the strobilus, the whole forming a closed, seed-like, reproductive body.

It is proposed to name the Coal-measure form *Lepidocarpon Lomaxi*, and that from Burntisland *L. Wildianum*. Both were included by Williamson under his *Cardiocarpon anomalum*, which, however, is quite different from the seed so named by Carruthers.

A full, illustrated account of these fossils is in preparation, and will shortly be submitted to the Royal Society.

* I have since examined a section, cut by Mr. Lomax from one of the Coal-measure specimens, in which the prothallus is even better preserved.—*Note, added October 9, 1900.*