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On Plant-Remains from the Silurian of Victoria, Australia, that Extend and Connect Floras Hitherto Described

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Phil. Trans. R. Soc. Lond. B 1935 **225**, 127-148
doi: 10.1098/rstb.1935.0009

IV—On Plant-remains from the Silurian of Victoria, Australia, that extend and connect Floras hitherto described

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(Communicated by Professor A. J. Ewart, F.R.S.—Received November 9, 1934—
Read January 31, 1935)

[Plates 10 and 11]

Introductory

Two accounts of plant-remains from the Early Palæozoic rocks of Victoria have been given recently. The more critical as to the age of the plants (Lang and Cookson, 1935) dealt with a small flora found in beds of mudstone containing graptolites. The latter, from two of the localities (Alexandra and Yarra Track), were determined by Dr. G. L. Elles and established the age of the beds as Lower Ludlow. The flora is thus certainly of this age in these two cases, but, since some of the beds in which it occurs are regarded as Middle Silurian by Australian geologists, the age was stated generally as " not younger than Lower Ludlow." There is no doubt as to these vascular or land-plants being Silurian.

In the earlier paper (Lang and Cookson, 1930) a distinct flora was described from the Centennial Beds. These are near the top of the Walhalla series and have usually been classed as Silurian though the possibility that they were younger has been entertained. There are no animal remains, that determine the age palæontologically, associated with these plants. Since the plants known to be of Lower Ludlow age are, if anything, more highly organized than the vascular plants of the Centennial Beds, the weight previously laid on this palæobotanical evidence as indicating a possible Lower Devonian age for the latter must be disregarded. From the Centennial Beds the chief plants were *Sporogonites Chapmani*, *Zosterophyllum australianum* and *Hostimella* sp. From the *Monograptus* Beds a plant with long, simple leaves (*Baragwanathia*), complex synangial fructifications (*Yarravia*) and remains comparable with *Hostimella* sp. were described. Evidence of the plants being vascular and of the structure of the xylem was obtained from both horizons.

The flora to be described in this paper not only contains some new types of plants of botanical interest, but connects the floras of the *Monograptus* Beds and the

Centennial Beds. It includes fructifications of the type of *Yarravia* and stems comparable with *Baragwanathia*, both known from the former, and also *Zosterophyllum australianum* known from the latter.

The plant-remains to be dealt with here were collected from two localities in the neighbourhood of Alexandra. The plant-containing sandstones in these exposures are distinct lithologically from the mudstones with graptolites and plants from the same district that are definitely determined as of Lower Ludlow age (Lang and Cookson, 1935). It appears, however, from a statement kindly supplied to me by Mr. D. Thomas, B.Sc., of the Victorian Geological Survey, that they are regarded as being of the same age as the mudstones. With this remark the stratigraphical problem may be left on one side as beyond the scope of this palæobotanical study.

Most of the material was obtained from a cutting in the old road between Alexandra and Thornton at a distance of about $1\frac{1}{4}$ miles from the former. The exposure occurs on the slope of Mt. Pleasant and will be referred to subsequently by that name. A second exposure, which has yielded similar types though less abundantly, is situated in a cutting on the road to Hall's Flat about 2 miles west of Mt. Pleasant. At Mt. Pleasant no undoubted animal fossils, with the exception of a few pieces of Eurypterid skin, have been found. At Hall's Flat Road the sandstone containing the plant-remains occurs in series with beds of dark mudstone through which run irregular gritty bands containing imperfectly preserved shelly fossils. The latter have, however, not yet been worked sufficiently, either in the field or the laboratory, to warrant more than this passing reference. It is convenient to mention here certain flat incrustations, the surface of which shows a nodular or reticulate pattern. These occur in both localities and are not included among the specimens described below, because it seems probable that they may be of animal nature. Some resemble *Dictyocaris*, Salter, a fossil of doubtful nature from the Downtonian and Silurian of Britain.

The rock in both localities is a fine-grained sandstone which contains distributed throughout it an enormous number of small plant-fragments. It splits irregularly and not along definite bedding planes. It presumably had a deltaic origin and has preserved the large accumulation of plant debris which often forms a conspicuous feature of such beds. The rock presents a considerable resemblance to that of the Centennial Beds of the North Road Quarry, but the plant-remains are even more numerous and more fragmentary than there; they are also less carbonized than some of the material from that locality. The contrast with the mudstone of the *Monograptus* Beds at Alexandra on the other hand is striking; in these the portions of plants preserved were isolated and often of large size but far less numerous.

The plant-remains at Mt. Pleasant and Hall's Flat Road are, even in the best examples, small and fragmentary. They are preserved as incrustations in the sandstone, but are only in a few instances represented by carbonaceous material. In almost all cases this has been replaced by a brown mineral material on which carbonaceous particles may remain. The form and, in the better specimens, the surface markings are preserved, but the material is unsuited for more detailed investigation by means of transfers or film-pulls. These have only yielded information in a few cases where the carbonaceous material has persisted. Some are in part casts, formed by the matrix occupying the interior of the specimens, only the superficial layers being preserved in the brown mineral material. Investigation has thus depended almost entirely on the examination of specimens in the rock by reflected light. Studied in this way they have afforded a considerable amount of information, though some critical points often remain uncertain. The colour of the specimens does not contrast well with the rock, so that difficulties are met with in obtaining clear photographic illustrations which show all that can be observed. I am greatly indebted to Mr. E. Ashby for the trouble he has taken in obtaining the best photographs possible of these difficult objects.

Many fragments are uninstructive and indeterminable, serving only to indicate the abundance of plants in this flora. On the other hand, a number of types that are distinguishable occur among them, often in repeated similar specimens. These include plant-fossils which, while still teaching little about the plant, may be useful for comparison with the floras of other deposits. Some specimens, as mentioned above, can be identified with types already known from the Centennial Beds or the *Monograptus* Beds. In a few instances the specimens demonstrate new Silurian plants of botanical importance.

The best course, in furtherance of our growing knowledge of Silurian floras, appears to be to describe what can be ascertained from the various fragmentary remains, dealing with some very briefly and treating those that are more instructive or critical more fully. This will be of value even though a number of the forms are for the present left unnamed. The various types of plant-remains will therefore be taken in the most convenient order for description. The full discussion will be reserved for the concluding section of the paper.

(*a*) Pachytheca *sp., figs.* 1, 2

Two specimens that can be identified with certainty as examples of *Pachytheca* have been found at Mt. Pleasant. Both are small, spherical, carbonized bodies which have been broken across so as to expose their internal structure. The larger and better preserved example is about 4 mm in diameter. It is shown in fig. 1, Plate 10, at a magnification of two diameters. In it a central medulla 1·5 mm in diameter and an outer cortex approximately 1 mm wide can be distinguished. The latter, when examined with reflected light (fig. 2, Plate 10), shows fine radial striations which indicate the tubular structure that is known to characterize the cortex of *Pachytheca*. It is, therefore, a perfectly typical carbonized specimen of that Alga. The smaller specimen has a diameter of 1·5 mm and, although less well preserved than the figured specimen, shows the differentiation of cortical and medullary regions.

The recognition of *Pachytheca* at Mt. Pleasant has led to the re-examination of a few spherical carbonized bodies from the Centennial Beds at the North Road Quarry,

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Walhalla. These had previously been regarded as indeterminable but, in the light of the good specimen from Mt. Pleasant, can now be recognized as imperfectly preserved examples of *Pachytheca*. The specimens are 2–3 mm in diameter and the split surface shows, though somewhat obscurely, the distinction of cortex and medulla, which affords sufficient direct evidence for their identification. The few specimens as yet found are adequate for the identification of the genus but do not provide structural details for specific diagnosis. Their interest and importance lie in their providing the first record of the occurrence of *Pachytheca* from Australia and indeed from the southern hemisphere.

(*b*) *Spherical tuberculate bodies*, *figs*. 3, 4, 5

The specimens grouped under this heading, unlike those of *Pachytheca*, are of wholly uncertain nature and systematic position; it is not even known that they were of vegetable origin though that is most probable. They are spherical or oval bodies 3–5 mm in diameter which have a varying number of tubercles or nodules on their exposed surfaces. A good example is shown in fig. 3, Plate 10. It is 3 mm in diameter and shows about eighteen medium-sized tubercles. The sandy cast of the fossil is enclosed by a thin brown layer and the concave surface of the counterpart, lined with a similar layer, shows a number of small depressions which correspond to the tubercles of the specimen. In some cases, as in the larger example shown in fig. 4, Plate 10, the surface has a smaller number of tubercles than in the preceding example. They are of larger size and are represented in the hollow mould (fig. 5, Plate 10) as conspicuous round depressions. In this specimen a black layer, about 0·5 mm thick, can be seen around the circumference of the brown cast as well as at the edge of the hollow cavity of the counterpart. The margin of this layer is raised into irregular prominences. This additional layer cannot be seen in any of the other examples. It is probable, therefore, that these are incomplete and that the tubercles, though not of superficial origin, were indicated on the true external surface of the organism.

No information has been obtained regarding the detailed structure of these fossils. In a general way they suggest resemblance to *Pachytheca*, but there is no satisfactory reason why they should be connected with that type. Exactly comparable fossils are not so far known from Australia or elsewhere, but somewhat similar and equally obscure objects have been described by HEARD (1927) from Brecon, and by HALLE (1916) from the Lower Devonian at Röragen in Norway.

(*c*) *Tuberculate stalked reniform bodies ; Sporangia*, *figs*. 6, 7, 8

A different type of apparently tuberculate fossil occurs in considerable numbers isolated amongst the fragments at Mt. Pleasant. They are small incrustations with short stalks and reniform terminal regions of from 1·5–3 mm broad and about 1–3 mm high. The expanded portions show a number of small spherical tubercles, or concavities in the case of the corresponding counterparts, and have clearly defined margins. Typical examples are shown in figs. 6 and 7, Plate 10. In the specimen represented in fig. 8, Plate 10, a single reniform body with circular depressions is attached by a stalk to a stouter axis that apparently continued farther, but no grouping of these structures into fertile spikes has been seen. The tubercles vary both in number and size. There is some reason to think that the tuberculate surface of the cast is not the true outer surface of the reniform body and that, if this had been exposed, the tubercles would not have appeared upon it. A thin dark layer that did not show tubercles externally was removed from one specimen ; the surface then exposed showed small circular depressions, while the inner side of the flake of dark material had corresponding elevations. It is a significant fact also that tubercles are not evident along the convex margin in any specimen. The question of the nature of the tubercles cannot be settled satisfactorily from the present material. There is no evidence that they represent contents such as large spores.

This type of fossil is at present insufficiently understood. The general form closely resembles that of isolated sporangia of *Zosterophyllum australianum*, as described from the Centennial Beds, but the tuberculate surface is a distinct point of difference. It is nevertheless most naturally tentatively compared with isolated sporangia of *Zosterophyllum* and may possibly, when further known, prove to belong to another species of this genus.

(*d*) Zosterophyllum australianum, Lang *and* Cookson, *figs*. 9–12

The occurrence of this recognizable plant, known from the Centennial Beds (Lang and Cookson, 1930), in the deposits at Mt. Pleasant and Hall's Flat Road is one of the stratigraphically instructive features of this flora. Among the fragments not only are there isolated sporangia but portions of fertile spikes showing a number of sporangia borne on a main axis. One of these is shown in fig. 9, Plate 10. The whole specimen is 3·3 cm long, and the portion of the fertile axis beneath the sporangial region, which is devoid of appendages, is 2 cm long and 2·5 mm wide. At its upper part it bears six fairly closely arranged sporangia; three of these are placed laterally on the left-hand side, two on the right-hand side, and the distal one is viewed from behind. The lowest sporangium on the left-hand side is broken across and the plug of matrix has fallen away exposing the cavity, its stalk is 3 mm long and 1 mm broad. The lowest sporangium on the right-hand side is obliquely placed ; it shows a well-defined stalk about 3 mm long that broadens out into the expanded terminal region around the periphery of which a groove can be clearly distinguished. The third sporangium to the left is lying so that its distal end faces the observer with the two lips widely separated by a plug of matrix, and the distal sporangium, seen from behind, shows well the tangential line of dehiscence. The attachment of the sporangia to the fertile axis can be seen even more clearly in the specimen shown in fig. 10, Plate 10, which represents the base of a fertile spike. Two of the sporangia, one on either side, of the axis are attached by stalks each about

4 mm long ; the median sporangium is viewed abaxially. All the sporangia show clear evidence of the tangential groove which marks the region at which dehiscence occurred. The spikes are preserved as black or brown incrustations ; no proof of spores has been obtained from them.

Many examples of isolated sporangia comparable with those seen in the spikes described are met with on the rock surface. They are tangentially expanded bodies, 2·5–4 mm wide, with stalks from 2–4 mm long ; their walls are smooth and many show a distinct marginal rim. A small example is shown in fig. 11, Plate 10. In addition, specimens of larger size have been found, one of these is shown in fig. 12, Plate 10. It is a flattened incrustation in which the expanded region is 8 mm broad and the stalk 6 mm long.

The spikes described above show clear agreement with those of *Z. australianum* from the Centennial Beds. In some cases the sporangia are more laxly arranged than in the latter and the length of the individual stalks is greater. These, however, are minor points and there is no doubt that the specimens from both localities represent the same plant. Many of the isolated sporangia agree exactly with detached sporangia found in the stone at Walhalla. A few (fig. 12, Plate 10) are larger than average sporangia of *Z. australianum* and have a rather leaf-like appearance. These come, however, just within the range found in this species from the Centennial Beds and there seems no reason why they should be interpreted otherwise than as long-stalked sporangia of *Z. australianum*. The additional specimens from these localities do not add to our considerable knowledge of the fertile parts of *Z. australianum* obtained from specimens from the North Road Quarry, Walhalla. Their interest lies in the clear connection they establish between the flora from Mt. Pleasant and Hall's Flat Road with that of the Centennial Beds.

(*e*) *Vegetative branch-systems of* Zosterophyllum, *figs.* 13, 14, 15

Small, smooth branch-systems of peculiar form are present among the fragmentary remains from both deposits. They resemble closely the distinctive H-shaped branch-systems which have been connected with *Z. myretonianum* (Lang, 1927). Such branched axes are here associated with spikes and sporangia of *Z. australianum* and may therefore reasonably be referred to that plant, although organic connection has not been established. The piece of stone from Hall's Flat Road shown in fig. 13, Plate 10, bears a number of branched axes. The branch-system on the left shows typically the ascending and descending limbs of a short lateral branch. In the somewhat different specimen to the right a more horizontal branch gives off ascending axes. The specimen from Mt. Pleasant shown in fig. 14, Plate 10, also has this characteristic type of branch-system with ascending and descending members parallel to the main axis. Further illustration of this feature is afforded by a small axis (fig. 15, Plate 10) which appears to have given off a branch that divided into an ascending axis and one that was directed obliquely downwards. Numerous examples illustrating this type of branching have been found. Their reference to *Zosterophyllum* depends on the special morphology of the branching, since they have not been found combined in one specimen showing the vegetative and reproductive portions as in *Z. myretonianum*. The vegetative characters of *Z. australianum* and *Z. myretonianum* are thus in as striking agreement as the fertile regions.

(*f*) *Smooth-branched axes, cf.* Hostimella *sp., figs.* 16, 17, 18

As is usual in such deposits with fragmentary remains from Early Palæozoic rocks, portions of slender smooth or leafless axes, sometimes showing branching, are common. Such remains are often conveniently referred to as *Hostimella* sp. It is impossible to say that they belonged to any one plant. In this deposit, as in the Centennial Beds, probably some of them were portions of *Z. australianum*, but only connected specimens can demonstrate this. The specimen, illustrated in fig. 16, Plate 10, provides an example of this type from Mt. Pleasant ; the relatively main axis, 2 mm wide, has two alternating lateral branches. Other more disconnected specimens are small Y-shaped structures which suggest dichotomous branching. None shows the oval axillary body often met with in Early Devonian specimens from Scotland and Europe and shown strikingly in examples from the Centennial Beds. Several specimens, however, indicate the presence of an additional and more slender branch just behind the point of bifurcation, figs. 17, 18, Plate 10. In each the raised area on the axis beneath and below the division consists of a core of matrix that is enclosed by a thin layer continuous with that covering the general surface of the stem. A similar feature was described in a specimen of *Hostimella* sp. from the Centennial Beds (Lang and Cookson, 1930, fig. 8). At that time the resemblance to specimens described and figured by Heard (1927) as *Goslingia* was mentioned. The comparison noted then is also applicable to the Mt. Pleasant specimens. They do not supply any further details regarding the morphology of this structure but are useful to connect some of the smooth axes from Mt. Pleasant with those of the Centennial Beds and, possibly, with remains from other regions.

(*g*) *Smooth circinate tips, fig.* 19

A number of examples of slender smooth axes with circinately coiled tips have been met with at Mt. Pleasant. One is shown magnified 10 diameters in fig. 19, Plate 10. The coiled portions range from 1·5–5 mm across and the stems themselves from about 0·25–0·75 mm in width. In the absence of evidence of continuity these coiled terminations cannot be referred to other remains. Comparison is suggested with the smooth axes just described, but none of the latter are sufficiently small to fit directly on to such slender tips. These specimens therefore merely provide evidence of the occurrence of a type of immature tip known from early rocks. None was met with in the Centennial Beds, but an example was found in rock from Waratah Bay, regarded as Upper Silurian by the Geological Survey of Victoria and was figured in 1927. (Lang and Cookson, 1927, fig. 9.)

(*h*) *Pinnately-branched axes, figs.* 20, 21, 22

The specimens placed together here represent a hitherto undescribed type. The example shown in fig. 20, Plate 10, is a slightly curved branch-system 1 cm long seen from one side. From the concave side of the axis five short branches arise and it terminates in a slightly flattened lobe identical with these. The latter are about 2 mm in length and 1 mm in width and broaden gradually as they curve towards the stone. A second specimen, illustrated in fig. 21, Plate 10, shows two of these branch-systems, clearly connected at the base. That on the left, which is seen laterally, corresponds to the previous specimen. It has on the concave margin four branches each about 1·5 mm wide. The branch-system on the right is viewed not laterally but from its inner face. It indicates that the short pinnule-like branches were borne alternately on either side of the relatively main axis. There are three lateral branches on the left-hand side and on the right-hand margin indistinct but recognizable remains of similar branches. Taking the two specimens together it appears that each branch-system approximates to a pinna bearing alternately placed pinnules, though the latter are only slightly flattened branch-terminations and not definitely leaf-like. When seen from the side, as in fig. 20 and in the branch-system on the left in fig. 21, Plate 10, only one row of pinnules is visible.

It is possible that a group of such branch-systems was terminal on an axis. This suggestion is supported not only by the way in which the two pinnæ in fig. 21, Plate 10, are connected basally but by a specimen from Hall's Flat Road illustrated in fig. 22, Plate 10. The main axis in this example, which is 1·5 mm wide and 4 mm long, bears terminally two branches of equal width which curved towards one another. The left-hand branch, which is 1 cm long and 1·25 mm wide, gave off two more slender lateral branches from its inner margin and ended in an enlarged rounded apical region. From the right-hand axis, which is 8 mm long, a single branch only from the inner side can be seen ; the tips of both the branch and axis are covered by the stone. The resemblance of each of these branch-systems to those described above, figs. 21, 22, Plate 10, is evident. The ultimate divisions in the specimen in fig. 22 are, however, longer and to this extent are more like branches and less suggestive of pinnules than the examples first described.

These pinnately-branched axes, and particularly the example illustrated in fig. 20, show some agreement with a small fragment from the Falkland Islands described by Halle (1911). This fragment is a small curved stem on the concave side of which several small appendages are borne. The latter, however, appear to be quite distinct from the pinna-like branches of the Victorian specimens and to have been of fertile rather than foliar nature. No close connection, therefore, on the present evidence can be established between them.

Pinnules are not recognized with certainty in rocks earlier than the Middle Devonian where they are represented by the small ultimate divisions of pinnate branch-systems, *e.g.*, *Protopteridium* (Lang, 1925, Kräusel and Weyland, 1933). It may be mentioned that two obscure specimens from the Lower Devonian of Scotland

(HENDERSON, 1932) suggest a pinnate form. The ultimate divisions of the examples described here are perhaps more branch-like than those of *Protopteridium*, but their relative position on the axis bearing them and their shape suggest comparison with pinnules borne on a pinna. If the tentative suggestion that these pinnæ formed a terminal group on an axis is confirmed by more complete specimens, the type under discussion would contrast with *Protopteridium* in which the pinnæ are laterally arranged.

(*i*) Hedeia corymbosa *n.g.*, *n.sp.*, *figs*. 25–33

A number of fairly complete and connected specimens demonstrate the existence and main features of a new type of fructification, which can be placed in the Psilophytales. In each of them a branch-system is terminal on an apparently smooth axis, and the ultimate divisions, or most of them, end in large elongate bodies that can be recognized with reasonable certainty as sporangia. The tips of the sporangia all come to about the same level, giving a corymbose appearance to the fructification as a whole. Naturally, as they are preserved they show branches mainly in one plane, but there are indications that complete branch-systems are not represented. One imperfect example had the members of a branch-system exposed in different planes by the irregular splitting of the rock. This was ground transversely to the specimen ; the polished surface obtained to a certain extent confirmed the opinion, formed from the examination of the surface view, that this fructification had a radial construction. It is highly probable therefore that the terminal branch-systems were radial or cyclic structures. The specimens show general agreement with one another but differ in the details of the branching and form a series. It is impossible on our present knowledge to determine what systematic value to attach to these differences, and all will be kept for the present under the name *Hedeia corymbosa*.

The specimen which shows the most regular subdivision of the fertile branch-system is illustrated in figs. 25, 26, Plate 11. The main axis, which is 3 mm wide, divided at one level into equal branches 1·75 mm wide, of which four are evident. These at first sight appear in the flattened specimen to be in the same plane, but the two outer ones are actually slightly more deeply placed than the two central ones. Their position is sufficiently distinct to suggest that the branch-system was radially constructed. Three of the secondary axes are fully exposed, but the fourth on the extreme left is almost completely covered by the stone. Two of these branch equally and each subdivision terminates in one or two sporangia. The division of the third axis on the extreme left-hand side is less clearly defined. It narrows at the level corresponding to that at which the first division of the other branches occurred, and it is possible, but not certain, that the diminution in width indicates that a division took place. At this point, however, only one branch can be distinguished and this continues upwards to end in two sporangia. The sporangia are remarkably uniform in size and shape; they are bluntly pointed oval bodies about 1·5 mm broad and 7 mm long and all attain to the same level. No evidence of spores has been obtained but their shape and their width in relation to that of the axes which they terminate leave no doubt as to their sporangial nature.

A second specimen, that comes close in general features to the preceding one, is shown in figs. 27, 28, Plate 11. In it only two primary divisions of the main axis are clearly exposed, but there is evidence of the base of a third more deeply placed branch at a slightly lower level. The ramifications of the left-hand branch are obscure and need not be considered, since the corresponding branch-system on the right-hand side is clear. The axis of this branch-system, which is 1·5 mm broad, divided equally into two more slender branches. One of these, the inner, divided again, and each of the two divisions enlarged almost immediately into a sporangium 9 mm long and 1·5 mm broad. The outer division also branched equally; its inner branch enlarged directly into a sporangium, while the outer branch continued upwards and ended at a higher level in two sporangia each 7 mm long and 1 mm broad. The sporangia all reached the same level above even when they arose at slightly different levels in the fructification, as in the branch just described. In this specimen the more distal sporangia were a little smaller than those originating at the lower level, so that the uniform height of the fertile branch-system was maintained.

A specimen, which shows more conspicuously than did the previous example the lateral position which the sporangia may occupy in these fertile branch-systems, is shown in figs. 29, 30, Plate 11. The main axis, which below is 3·25 mm broad, narrows abruptly to 2·5 mm a short distance beneath its subdivision; it is probable, therefore, that it is incompletely preserved and that only a portion of the whole fructification is represented in the incrustation. Two subdivisions of the main axis are clearly exposed. They are slender stems each 1·5 mm broad which diverge from one another at an acute angle. The branch on the left-hand side, after a length of 3 mm, divided equally; the short inner subdivision terminated in a large sporangium 2 mm wide and 8 mm long and the outer continued on to divide at a higher level. The inner of the two branches produced by this second division formed a sporangium 1·5 mm wide and 5 mm long, while the outer continued beyond as a slender axis. The latter cannot be followed far beyond the insertion of the sporangium. The right-hand subdivision of the main axis is less clearly exposed, but its appearance suggests that the divisions correspond to those of the companion branch. Its first division resulted in a short branch which terminated in a large sporangium and a slender axis which continued upwards. The latter appears to have divided again, at a higher level, into an inner branch which formed a sporangium and an outer which continued on as a slender axis. Between the two clearly defined sporangia on the left-hand side the terminal portion of at least one more sporangium can be seen more faintly. Its point of origin is not exposed, but there is no doubt that it was a part of the fructification. It may quite well have been developed from a branch situated in a different plane. The sporangia in this fructification are of two distinct sizes, the larger originating lower on the axes than the smaller and more distal. The result is that all the sporangia reached a uniform level in the fructification although they did not arise at the same level within it. The sporangia, which are particularly well shown in this specimen, fig. 30, Plate 11, have a uniform appearance up to their rounded tips.

A fructification of very similar form to the one just described is represented in fig. 31, Plate 11. Two subdivisions of the main axis are exposed, one showing more clearly in the figured surface than the other. The right-hand branch, which is 1·5 mm wide, bears on its inner side a sessile sporangium 5 mm long and 1·25 mm wide and continues beyond the sporangium as a slender axis. The latter passes, after a length of 2·75 mm, into the stone without any indication of a sporangial termination. A similar branch can be seen faintly on the left-hand side of the figure; this is more clearly represented in the unfigured counterpart. It bears, on its inner side, a sessile sporangium and continues on for a short distance as a slender stem. Two slightly longer sporangia, 7 mm long and 1·25 mm wide, occupy a central position in the fructification; one of these is shown in the specimen figured, the other in the counterpart, but their relation to members of the branch-system cannot be determined.

The right-hand axis showing the attachment of the sporangium and the sterile part of the branch beyond it is illustrated at a higher magnification in fig. 32, Plate 11. The sporangium itself is split so as to expose a central dark mineralized cast and a thin brown layer which represents the wall. When viewed by reflected light at a still higher magnification, as in fig. 33, Plate 11, the wall shows oblique striations, and is readily distinguishable from the finely granular central cast. The latter is not formed of matrix but from altered contents, and its appearance gives strong support to the view that it represents a mass of spores. The cast is restricted to the lower two-thirds of this and other sporangia and is definitely absent from the terminal portion. It seems, therefore, that the sporangia in this specimen each possessed a sterile tip distinct from a fertile region. This feature is not evident in any of the specimens already described.

The specimen now under consideration (figs. 31, 32, Plate 11) agrees most closely with that illustrated in fig. 30, Plate 11. The sporangia in both appear to have been developed laterally, at different levels, on the inner side of the fertile axes, and to have attained the same level in the fructification by an inequality in their size. The apparent differentiation of the terminal region in the sporangium is a point of difference. A striking feature of agreement, on the other hand, between these two specimens is the sterile continuation of each branch bearing lateral sporangia.

All the specimens placed under the name *Hedeia corymbosa* are of the same general type. There are indications, however, of a range from equal divisions of successive branches that ended ultimately in sporangia to unequal divisions with a lateral arrangement of sporangia on one side of the fertile branches. In the first specimen, described above, each of the subdivisions ended in a sporangium. In the last specimen, on the other hand, the sporangia were borne subterminally on fertile branches that ended in slender sterile terminations. This arrangement is consistent with differences in the appearance of specimens on the rock, and is applicable whether the specimens were branch-systems in one plane or, as is more probable, were radially arranged groups of axes. The specimens do not suffice to go further than this. They appear to be a set of fructifications showing large terminal sporangia

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

grouped together in distinctive branch-systems. The sporangia sometimes have sterile tips, and always reach the same level in the fructification. The matter will be left thus and will be referred to later in the comparative discussion.

(*j*) *Cf.* Yarravia, *figs.* 34, 35

This genus (Lang and Cookson, 1935) includes cyclic or radial fructifications in which a small number of large elongate-oval sporangia are enclosed by tissue continuous with the stalk, to form a synangial structure that possibly surrounded a central space. The original specimens from the *Monograptus* Beds at Yarra Track are flattened carbonaceous incrustations. Some specimens from Mt. Pleasant, though differently preserved, appear to be closely comparable, in the essential features of their construction, with those from Yarra Track and can be placed under the above heading. Two of these can be compared most easily with *Y. oblonga*. They differ from each other in some details but have not been distinguished here as separate species.

The specimen shown in fig. 34, Plate 11, is a thin incrustation of the brown mineral material. It is the best of a small number of similar examples which agree closely in size and shape with *Yarravia oblonga*. The stalk is about 2·5 mm wide and the terminal fructification measures about 9 mm in length by 6 mm in width. The uniform brown colour of the material renders the distinction of regions, within the oblong fructification, more difficult than in carbonized specimens. At the upper free end the projecting tips of three sporangia can be distinctly seen. The sporangia are held together in the fructification but, although indications of the outer layer continuous with the stalk and of the connecting tissue between the sporangia can be detected, this construction is not so evident as it was in the carbonized specimens. The sporangia of the figured specimen are about 2 mm wide and 9 mm long. They show no indication of the distinction between a lower spore-producing region and a sterile tip that was seen in *Y. oblonga*, but this may be due to the different preservation. Only three sporangia are clearly shown but, presuming the fructification to have been radially constructed, there may have been five or six in all. A circular mark, appearing in the figure as a lighter area below the middle sporangium, may represent the base of a sporangium that lay at a different level. It may be mentioned that in a specimen which had split irregularly there were indications of three sporangia at one level and two at another. It was, however, found impossible to show this feature clearly in a figure.

A single specimen shown in fig. 35, Plate 11, is also clearly a synangial fructification with the morphological construction of *Yarravia*. It is preserved in the solid but is not a mere cast, since it exhibits differences between the various regions of the fructification. The stalk is 1·8 cm long and 3 mm wide while the terminal fructification is 8 mm long by 6 mm in width. The latter is contracted somewhat at the summit so that it appears globular rather than oblong. Continuous with the stalk, and represented like it by a fine-grained grey mineral that contrasts with the sandstone, is a thick outer layer which can be traced on either side of the fructification. Within this are a small number of large sporangia. Two of these are fully exposed, one on either side of the middle line, and the base of a third sporangium is seen between and beneath them. It seems possible that four or even five could have been included in the fructification but only three are distinctly shown. Each of the two completely exposed sporangia exhibits a clear distinction into a solid, oval, yellow mass 2 mm in width and 4 mm long and a flattened, bluntly-pointed, terminal region 2 mm long in which none of the yellow material is present. The most natural interpretation appears to be that the yellow material here represents the mass of spores which was absent from the sterile tip. The whole sporangium would thus be about 6 mm long. A corresponding differentiation was noticed in the carbonized sporangia of *Y. oblonga* (Lang and Cookson, 1935, figs. 40, 41). While this is a detailed feature of agreement, the contracted summit and the more globular form of the fructification as a whole in this single specimen are differences from *Y. oblonga*. When more specimens are available it may be desirable to regard it as a distinct species.

(*k*) *Fructification ;* incertæ sedis, *fig.* 36

The single specimen shown in fig. 36, Plate 11, is of considerable morphological interest, but presents great difficulties in its interpretation and description. It is possible to compare it with *Yarravia* in certain respects and in others with *Hedeia*.

It appears to be the flattened incrustation of a fructification, the general form and proportions of which are defined by the bright yellow material which contrasts with the stone in which it lies. Only the fructification, which measures 8·5 mm in length by 7·5 mm in width, is preserved, but there is no reason to doubt that it was borne terminally on a stalk. The yellow area appears to be delimited from the rock by a thin brown layer. Within the yellow material large sporangia are clearly defined by their brown walls and by the deeper yellow tint of their flattened contents. Three sporangia about 1·5 mm wide and 7 mm long can be recognized on the exposed surface. One is in a central position, one incompletely preserved is on the right, and another that is complete is seen on the left. The most complete sporangium widens out from a distinct stalk and has a rounded tip not differing from the rest of the sporangium. The dark-brown material which represents the sporangial wall shows oblique striations. No evidence of spores has been obtained. The tips of two other sporangia emerge from the stone at a deeper level and are seen in the figure. Taking these into account, there would have been at least five sporangia in the fructification arranged in a cyclic manner around a central space. A striking and peculiar feature, which is, however, quite definitely shown on the left-hand side and is also to be made out on the right, is that each sporangium is borne on the inner side of an "axis-like" structure ; this continues upwards, within the yellow area, parallel to the outer side of the sporangium. Judged from what is shown by these two laterally-placed sporangia, it seems probable that all the sporangia in the fructification were borne in this fashion. The brown limiting layer of the "axis-like" structure is longitudinally striated and thus contrasts with the oblique striation of the sporangial wall.

This single specimen presents a morphological dilemma which can only be resolved by further evidence. On the one hand, the lateral position of each sporangium on the inner side of an " axis-like " structure is in favour of a comparison with *Hedeia* (*cf.* fig. 31, Plate 11). This view involves regarding the brown, longitudinally-striated layer as the outer surface of the axes and disregarding the yellow material in which both sporangia and axes appear to be embedded. On the other hand, the continuity of the brown outer layer over the whole fructification and the yellow material connecting the sporangia are features strongly in favour of interpreting the fructification as synangial. It would then be comparable with the fructification of *Y. subsphærica*, though more complex. If this second view is adopted, however, the continuation of the " axis-like " structures in the yellow material must be regarded as vascular cylinders only. This seems to be the more possible interpretation of this fructification, though not a completely satisfactory one.

This exceptionally interesting specimen must be left with these suggestions of alternative explanations in the hope that further examples may bring greater clearness.

(*l*) *Stems with relatively large leaves ; cf.* Baragwanathia longifolia, *figs.* 37–40

Several examples, at Mt. Pleasant, demonstrate the presence in this flora of relatively broad stems that bore large and probably long, linear leaves. Complete leaves are not preserved in any specimen, but the width of the stems and the relative proportions of the leaf-bases provide sufficient evidence to justify comparison with *Baragwanathia longifolia*.

The specimen shown in fig. 37, Plate 11, is an unbranched stem 1·5 cm broad preserved as a slightly flattened incrustation. Along the left-hand margin the bases of several leaves are inserted at intervals of 4–6 mm. All the leaves are incomplete, but a sufficient length is preserved in some of them to show that they were linear in form and about 1 mm broad. They pass back into the stem without any appreciable basal expansion. The central cast of the stem, which is enclosed by a thin layer of brown material, has been removed from the upper part of the specimen. In the region thus exposed there are several irregularly placed oval depressions each about 1 mm diameter. These apparently mark the insertion of leaves on the surface of the stem that lies against the rock. More frequently the leafy character of broad stems from this locality is indicated only by round or oval elevations on the exposed surface of the incrustation or by similarly shaped depressions in the counterpart. A specimen of this nature is shown in fig. 38, Plate 11. This incrustation, which is about 1·2 cm broad, shows clearly leaf-bases which are arranged in a definite spiral. The surface of the stem is longitudinally folded but the ridges do not appear to be especially related to the leaf-scars. No leaves or their bases can be seen on either margin. A small portion of a stem 3·5 cm wide is shown in fig. 39, Plate 11, it bears several large leaf-scars each 2·5 mm in diameter. Thus the specimens in figs. 37–39, Plate 11, exhibit a considerable range in size (1·5–3·5 cm).

The Mt. Pleasant material does not add anything to our knowledge of the morphology of this type of plant, but the brown material of some of the incrustations, including the first two described, has a surface sculpture which preserves the form of the cells of the epidermis. A small fragment of a larger stem, that includes two leaf-scars, was particularly instructive in this respect. A portion of its surface, as viewed by reflected light, is shown in fig. 40, Plate 11. The pattern consists of raised rectangular areas 72–130 μ long and 36–45 μ wide, separated by narrow furrows, and at frequent intervals small oval depressions lined with black material. These depressions, which are 54–74 μ long and 36–45 μ wide, may possibly indicate the position of stomata, but there is no structural evidence to confirm this. A similar pattern is also present on the surface of the leaf-bases, but here the areas are narrower and proportionately longer. These specimens demonstrate definitely the occurrence in this flora of plants with broad leafy stems. Examples showing the size and shape of the complete leaves have not been obtained, so that only general comparisons with similarly imperfect shoots of other leafy types can be made. The most natural of these is with *Baragwanathia longifolia* from the *Monograptus* Beds, although the agreement of these imperfect specimens with *Drepanophycus* (*Arthrostigma*) from the Lower Devonian of Scotland, Germany and Canada is almost equally close.

(*m*) *Stems with small leaves or spines, figs.* 41, 42

The absence of stems with small leaves or spines, such as *Psilophyton princeps*, has been a remarkable feature of the plant-containing beds of the Victorian Silurian. The present flora, although it has not provided undoubted examples of this species, does contain some specimens showing small leaves or spines, but these are peculiar in several respects. One of them is shown in fig. 41, Plate 11. It represents a small curved stem about 0·5 mm broad and 12 mm long. On its concave margin ten small spine-like appendages are inserted at right angles. As exposed, the spines measure about 1 mm in length and gradually taper towards their apices. In no case can their entire length be determined since the extreme tips of all the spines are covered by the rock. The outer margin of the stem is sharply defined and devoid of spines and there is no evidence of these on its surface. Another almost identical specimen was found.

A single specimen (fig. 42, Plate 11) shows two small axes of this type as the ultimate divisions of a branch-system. The relatively main axis, which is a smooth stem about 1 mm broad, gives off a branch to the right which terminates in two small axes directed towards one another. The outer of these is a small slightly curved stem about 0·5 mm broad. On its inner side four small spines are inserted. Two of these are complete and show that the widened basal region narrows into a linear termination, the other two are represented by their bases only. Spines are completely absent from the outer margin and there is no evidence of them on the flattened surface. The corresponding inner branch has portions of at least three spines on the slightly concave margin. These are less clearly defined than those of the companion branch and being out of focus cannot be seen in the figure. In this branch also there is no evidence of spines either on the outer margin or on the exposed surface. The spines are restricted in this specimen to these two small ultimate divisions of the branch-system. Further they appear to have been developed only on the inner slightly concave margins of the small curved axes. The latter are closely similar to the isolated curved axis (fig. 41, Plate 11) described above, and it is probable that they were identical structures. In all the specimens the spines appear to be restricted to the inner margin of small branches. This is a peculiar and hitherto undescribed character. The fact that the same character has been repeated in three separate examples strengthens the probability that the localization of the spines is a natural feature.

(*n*) *Stems with small, spirally arranged elevations, figs.* 43, 44, 45

Among the fragmentary axes of medium size at Mt. Pleasant are numerous examples with small elevations on their surfaces. In the counterparts these appear as depressions. The specimens include stems of from 2–15 mm in width, but the majority are about 3 mm broad. The elevations are round or oval in form; their range in length is from 0·2–0·7 mm and their long axes are parallel to the length of the stem. Frequently, as in fig. 43, Plate 11, the elevations are extremely numerous and closely arranged, in others, as for example in fig. 44, Plate 11, they are more widely spaced and their outline is more sharply delimited. They appear to have been arranged spirally on the stems. Branching in stems of this type is either by unequal division, when the appearance is that of lateral branching, or by equal division, as in the specimen represented in fig. 45, Plate 11. One small stem, with conspicuous circular elevations, appeared to have a coiled tip. The significance of these elevations has been rendered the more obscure by the appearance of the specimen shown in fig. 45, Plate 11. In this case the central cast has been removed from the greater part of the stem so that the inner side of the rather thick external brown layer is exposed. The inner surface shows small markings in relief which resemble in form those on the outer surfaces of other specimens.

Although a considerable number of examples has been available for investigation, the nature of these surface markings remains obscure. No stems of this type have shown indications of the attachment of small leaves either to the margins or to their flattened surfaces. It seems probable that the small elevations represent the bases of small leaves or emergences, but the evidence is not sufficiently clear to make this certain. While not demonstrating the presence of small-leaved plants in this flora, these specimens suggest that future collecting probably will establish their occurrence.

(*o*) *Vascular tissue, fig.* 23

In a transfer of one specimen of the type described above, that is a stem with small elevations, indications have been obtained of a small central strand in position in the stem. At the edge of the strand a few tracheides are preserved which show remains of the thickening on their walls. This has the form of narrow rings that are separated by wide unthickened areas. Vascular tissue composed of similar tracheides has been seen also in pulls from isolated carbonized or mineralized fragments in the rock from both Mt. Pleasant and Hall's Flat Road. A single tracheide from one such piece is shown at a magnification of 460 diameters in fig. 23, Plate 10. The thickened rings are narrow and clearly defined, but the wall in the wide unthickened areas between them is considerably broken down. The tracheide is clearly of the annular type and can be regarded as typical of all the woody fragments examined from both deposits. Parenchyma is not associated with the tracheides. Vascular tissue of this type has been described in Victoria from both the Centennial Beds and the *Monograptus* Beds. It is met with also in most of the early Palæozoic plants from other regions. The isolated fragments studied cannot be assigned, therefore, to any particular member of the flora since they may quite well have belonged to any one or to a number of plants preserved in these beds.

(*p*) *Ribbed stems, fig.* 24

Fragments that demonstrate the presence of a distinct type of stem in this flora occur at both localities. They are portions of smooth stems, from 4–6 mm wide, with distinct and approximately equal, longitudinal ribs. None gives any idea of the form of the plant. The example illustrated in fig 24, Plate 10, is a branched axis of this type. The relatively main axis, which is 5 mm wide, shows a single slightly unequal division. Its surface has five distinct ribs, each about 1 mm wide, which are continuous with those of its branches. There is no evidence that such stems possessed leaves or emergences.

Longitudinally ribbed smooth stems have been recorded from the North Road Quarry, Walhalla, and from a locality at Knott (Lang and Cookson, 1930, p. 136). These were more slender than the present examples, but the ribs though consequently fewer in number were equally distinct. It is probable, therefore, that both were parts of the same general type of plant. The present material is extremely fragmentary and will only be of interest should more complete examples be found.

Conclusion

The comparative bearings of the various types of plant, distinguished in the flora from the beds at Mt. Pleasant and Hall's Flat Road, have been touched on in the course of their description. Some of the remains call for more general consideration, but in a number of cases there is little or nothing to be said. Among these the globular tuberculate bodies and the tuberculate, reniform " sporangia " have only been met with so far in this flora and are of wholly uncertain nature. Nor is there anything more to say regarding the fragments of longitudinally-ribbed stems. The remains compared with *Hostimella* sp. are of a type widespread in early rocks and need no further discussion. There is no reason to doubt that they and most of the other plants in this deposit were vascular, and proof of the occurrence of vascular tissue is afforded by some fragments showing tracheides with annular thickening. The smooth pinnately-branched axes, though still insufficiently known, are of interest in affording the only indication of " pinnule-like " structures among the plant-remains.

The fertile spikes and isolated sporangia of *Zosterophyllum australianum* add nothing to our previous knowledge but clearly connect this flora with that of the Centennial Beds from which the species was described. The discovery of characteristic branch-systems which doubtless belong to this plant is of more interest. They agree with branch-systems belonging to *Z. myretonianum* (Lang, 1927) that have long been known from the Lower Devonian of Scotland and were originally figured by Hugh Miller (1857, fig. 123). A branch-system of this type from the Perry Basin, Maine, which was described by White (Smith and White, 1905) under the name *Psilophyton alcicorne*, was referred to the Upper Devonian. Seward (1931, p. 124) suggested that it probably came from a lower horizon and that it might well have been a piece of *Zosterophyllum*. The fact that the branched axes under consideration here were found associated with fertile spikes of *Z. australianum* makes it almost certain that they were the vegetative portion of that plant.

The evidence obtained as to the occurrence in this flora of fairly large stems that bore simple leaves which must have been of considerable size, is of interest in several respects. The specimens are most naturally compared with *Baragwanathia* from the *Monograptus* Beds. In the imperfect condition in which the specimens are preserved a comparison with *Drepanophycus* would also be possible, but the portions of the leaves that persist are more suggestive of *Baragwanathia*. In any case the occurrence of a plant of this type connects the flora with that of the *Monograptus* Beds. The only addition to our knowledge made by the specimens from Mt. Pleasant is the demonstration of the form of the epidermal cells.

The question of the occurrence of plants with small leaves or emergences is one that requires some consideration. There has, so far, been a remarkable absence of this type of plant from the early floras of Australia. One obscure and doubtful specimen was mentioned in this connection in the paper on the flora of the Centennial Beds. Neither *Psilophyton princeps* nor any other similar small-leaved plant has so far been shown to occur in the southern hemisphere. The deposit under consideration has provided somewhat better evidence in this connection. A few specimens from Mt. Pleasant have been shown to bear definite small spine-like leaves or emergences, but these appear to be limited to one edge of peculiar ultimate divisions of a branch-system. Direct comparison with *Psilophyton princeps*, where the spines occur all over the surface of the cylindrical branches, would be therefore unjustifiable. The stems from Mt. Pleasant that bear small elevations or scars spirally-arranged on the surface may, however, be more comparable to *Psilophyton princeps*. The appearance and arrangement of the projections on these stems suggests that small appendages may have been borne on them, but no proof of this has been obtained.

Perhaps the most important group of remains in the Mt. Pleasant flora are those of terminal fructifications. In this respect the flora has proved surprisingly rich

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

and has provided instructive specimens. Some of these are sufficiently similar to *Yarravia oblonga* to be placed as at least closely comparable with it. Several types of non-coherent fertile branch-systems placed under the name *Hedeia corymbosa* are not only quite new but may prove to have important bearings on the fructifications of the *Yarravia* type. There is reason to think that the primary branching of the fructifications of *Hedeia* was more or less cyclic and terminal on a main axis. The primary branches subdivide and bear large terminal sporangia, the tips of which are in various ways brought to the same level in the corymbose structure. The specimens exhibit a range from equal dichotomy of the branches (all the subdivisions ending in equally large sporangia), to a one-sided branching in which the more distally placed sporangia are shorter than the more central, so that all the tips reach the one level. In some specimens the ultimate outer division of the branch is a sterile axis. This last type appears to lead on to a remarkable but imperfectly understood fructification that superficially resembles *Yarravia* and may indeed prove to be synangial like this.

The morphological problems raised by this series of specimens will not be entered into here. In describing the synangial fructification of *Yarravia* from the *Monograptus* Beds (Lang and Cookson, 1935), the support which its discovery gives to certain phylogenetic speculations of Dr. T. G. Halle (1933, pp. 56-59) was mentioned. In dealing with morphologically similar spore-producing organs from the Carboniferous, which belong to the Pteridosperms, he suggested their possible origin from fertile branch-systems of the Psilophytales. The discovery of complex fructifications of the types included in *Hedeia*, in association with synangial fructifications like *Yarravia*, in the beds at Mt. Pleasant lends further support to Halle's general view. These fructifications are more complex than the Psilophytalean type of fructification assumed by Halle as his starting-point and raise morphological problems which cannot be treated at present. Enough has been said to indicate the interest of this group of remains. It may be well to await the discovery of further types or a fuller knowledge of the types described here before venturing on further speculations. Stratigraphically the occurrence of *Yarravia* in the Mt. Pleasant Beds is another link with the flora of the *Monograptus* Beds.

The last of the plants from the Mt. Pleasant flora that must be commented upon is *Pachytheca*. The discovery of well-characterized carbonized specimens of this peculiar Alga in the Silurian of Australia is of considerable botanical interest. In appearance and structure the specimens agree with the carbonized examples from the early Palæozoic rocks of the northern hemisphere. Its discovery in Victoria, however, greatly extends the geographical range of *Pachytheca*. So far it is certainly known from Britain and Canada and more doubtfully from Norway. In Britain its stratigraphical range is from the Wenlock Shale to the Lower Old Red Sandstone, with a single specimen in beds of the Rhynie outlier, that are regarded as of Middle Devonian age (Kidston and Lang, 1924). Its presence in the rocks at Mt. Pleasant and in the Centennial Beds is thus quite consistent with their Silurian age but not evidence of this.

The preceding remarks will serve to bring out the chief points of interest of some of the plants in the flora under consideration. By the addition of new forms the flora extends our knowledge of the Silurian plants of Australia. It also serves to connect the floras previously described from the *Monograptus* Beds and Centennial Beds by including types hitherto known from only one or other of them. Thus, as pointed out, *Zosterophyllum australianum* has hitherto been found only in the Centennial Beds and *Baragwanathia* and *Yarravia* only in the *Monograptus* Beds. The examination of the plant-remains from Mt. Pleasant shows that these types coexisted and thus gives a more general idea of the composition of the Silurian flora.

It may be mentioned here that specimens comparable with *Hostimella* sp. and fructifications of the type of *Yarravia* have been collected from the mudstones underlying the Yeringian (Wenlockian) Limestone at Lilydale, Victoria. The Silurian flora is thus known from four sets of localities, the *Monograptus* Beds, the Mt. Pleasant Beds, the Lilydale mudstones, and the Centennial Beds. This flora may well have had a considerable vertical range. Its similarity in these localities need not indicate that they are at the same stratigraphical level within the Silurian. No opinion is expressed here on this geological question.

The flora now includes, to mention only named forms, *Pachytheca*, *Sporogonites*, *Hostimella* sp. *Zosterophyllum*, *Baragwanathia*, *Yarravia*, *Hedeia*. It is clear from our growing knowledge that it was not only extensive for an early flora but included a variety of complex types of plants. There is no reason to doubt its Silurian age, which is conclusively established for some of the plant-containing beds. Yet as compared with what is known from the northern hemisphere this flora could be regarded as Lower Devonian. So far no plant-remains have been found in the Lower Devonian of Australia. It would be of great interest to know the composition of the flora and the grade of organization of the plants of this period in the southern hemisphere.

This investigation, begun in the University of Melbourne, has been completed and the results prepared for publication in the Barker Research Laboratory of the University of Manchester. The material was re-examined and the problems raised were discussed with Professor W. H. Lang, F.R.S. The present form of the paper is, indeed, largely due to his help and criticism, both of which I wish to acknowledge with gratitude. This paper, together with two joint papers previously published (Lang and Cookson, 1930, 1935) will serve to give the results of the preliminary survey and botanical investigation of the plants of the Silurian flora of Victoria.

Diagnosis of New Genus and Species

Hedeia, n. gen.

Fertile branch-systems, the main axis bearing secondary branch-systems terminally. Large elongate-oval sporangia terminate the sub-divisions of the secondary branches, all their tips coming to the same level in the corymb-like branch-system. Secondary branches may either subdivide dichotomously, the terminal sporangia all being the same length ; or the sporangia may be borne to the inner side of the branch-system, those centrally placed being longer than the more distal. In some cases the ultimate division of the secondary branch-system is sterile.

H. corymbosa, n. sp.

Characters of genus—Fertile branch-systems 1–2·5 cm long by 1–2 cm across ; sporangia 5–9 mm long and 1–2 mm broad.

Horizon—Silurian, probably Lower Ludlow.

Locality—Mt. Pleasant, Alexandra, Victoria, Australia.

Summary

1—The flora, preserved as fragmentary remains, in beds of sandstone at two localities (Mt. Pleasant and Hall's Flat Road) near Alexandra, Victoria, Australia, is described.

2—The plants include *Pachytheca* sp. ; *Zosterophyllum australianum* ; stems with leaf-bases, *cf. Baragwanathia* ; stems with small spine-like leaves or small protuberances ; synangial fructifications, *cf. Yarravia* ; a new type of fructification, *Hedeia corymbosa*, n. g. n. sp. ; besides several kinds of less determinable plants.

3—The possible bearing of the fructifications of *Hedeia* on the morphology of such a synangial type as *Yarravia* is briefly considered.

4—The flora at Mt. Pleasant serves to connect the two floras previously described. It includes *Zosterophyllum australianum* hitherto only met with in the Centennial Beds, and on the other hand *Yarravia* together with stems like those of *Baragwanathia* found in the *Monograptus* Beds.

5—The flora is of the type found in the Upper Silurian rocks of Victoria and thus is consistent with the opinion of the Geological Survey of Victoria that the beds at Mt. Pleasant are of the same age as the *Monograptus* beds.

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PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Explanation of Plates

(All the figures are from untouched negatives. All specimens from Mt. Pleasant except where mentioned. C. before a specimen number refers to the Cookson Collection.)

Plate 10

Fig. 1—*Pachytheca* sp. A carbonized specimen split across. × 2. (C. 35.)

Fig. 2—*Pachytheca* sp. The same specimen enlarged to show differentiation into cortical and medullary regions and radial striations in the cortex. × 7·5.

Fig. 3—A spherical tuberculate body. × 5. (C. 164.)

Fig. 4—A brown tuberculate cast showing an outer layer, raised into blunt projections around the circumference. × 5. (C. 165.)

Fig. 5—Concave mould of the previous specimen showing position of tubercles as large depressions. (C. 165 (*a*)) × 5.

Fig. 6—A shortly-stalked, tuberculate reniform body (? sporangium). × 5. (C. 54.)

Fig. 7—The concave mould of another tuberculate reniform-body showing small circular depressions, a distinct stalk, and marginal rim. × 5. (C. 53.)

Fig. 8—A reniform body with small concavities, showing its attachment by a short stalk to an axis. × 4. (C. 52.)

Fig. 9—*Zosterophyllum australianum*. A fertile spike showing the insertion of six sporangia. × 4. (C. 6.)

Fig. 10—*Z. australianum*. Portion of another spike, showing the insertion of sporangia by long stalks on the fertile portion of the axis. × 5. (C. 159.)

Fig. 11—*Z. australianum*. A small isolated sporangium showing a long slender stalk, and distinct marginal rim. × 4. (C. 175.)

Fig. 12—*Z. australianum*. A large isolated sporangium. × 4. (C. 50).

Fig. 13—*Z. australianum*. Branched stems from Hall's Flat Road. × 2. (C. 76.)

Fig. 14—*Z. australianum*. A vegetative axis with a lateral branch divided into ascending and descending limbs. × 5. (C. 26.)

Fig. 15—*Z. australianum*. Another example of a small branch-system. × 5. (C. 25.)

Fig. 16—*Cf. Hostimella* sp. Smooth axis with two lateral branches placed alternately. Nat. size. (C. 169.)

Fig. 17—*Cf. Hostimella* sp. Dichotomously divided axis showing the cast of a third branch below the bifurcation. × 5. (C. 12.)

Fig. 18—*Cf. Hostimella* sp. Another example of a branched axis showing the base of a third branch in an axillary position. × 5. (C. 7.)

Fig. 19—A smooth circinately coiled stem-tip. × 10. (C. 36.)

Fig. 20—A pinnately-branched smooth axis showing five short lateral branches arising from the concave margin. × 5. (C. 46.)

Fig. 21—Mould of an incrustation representing two connected pinnately-branched axes. × 4. (C. 168.)

Fig. 22—A branch-system from Hall's Flat Road showing short lateral branches from the concave margins of two subdivisions of the main axes that face one another. × 4. (C. 47.)

Fig. 23—A single tracheide with annular thickening from a small carbonized vascular fragment. × 460.

Fig. 24—Ribbed stem with one lateral branch. × 4. (C. 81.)

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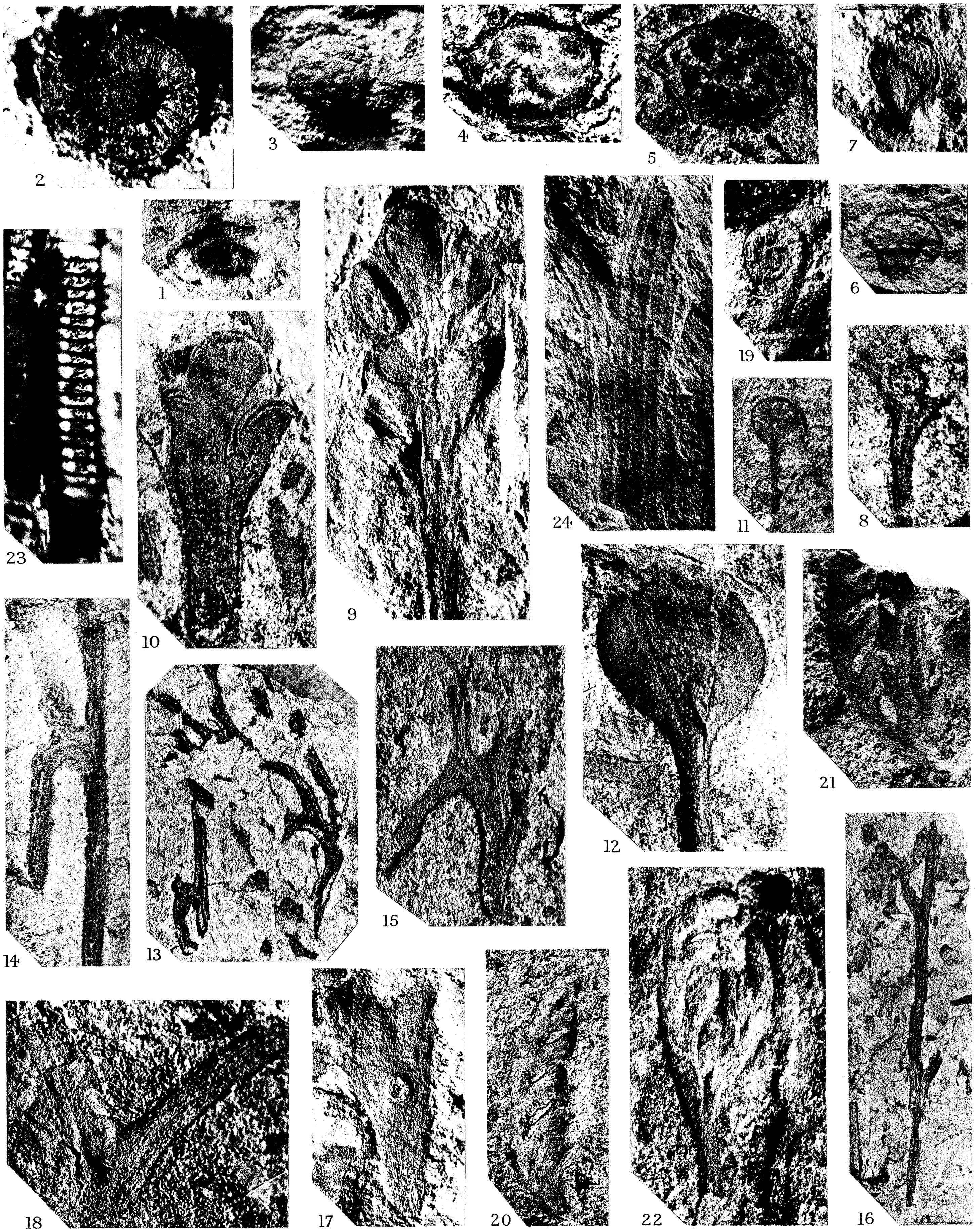
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Plate 11

Fig. 25—*Hedeia corymbosa.* A fertile branch-system showing equal sub-divisions at equivalent levels and large terminal sporangia. Nat. size. (C. 70.)

Fig. 26—Upper part of the same specimen. × 5.

Fig. 27—*H. corymbosa.* Another specimen showing dichotomous branching and terminal sporangia that reach the same level; the branch on the extreme right shows the sub-lateral position of two sporangia. Nat. size. (C. 5.)

Fig. 28—The above specimen. × 2½.

Fig. 29—*H. corymbosa.* A specimen showing the branching of two secondary axes, and the relation to them of laterally-borne sporangia of two sizes. Nat. size. (C. 152.)

Fig. 30—The same specimen. × 5.

Fig. 31—*H. corymbosa.* A fructification showing internal position of sporangia and the continuation of branches beyond the sporangia as small sterile axes. The left-hand branch is only faintly represented. × 4. (C. 71.)

Fig. 32—A portion of the right-hand branch of the same specimen enlarged to show attachment of sporangium, and the small sterile axis beyond it. × 10.

Fig. 33—A small area of the above sporangium showing the obliquely striated wall and the granular mineralized cast that represents its contents. × 29.

Fig. 34—*Cf. Yarravia oblonga.* A brown incrustation showing the free tips of three united sporangia. × 4. (C. 195.)

Fig. 35—*Cf. Y. oblonga.* A stalked synangium with a thick wall showing two complete sporangia with sterile tips and the base of a third sporangium. × 4. (C. 45.)

Fig. 36—Fructification, *incertæ sedis.* Radial group of possibly united sporangia showing the sub-lateral relationship of one of these to an "axis-like" structure; further description in the text. × 4. (C. 197.)

Fig. 37—*Cf. Baragwanathia longifolia.* Stem with leaf-bases on the left-hand margin. Nat. size. (C. 187.)

Fig. 38—*Cf. B. longifolia.* Brown incrustation showing spirally arranged, circular leaf-scars. Nat. size. (C. 174.)

Fig. 39—*Cf. B. longifolia.* Broad stem with large leaf-scars. Nat. size. (C. 32.)

Fig. 40—Portion of an epidermal pattern on surface of an incrustation as seen by reflected light, showing the form of the epidermal cells and smaller dark areas, which possibly indicate the position of stomata. × 29. (C. 158.)

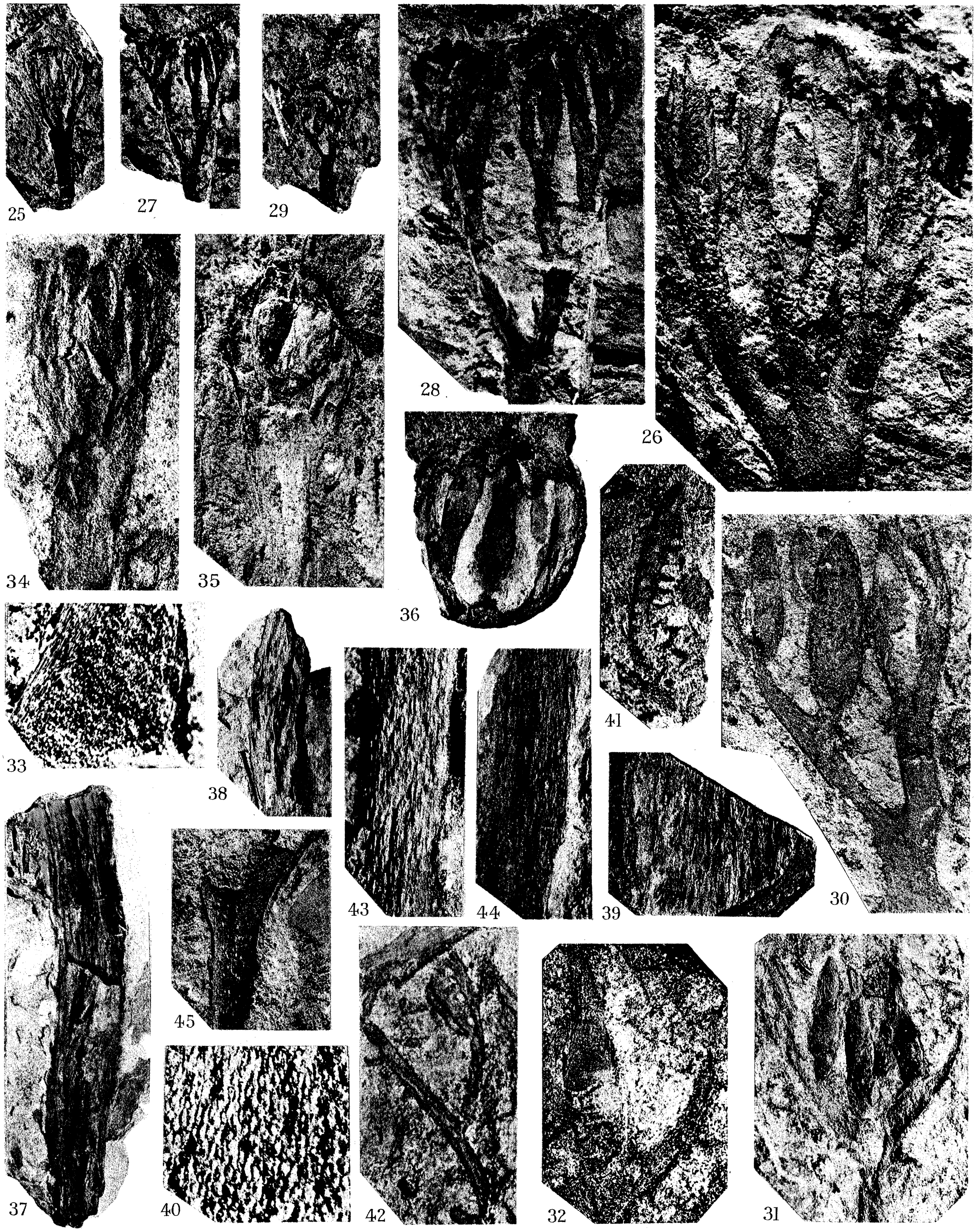
Fig. 41—Small curved stem showing small spines on the inner margin. × 5. (C. 166.)

Fig. 42—Small branch-system the right-hand axis of which ends in two small branches. The outer of these shows the position of small spines on its inner margin. × 4. (C. 41.)

Fig. 43—Stem showing numerous small elevations. × 5½. (C. 191.)

Fig. 44—A similar stem with more widely spaced, larger elevations. × 5½. (C. 157.)

Fig. 45—Branched stem showing small oval elevations on inner surface of the concave brown layer. × 2. (C. 39.)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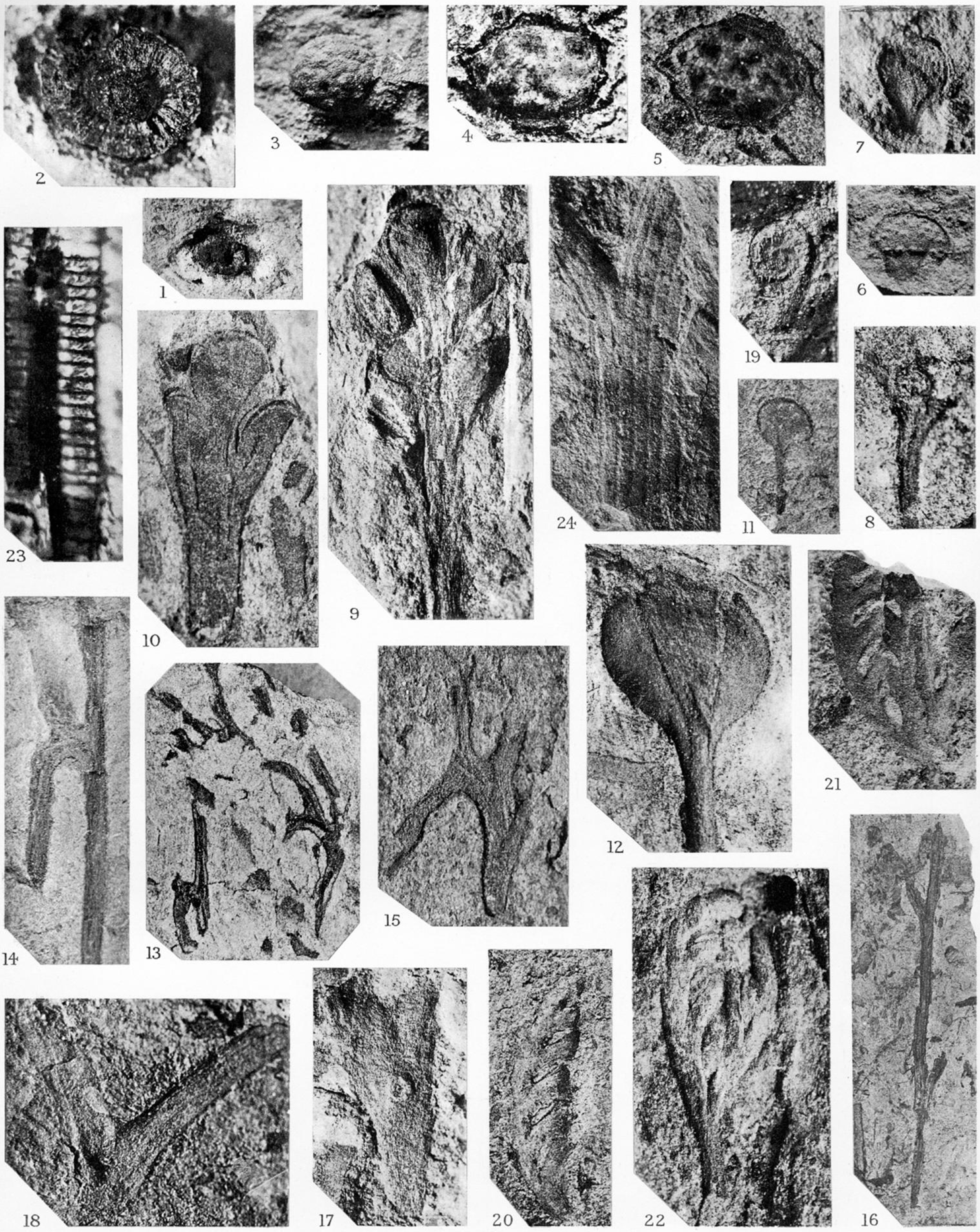

PLATE 10

FIG. 1—*Pachytheca* sp. A carbonized specimen split across. × 2. (C. 35.)

FIG. 2—*Pachytheca* sp. The same specimen enlarged to show differentiation into cortical and medullary regions and radial striations in the cortex. × 7·5.

FIG. 3—A spherical tuberculate body. × 5. (C. 164.)

FIG. 4—A brown tuberculate cast showing an outer layer, raised into blunt projections around the circumference. × 5. (C. 165.)

FIG. 5—Concave mould of the previous specimen showing position of tubercles as large depressions. (C. 165 (*a*)) × 5.

FIG. 6—A shortly-stalked, tuberculate reniform body (? sporangium). × 5. (C. 54.)

FIG. 7—The concave mould of another tuberculate reniform-body showing small circular depressions, a distinct stalk, and marginal rim. × 5. (C. 53.)

FIG. 8—A reniform body with small concavities, showing its attachment by a short stalk to an axis. × 4. (C. 52.)

FIG. 9—*Zosterophyllum australianum*. A fertile spike showing the insertion of six sporangia. × 4. (C. 6.)

FIG. 10—*Z. australianum*. Portion of another spike, showing the insertion of sporangia by long stalks on the fertile portion of the axis. × 5. (C. 159.)

FIG. 11—*Z. australianum*. A small isolated sporangium showing a long slender stalk, and distinct marginal rim. × 4. (C. 175.)

FIG. 12—*Z. australianum*. A large isolated sporangium. × 4. (C. 50).

FIG. 13—*Z. australianum*. Branched stems from Hall's Flat Road. × 2. (C. 76.)

FIG. 14—*Z. australianum*. A vegetative axis with a lateral branch divided into ascending and descending limbs. × 5. (C. 26.)

FIG. 15—*Z. australianum*. Another example of a small branch-system. × 5. (C. 25.)

FIG. 16—*Cf. Hostimella* sp. Smooth axis with two lateral branches placed alternately. Nat. size. (C. 169.)

FIG. 17—*Cf. Hostimella* sp. Dichotomously divided axis showing the cast of a third branch below the bifurcation. × 5. (C. 12.)

FIG. 18—*Cf. Hostimella* sp. Another example of a branched axis showing the base of a third branch in an axillary position. × 5. (C. 7.)

FIG. 19—A smooth circinately coiled stem-tip. × 10. (C. 36.)

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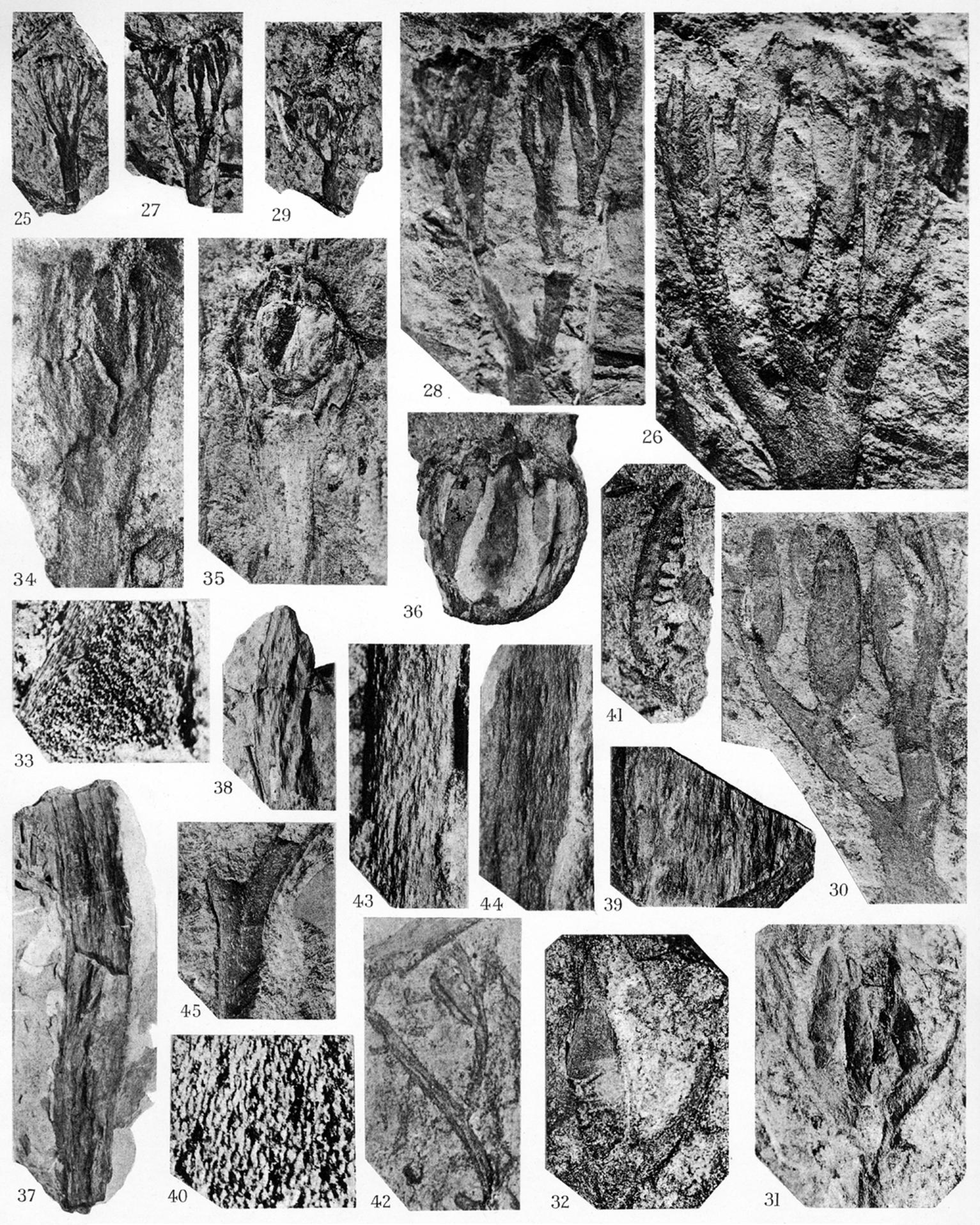

PLATE 11

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