Aspects of Fossil Botany.¹

By Dr. D. H. SCOTT, F.R.S.

I. FERNS AND SEED FERNS.

THE fact that many of the well-known fern-like fossils of the Carboniferous formation were not ferns at all, but true seed-bearing plants, has long been familiar to students of palaeobotany. It is a quarter of a century since the recognition of the seeds of *Lyginopteris oldhamia* by Prof. F. W. Oliver first led to the institution of the class Pteridospermeae, or, in popular language, seed ferns. Yet, after this lapse of time, and in spite of all the attention given to the subject, much still remains obscure. We are still ignorant of the relation between true ferns and seed ferns, either as regards their respective importance in Carboniferous times, or the degree of affinity between them.

The early discoveries, in *Lyginopteris*, *Neuropteris*, *Aneimites*, and *Dicksonites*, cast doubt on such extensive groups of supposed ferns, that the impression was soon created that a majority of the Carboniferous 'ferns' were, in reality, seed-plants. At the present time even the great tree-ferns, the so-called Marattiaceae of the Coal-measures, are called in question: Were they ferns or Pteridosperms?

Since the original discoveries of 1903-5, a number of additions have been made to our knowledge of seed-bearing plants of fern-like habit. Cases of direct continuity of seed with frond have been demonstrated in a further species of *Neuropteris*, in a *Sphenopteridium* and in a *Sphenopteris*, the two latter of Lower Carboniferous age. Prof. Halle, in his important investigation of the fossil flora of China, has already discovered five new cases of the kind, in the Permo-Carboniferous beds of the Province of Shansi, in northern China. One of his discoveries must be specially considered, for it has a direct bearing on the position of the supposed Marattiaceae of the period.

The plant is *Pecopteris Wongii* (named after a Chinese colleague). There seems to be no doubt that one seed at least is attached to the rachis of the frond, while others are so grouped as to suggest a connexion. The seed is an ovoid body about 7 mm. in length. The case is a critical one, for the new species is almost identical with the well-known *P. Miltoni*, which has the fructification of *Asterotheca* and is therefore referred to Marattiaceous ferns. If it were positively known that *P. Wongii* bore the sporangia of *Asterotheca* as its male organs, the new species would afford the strongest evidence in favour of the transference of the Carboniferous 'Marattiaceae' to the Pteridosperms.

In *Nystroemia*, a new genus, both sporangia and seeds were found, on distinct specimens, almost certainly belonging to the same plant. This plant thus appears to be one of the rare and fortunate instances in which both sexes are known in the same Pteridosperm.

The most important, however, of the new Pteridosperms is undoubtedly the American genus *Eospermatopteris*, described by Miss Goldring. It is of Upper Devonian age, and is thus the oldest known seed-bearing plant. To avoid repetition, *Eospermatopteris* will be considered in the following article, devoted to early floras.

The male or pollen-bearing organs of the Pteridosperms are of special importance in the present survey, for it is chiefly on them that the comparison with the contemporary tree-ferns, the so-called Marattiaceae, depends.

The original discovery, by Kidston, of the *Crossotheca* fructification of *Lyginopteris* is well known. The fertile pinnules are oval leaflets bearing pendulous sporangia or pollen-sacs on their lower surface. The peculiar feature is the bilocular structure of each pollen-sac, a point difficult to demonstrate in the imperfectly preserved material. Indirect confirmation is, however, afforded by clearly bilocular sporangia observed by Prof. Oliver in petrified specimens of other fructifications. Some doubt has been cast on the identification of the frond; Zeiller, however, accepted it as the foliage of *Lyginopteris*. The genus *Telangium*, founded by Dr. Margaret Benson, differs from *Crossotheca* in the sporangia standing erect on the end of the stalk, instead of being pendulous. Dr. Benson thought that her species, *T. Scotti*, was the male fructification of *Lyginopteris oldhamia*. It may have belonged to some allied plant, but the sporangia are not bilocular. Various other fructifications, preserved in the form of impressions, have been referred to *Telangium* and regarded as the male organs of Pteridosperms.

Our knowledge of the supposed male fructifications of seed-ferns is often unsatisfactory, owing to the obscurity of fossils preserved as structureless impressions. Kidston's case of *Neuropteris Carpentieri* is one of the best, for here the fertile pinnules are on the same frond with the sterile leaflets, differing somewhat from them in shape. The densely packed sporangia contain a quantity of spores—no doubt the pollen-grains. In *Potonia* the large orbicular discs have been shown to bear sporangia. This genus probably represents the male fructifications of species of *Neuropteris*.

It may be said that the polliniferous organs of the Pteridosperms, where known, are almost constantly borne on specially modified pinnules or on a naked rachis. The only case in which they have been found, as it appears, on the unaltered frond, is that of *Dicksonites Pluckenetii*, to which we shall return.

It has hitherto been generally assumed that there existed, in Carboniferous and Permian times, a considerable body of true ferns, side by side with the Pteridosperms, or seed-plants of fern-like habit. The true ferns were regarded as including three groups, the Primofilices, the great tree-ferns of the

¹ Based upon a short course of lectures delivered [at] University College, London, last autumn.

Upper Carboniferous, and a few others, such as the Permian Osmundaceæ.

The Primofilices are undisputed, and so are the Osmundaceæ of the late Palæozoic. The great problem is that of the tree-ferns commonly referred to the Marattiaceæ. These plants had tall stems, reaching at least 60 feet in height, clothed with a felt of descending roots. The highly compound fronds were of the *Pecopteris* type, resembling species of *Cyathea* among living ferns. The stems, known as *Caulopteris* or *Megaphyton* by their external features, as *Psaronius* when the structure is preserved, bore the large and conspicuous leaf-bases, and had a completely fern-like anatomy, usually with many concentric steles. There is a general, though not an exact, anatomical resemblance to the recent Marattiaceæ, and this is also shown in the polyarch roots.

The fructifications, in most cases borne on the underside of the fronds, are also Marattiaceous in type, the sporangia of each group being united together in various degrees, to form synangia. In most of the genera the sporangia are grouped about a centre, the synangium thus being more or less circular, as in the recent *Kaulfussia*. In *Ptychocarpus* they are completely united, and so also in a genus *Cyathotrachus*, discovered by Prof. Watson. In *Asterotheca*, of which many species are known, the sporangia are only slightly connected at the base, and the synangia are seated directly on the frond. In *Scolecopteris* the arrangement differs in the fact that the synangium (of four or five sporangia) is borne on a definite pedicel. In *Acitheca*, often included under *Scolecopteris*, a pedicel is present, but the sporangia are not seated on it but merely fixed around it.

I have recently observed a new species of *Scolecopteris*, and propose to name it *S. Oliveri*, after Prof. Oliver, who brought the material in which the specimens occurred from Autun. The sporangia are elongated, regularly four in each synangium; the most characteristic feature of the new species is that each fertile pinnule is immediately subtended by an apparent sterile pinnule, exactly fitting on to its lower side. It is probable that the two bodies are parts of one and the same pinnule, strongly incurved on itself.

So far, everything in these plants seems fern-like and much suggests the Marattiaceæ. Yet the highest authority, Dr. Kidston, in his latest work, expressed grave doubts as to the nature of this group. His opinion is stated in his great series of memoirs on the "Fossil Plants of the Carboniferous Rocks of Great Britain," which were in course of publication at the time of his death. In his first memoir, Dr. Kidston was still inclined to accept the current view, for he then thought it tolerably certain that the typical *Pecopterids*, with exannulate sporangia united into synangia, were ferns (Part 1, p. 17; 1923). In a later memoir, issued the same year, his tone is more doubtful, but he still allowed that *Asterotheca* and probably a few other Carboniferous plants that bear exannulate sporangia "may be Marattiaceous" (Part 4, p. 277). In the next memoir Dr. Kidston left the systematic

position of *Asterotheca* an open question, but added: "The generic differences which separate *Scolecopteris* from *Asterotheca* are those of degree rather than of structure. The former genus I believe to be more probably a Pteridosperm than a fern" (Part 5, p. 483; 1924). Thus one important genus was already given up, and it was becoming clear that its companion must follow. Lastly, in the final memoir so far issued, Dr. Kidston stated that the affinities of *Acitheca* seemed to him to be Pteridospermous, and if so, that he could not see on what grounds *Asterotheca* and *Scolecopteris* could be excluded from the Pteridosperms. "It would therefore appear that the evidence in support of the occurrence of Marattiaceous Ferns in Carboniferous times rests on supposition, rather than on satisfactory proof" (Part 6, p. 538).²

We thus have to face the question whether true ferns (apart from the special group of the Primofilices) existed in the Carboniferous period. We can come to no conclusion, but may briefly sum up the arguments on either side. In favour of fern-affinities of the plants in question we have:

(1) The habit (unimportant, for undoubted Pteridosperms are just as fern-like); (2) the fructifications, almost the same as in living Marattiaceæ, and, as in them, usually borne on the ordinary frond; (3) the anatomy of stem and root; both altogether like that of ferns, and especially of Marattiaceæ.

Thus, in every respect, these Carboniferous plants appear like ferns. But the following are the arguments on the Pteridosperm side:

(1) The resemblance of the synangia of these plants to those of *Telangium*: this appears to be the point which chiefly influenced Kidston, *Telangium* being regarded as the male fructification of certain seed ferns; (2) *Crossotheca*, known in one case to have been the male fructification of a Pteridosperm, also occurs on *Pecopterid* fronds; (3) *Dicksonites* (= *Pecopteris Pluckenetii*), once universally accepted as a fern, probably Marattiaceous, is now known to have been a seed-bearing plant; (4) the instance of *Pecopteris Wongii*, already discussed, may prove to be conclusive, but the case is not yet closed.

Dicksonites is at present the only plant of the so-called Marattiaceous group which has been definitely proved to be a Pteridosperm. It is therefore of critical importance. The pollen-bearing organs are somewhat obscure. They appear to have been borne on the ordinary leaflets and to have consisted of tufts of sporangia, which Kidston compared to the synangia of *Telangium*. It would be of the utmost value to learn the anatomy of *Dicksonites* to compare with that of *Psaronius*, the type of stem referred to the 'Marattiaceæ.' In the absence of such knowledge, a comparison of the cuticular structure might throw light on the question. If *Dicksonites* showed complete agreement with the remaining "Marattiaceæ," we could scarcely doubt that all alike were Pteridosperms. This, however, is not yet proved.

In the meantime, an anatomist must continue

² Parts 5 and 6 were issued posthumously.

to be influenced by the old anatomical evidence from the completely fern-like structure of the *Psaronius* stems and roots. If *Psaronius* belonged to seed-plants, comparative anatomy would be discredited. Yet it has proved its value, for it was anatomical data which first put us on the track of the Pteridosperms, before the seeds were discovered.

The question of the evolutionary relations of the Pteridosperms, whether they were "ferns which

had become Spermatophytes" or an independent line of descent, cannot be settled until we know whether the tree-ferns of the Carboniferous were ferns indeed or seed-plants simulating them. A seed-bearing *Psaronius* would go far to resuscitate the former hypothesis, which of late years has seemed the less probable of the two. No such case, however, is as yet demonstrated. The whole question is in urgent need of further investigation.

Geometrical Art in South-east Europe and Western Asia.

By Prof. JOHN L. MYRES.

BETWEEN the vivid naturalism of Minoan art, the mature style of Crete and the South Ægean in the later Bronze Age, and the serene idealism of Hellenic art, in the great centuries from the sixth to the third, intervenes a style profoundly contrasted with both, popularly known as the Geometric Style of the Early Iron Age. It inherited something from Minoan art, and contributed more than appears at first sight to Hellenic; but in its maturity it was the negation of all that either Minoan or Hellenic craftsmen aspired to express. Such a group of facts, or sequence of events, presents a problem as fully worthy of scientific treatment as any crisis in geology or natural history: the problem, namely, of the apparitions and disappearances of geometrical art in the lands around the Greek archipelago. For the geometrical art of the Early Iron Age was not the only such occurrence; and its significance is best appreciated by comparison with other geometrical styles.

What we call style is approximation to a standard of achievement; and perfection of style is beauty in art. Geometrical styles come into being in various ways. In primitive Crete, as in other parts of the Mediterranean, vessels of clay were decorated with ornaments which were linear because incised, and rectilinear because they imitated basketry. Such skeuomorphic ornament is not 'geometrical' so long as its imitative intent is obvious; it becomes so as this intent is superseded by appreciation of the linear designs as pure forms and spatial constructions. Before this stage was reached in Early Minoan art, these linear designs were superseded by more or less naturalistic representations of plants and animals, scarcely restricted at all except by the surface of the decorated object.

Similarly, the painted pottery of Thessaly, probably derivative from a widespread Ukrainian culture between Danube and Dnieper, is decorated with lines and bands the prototypes of which—textiles or leatherwork—are uncertain, but the application of which, with utter disregard of the forms of the vessels, is the antithesis of early Ægean 'skeuomorphs.' This primitive style also perished early (with one possible exception) in conflict with the paintless 'gray-ware' of Orchomenus, and the almost paintless 'smear-wares' (*Urfirnis*) of the Greek mainland.

East of the Ægean, in the heart of Asia Minor, another painted linear style, still imperfectly known, influenced Syria and Cyprus late in the Bronze Age. It may be connected either with the Ukrainian culture or with that of Susa and other sites in the Persian hills and early Babylonia. It does not, however, seem to have affected the coast cultures of the Ægean until the Early Iron Age, and even then but slightly.

After great naturalistic achievements, Minoan ornament declined into mechanical and conventional abbreviations, and broke up into numerous local schools, during the troubled centuries from 1400 B.C. to 1100 B.C. or later; and it is as the sequel to this artistic collapse that the Greek geometrical style comes into being. It has been commonly supposed that the new style was introduced into Greek lands by 'northern invaders' from beyond the Danube, or at all events from Danubian countries. But recent discoveries, especially in Macedonia, have shown that, though an invasion occurred about 1100 B.C., its range was restricted, its effects were transitory, and the culture it introduced temporarily had no geometrical elements, other than a fondness for compass-drawn concentric circles, which had a fairly wide vogue in the mature geometrical repertory of the Ægean, and a far more general popularity in the contemporary art of Cyprus, where there is some reason to suppose that it arrived overland through Asia Minor from the same south-east European source. A second suggested source for the geometrical style of the Ægean is in certain scattered and belated survivals akin to the primitive Thessalian decoration, which have been detected in north-western Greece: and as the 'Dorian' invaders of peninsular Greece were traditionally derived from this region, these may represent the decorative style which they had before they came south.

It is difficult, however, to reconcile this explanation either with the sequence of styles in stratified deposits at Sparta, the most purely Dorian state in historic Greece, or with the geographical distribution of more or less geometrical styles in the South Ægean, or (most significant of all) with the very early and emphatic outbreak of geometrical art in Attica and its neighbourhood, which traditionally had been the refuge and rallying ground of non-Dorian and pre-Dorian elements from all parts of the invaded area. That the colonies propagated

¹ Summary of a discourse at the Royal Institution on Friday, Feb. 1.