Cretaceous Plants from Kaipara, N.Z.

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THE following notes are based on some specimens collected by Dr. P. Marshall, who kindly handed them to me for examination. They all come from Bull's Point and Batley, Kaipara Harbour, New Zealand, and the geology of the district has been fully dealt with by Dr. Marshall himself.

Though the plants do not give any indication of their exact horizon, they are associated with ammonites which point fairly definitely to an Upper Senonian (Campanian) age.* Most of the plants so far discovered are either fragmentary or belong to form-genera which are of little use for correlation purposes; they are, however, of considerable interest botanically, more especially as there are some petrifactions as well as impressions.

They occur mainly in hard nodules with an irregular fracture, from which it is difficult to obtain complete specimens; and, moreover, the plants were evidently in a fragmentary condition before fossilization. The impressions are partially petrified; thus, in the case of the fern *Taeniopteris batleyensis*, sections reveal to some extent the structure of the midrib, while collodion imprints of some of the leaf-fragments show the outlines of the epidermal cells. The araucarian leaves show the rows of stomatal pits very clearly, and can also sometimes be sectioned fairly successfully, while some of the araucarian wood is very well preserved.

One of the nodules is of great interest, for it consists largely of petrified vegetable debris in a sandstone matrix, and at once suggests comparison with plants containing nodules from other places. In its general structure this nodule closely resembles those from Upper Cretaceous beds of Japan described by Dr. M. C. Stopes (1909), from which a large and interesting flora was obtained (Stopes and Fujii, 1910). The matrix of the Kaipara nodule (kindly examined for me by Mr. W. Campbell Smith) consists of very angular quartz-grains in a calcareous cement together with a few crystals of feldspar, traces of mica, some green flakes of chlorite, and a very few grains which might be glauconitic. All these constituents are probably of detrital origin. Scattered through the matrix are abundant petrified plant-fragments and a few Foraminifera and other shells. Sections of other nodules showed a very similar mineral structure (sometimes more finely grained), but with very little plant-debris except for highly comminuted tissue-fragments. The Japanese nodules also vary in the amount of the plant contents, some containing only shells and no plants, while only a few have the fragments thickly massed. The Kaipara nodule differs from the Japanese in being slightly coarser-grained, with rather more quartz, while the plant-remains are not so well preserved. Dr. Stopes gives a detailed

* The collections of ammonites include the well-known form *Pseudophyllites indra* and the local representative of *Gaudryceras kayei*; also species of *Puzosia*, a form close to *Acanthoceras notomagense*, and a form close to *Phylloceras velledae*. It appears, therefore, that if a single horizon is represented it must be somewhat lower than the Campanian. The question is discussed in a paper on "Upper Cretaceous Ammonites" in this volume.—P. MARSHALL.

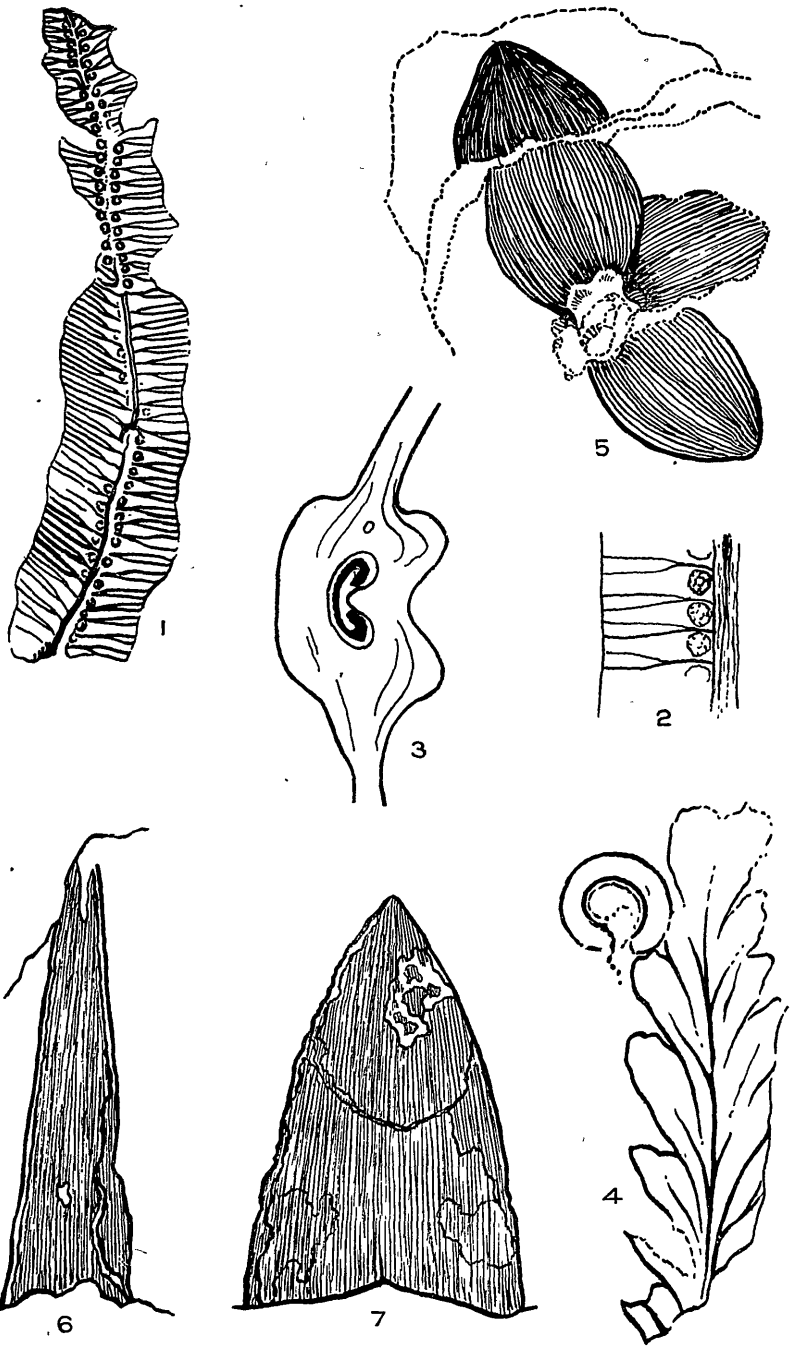
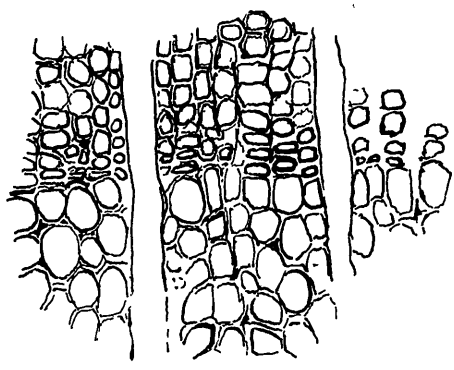
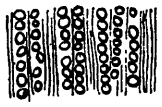


FIG. 1.—*Taeniopteris batleyensis* n. sp.
FIG. 2.—*Taeniopteris batleyensis* n. sp. The sori are very worn, and their structure is doubtful.
FIG. 3.—Fern-petiole from stem of *Dadoxylon*. Diagrammatic view of transverse section.
FIG. 4.—*Sphenopteris* sp.
FIG. 5.—*Araucarites marshalli* n. sp. Leaves attached to axis.
FIGS. 6, 7.—*Araucarites marshalli* n. sp. Single leaf.





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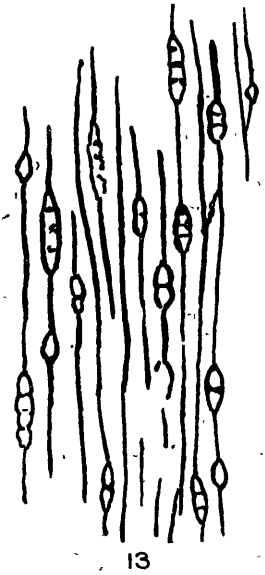

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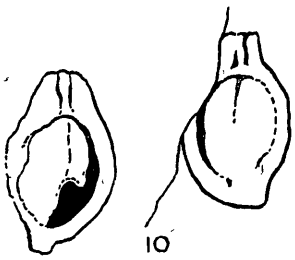

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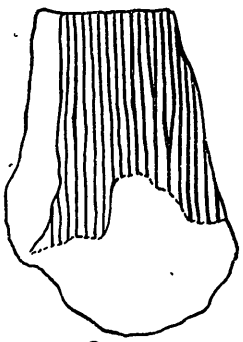

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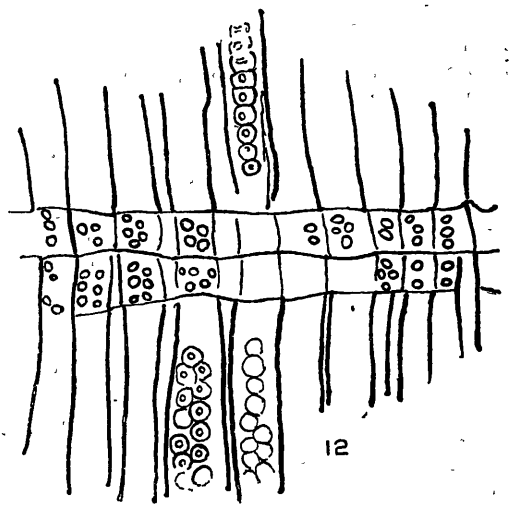

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FIG. 8.—*Araucarites marshalli* n. sp. Small portion enlarged to show rows of stomatal pits.

FIG. 9.—? *Dammarites* sp.

FIG. 10.—*Carpolithus zeelandica* n. sp.

FIG. 11.—*Dadoxylon kaiparaense* n. sp. Part of transverse section magnified, showing a fairly well marked annual ring, which, however, was not visible to the naked eye.

FIG. 12.—*Dadoxylon kaiparaense* n. sp. Radial section.

FIG. 13.—*Dadoxylon kaiparaense* n. sp. Tangential section.

comparison of her nodules with the coal-balls and roof-nodules of the English Carboniferous beds. The resemblance is greater to the latter—which, however, are much finer grained, and contain very little quartz, while the plant-fragments are never closely packed. The differences are due to differences in deposition: the plants in the roof-nodules had drifted and been sorted out, but "the numerous minute fragments of the Japanese nodules . . . could neither have drifted far nor long before they were covered and preserved in that potent preservative and petrifying solution, sea-water" (Stopes, 1909, p. 203). The granular Kaipara nodules with their marine animals were also obviously formed fairly near the shore where detrital matter was accumulating, but the plants had perhaps drifted a little farther, for they had decomposed more than the Japanese plants, so that only pieces of wood and the thicker and more resistant leaves have been at all well preserved. There are at Kaipara a few fairly large stem-fragments (see below), but in the nodule which has been particularly noticed here there are only small scraps of coniferous and dicotyledonous wood, fragments of bark and leaves, and some rather poorly preserved seeds, none of which can be identified definitely. It is possible, of course, that other nodules may be obtainable which, though of unpromising appearance, may contain recognizable petrified plant-remains.

The English roof-nodules are found in the beds immediately above coal-seams, while the Japanese nodules occur at least 100 ft. below the seams in their neighbourhood; but the association with coal-seams is probably more or less accidental, and the floras of the coal and of the nodules are not necessarily identical. They might, indeed, as Dr. Stopes believes is the case with the roof-nodules, belong to different plant associations, a fact which must be borne in mind when questions of correlation arise.

The recognizable plants from Kaipara are few in number. As in the Japanese nodules, and as in Upper Cretaceous floras generally, there is a mixture of ferns, gymnosperms and dicotyledons, but the material is insufficient for comparison with any other fossil flora. In the case of New Zealand no Upper Cretaceous flora has yet been adequately described, for the early work of Hector and Ettingshausen consists largely of *nomina nuda*, and Arber's monograph extended only to the Lower Cretaceous.

The following plants are recorded here: Ferns—*Taeniopteris batleyensis* n. sp., *Sphenopteris* sp. Gymnosperms—*Araucarites marshalli* n. sp., *Dadoxylon kaiparaense* n. sp., *Carpolithus zeelandica* n. sp., ? *Dammarites* sp. Dicotyledons—*Phyllites* sp., dicotyledonous wood.

Descriptions of Specimens.

Taeniopteris batleyensis n. sp. (Figs. 1, 2.)

Frond with the habit and venation of *Taeniopteris*, with secondary veins at right angles to midrib, but having circular sori with few sporangia between lateral veins, forming a row on each side of and close to midrib.

Dimensions: Maximum breadth, 1 cm.; length (incomplete), 5 cm.; diameter of sori, 1 mm. or slightly less.

Locality: Batley. One specimen only, with portion of counterpart.

The reference of this fertile frond to the form-genus *Taeniopteris* is purely provisional. The sporangial characters are not very well shown, and though the fern does not agree closely with any known genus of ferns Recent or fossil, it seems inadvisable at present to create a new genus for

its reception, and additional material may throw further light on its affinities.

The midrib is stout and is partly petrified; the vascular bundle is apparently U-shaped in section, but the details are not clear. The secondary veins are at right angles, or nearly so, to the midrib, usually forking almost immediately, but sometimes running half-way to the margin before forking. In one case one of the branches can be seen to fork again. The sori are always close to the midrib and between the secondary veins. They are round papillae with a depression in the centre, and sometimes seem to contain 5 to 10 sporangia. The structure of the sori and sporangia cannot, however, be made out clearly, and it is impossible to see any trace of an annulus or of an indusium. In general appearance the sori resemble those of *Laccopteris*, which, however, are not situated definitely between the secondary veins, while the venation is distinctly reticulate. The genus *Nathorstia* is almost identical with *Laccopteris* in its vegetative characters, but the sporangia form a synangium, and *Nathorstia* can be recognized only in extremely-well-preserved material. In any case, the venation characters preclude a reference of our fossil to either of these genera, and it may further be noted that neither of them is known later than the Cenomanian.

Among Recent ferns the same type of venation occurs in *Oleandra*, but here the sori, which have a reniform indusium and numerous small sporangia, are situated immediately on the lateral veins, and usually at a short distance from the midrib. The genus is not known fossil, though sterile taeniopterid fronds have occasionally been referred to it on entirely inadequate grounds. Dawson described an inconclusive sterile fragment from Upper Cretaceous beds of Canada as *Pteris* (*Oleandra*) *glossopteroides*, but fossil fronds of the *Taeniopteris* type are mostly found in Jurassic and Lower Cretaceous beds. Some of these are now known to be cycadean, though the provisional generic name doubtless also includes some ferns. Several members of the Marattiales with a similar venation have been found fossil in a fertile condition, but the Kaipara fern does not agree with any of them in soral characters, nor with any of the living ferns of the taeniopterid type with which I am acquainted.

Fern-petiole (fig. 3).—In the hollow pith of the araucarian wood described below a fairly-well-preserved fern-petiole is seen in transverse section. The C- or U-shaped vascular bundle, with the incurved xylem strand, is so characteristic of ferns in general that without further evidence reference even to a family is difficult. Its occurrence is of interest as showing the possibilities of the material, and it seems quite probable that it belongs to the same species as *Taeniopteris batleyensis*.

Sphenopteris sp. (Fig. 4.)

Locality: Bull's Point.

The only specimen is a small fragment of a fern-frond about 3 cm. long. The pinnules are narrow, cuneate-lanceolate, alternate, decurrent and uninerved, with an entire margin. It is difficult to place such a sterile fragment in its exact systematic position. Similar fronds occur frequently in Mesozoic rocks, and have often been referred to the Cyatheaceae, and especially to the genus *Thyrsopteris*, on insufficient evidence. Others of a similar type have been named *Asplenium* or *Asplenites*, and the present specimen also resembles some species of *Onychiopsis*, which is a widespread Lower Cretaceous genus. It does not seem possible to identify the fragment with any degree of accuracy, and it is therefore referred to simply as *Sphenopteris* sp.

Araucarites marshalli n. sp. (Figs. 5–8.)

Leaves thickly set on axis (usually occurring isolated), coriaceous, ovate or lanceolate, subacute, sessile with unguiculate base, finely striate longitudinally with numerous rows of stomatal pits. Internal structure: Numerous bundles with well-developed centrifugal wood radially arranged, centripetal wood (transfusion tracheides) present but not clearly preserved, resin-canals frequently but not always associated with bundles, numerous strands of hypodermal fibres, thick-walled idioblasts scattered through mesophyll.

The commonest fossils in the collection are leaves which I believe to belong very probably to the genus *Araucaria*, though, as there is always some uncertainty about detached organs, the usual termination *ites* is employed. They are referred to a new species, which I have much pleasure in naming after Dr. P. Marshall. Among Recent species there is considerable resemblance to the section *Colymbea*, and *Araucaria brasiliensis* in particular shows the rows of stomatal pits clearly, though they are not so distinct and well-marked a feature as in the fossil. This is a character which is not present in living specimens of *Agathis* as far as I have observed in herbarium specimens. Stomata were apparently present on both surfaces, but in the sections examined their structure was not preserved. Though the detached leaves from Kaipara exhibit considerable variation in size and shape, it seems probable that they all belong to the same species, in view of the similar variation among living araucarians.

Among comparable fossil species the nearest is *Araucarites macrophylla* (Bozzi, 1892, p. 375, pl. 16, figs. 1, 2) from the Lower Senonian of Italy, which externally is very similar indeed, though Bozzi's species showed no internal structure, and he does not mention the rows of stomata. Another similar type is *Araucarites ovatus* Hollick (1898, p. 128, pl. xii, figs. 3*a*, 4) from the Magothy Formation (Cenomanian), in which, however, the leaves are acuminate, while in *Araucarites hatcheri* Wieland (1910, p. 80, pl. 1, fig. 2) they are narrower and even more acuminate. This species seems to show traces of the stomata, for the figures indicate dots on the surface, and the stomata are more clearly seen in rows in some specimens of *Araucarites bladenensis* (Berry, 1908, pl. 14, fig. 3).

Kraeusel (1922, p. 7) unites *A. bladensis* and *A. toucasi* Sap. with *A. crassifolia corda*, and also includes the specimen from Lesina figured by von Kerner as *Pachyphyllum rigidum*. He records the species from the Lower Senonian of Swalmen, Holland, and says that the American specimens differ solely in being slightly larger. All these forms, however, are much smaller and more acuminate than *Araucarites marshalli*.

The fossil araucarians of New Zealand have scarcely been adequately studied. The foliage described by Ettingshausen (1887, p. 154) from Shag Point and Malvern Hills as *Araucaria haastii* seems to be similar to the present species, though the leaves are rather more lanceolate and acute and have a definite median rib. Ettingshausen also states that isolated leaves are not found. The specimens figured by Hector (1886) are without descriptions and are too poorly drawn for exact comparison, but they do not seem to be identical with our fossil. An examination of the originals, if available, might show an agreement between *Araucarites carinaria* (Hector, 1886, fig. 24*a*, No. 13: the name is misspelt) and *Araucaria haastii*, &c. Tertiary araucarians evidently occur in New Zealand, as in Australia, but it is usually very difficult to say whether they should be referred to *Agathis* or to *Araucaria*. Among similar Australian species we may note *Araucarites imbricatiformis* (Johnston) from the leaf-beds of Macquarie Harbour, Tasmania (Johnston, 1888, pl. 36, fig. 1, p. 294).

Some account of the internal structure has been included in the diagnosis, though the anatomical characters are not in general specific. Attempts to distinguish living species of *Araucaria* by their anatomy have not been very successful, and have been criticized by Seward and Ford (1906). On the whole, the anatomy of the present specimen resembles that of *Araucaria* rather more than that of *Agathis*, but the extent of the transfusion-tissue is not clear. In both *Agathis* and *Araucaria* sec. *Colymbea* the resin-canals alternate with the veins, whereas in the fossil they are usually below them, but also occur above or in the mesophyll more or less between the veins. Seward and Ford state that the canals are below each vein in *Araucaria rulei*, which is the flattest-leaved of the *Eutacta* group. The preservation of the fossil is scarcely good enough, however, for detailed comparison with living species.

? Dammarites sp. (Fig. 9.) Batley.

A portion of a leaf 2 cm. long and 1·5 cm. wide, with parallel venation, is obviously distinct from *Araucarites marshalli*. The veins, about 1 mm. apart, are more prominent, and occasionally bifurcate; there are no signs of stomatal pits, and the texture seems to be thinner. The leaf resembles some living species of *Agathis*, such as *Agathis vitiensis*, and some leaves of *Podocarpus* sec. *Nageia* are also rather similar. It is recorded here as evidence of another genus of plants, probably gymnospermous, in the Cretaceous rocks of Kaipara.

Dadoxylon kaiparaense n. sp. (Figs. 11–13.)

Annual rings of araucarian type, fairly well marked in places; bordered pits on radial walls in one or two (rarely three) rows in contact and sometimes slightly compressed; no pits on tangential walls; resin parenchyma absent; tracheids bordering rays sometimes containing resin, which is occasionally seen as "spools" in longitudinal section; medullary rays 1–8 cells high (usually 2 or 3), 1–10 pits in the field, and no abietinean pitting.

Locality: Bull's Point.

The above description is based on a stem 4 cm. in diameter, the centre of which is filled with the sandstone matrix containing the fern-petiole described above. A second (smaller) specimen, not so well preserved, doubtless belongs to the same species, the only observed difference being in the slightly greater height of the rays (up to 14 cells), which are sometimes biseriate.

I follow Professor Seward in referring fossil araucarian wood to *Dadoxylon*, though the present specimens, like many others of Upper Cretaceous and Tertiary age, closely resemble the wood of Recent members of the family. In fact, it seems to me quite probable that this is the wood of a species of *Araucaria* itself, and that it bore the foliage described above as *Araucarites marshalli*. There is, however, no evidence of connection, and it is unfortunate that the fragments of axis with leaves attached were not sufficiently well preserved to show the pitting. It must further be remembered that the wood of *Araucaria* and *Agathis* is extremely similar, and, indeed, indistinguishable in the fossil state.

The best-preserved fossil araucarian wood from New Zealand is *Dadoxylon* (*Araucarioxylon*) *novae-zeelandiae* (Stopes), from the Mid-Cretaceous (?) of Amuri Bluff. It differs from the present species in having better-marked annual rings, slightly larger tracheids, and a much greater development of resin in tracheids adjoining the rays (Stopes, 1914). The slight differences in the number of pits in the field and the height of the rays are probably unimportant. *Dadoxylon ettingshauseni* (Stopes) is poorly

preserved, but has larger tracheids and separated bordered pits. The wood from Amuri Bluff referred by Ettingshausen (1887, p. 156) to *Dammara oweni* is inadequately described and figured, but the drawing of the radial section (pl. 6, fig. 14) suggests that abietinean pitting of the ray-cells was present, and it seems quite probable that this wood may belong to *Protocedroxylon hectori* (Stopes). There is, therefore no fossil araucarian wood from New Zealand closely resembling that from Kaipara, and it is consequently described as a new species.

Carpolithus zeelandica n. sp. (Fig. 10.)

Seed oval, winged, 8 mm. × 5 mm.; nucule 5 mm. × 3·5 mm. Wing or margin slightly contracted at base, broadly obtuse at apex. Nucule with median rib.

Locality: Bull's Point. One specimen, with counterpart; also one isolated nucule, probably of the same species.

Among the many figures of Cretaceous species of *Carpolithus* which I have examined there is none closely resembling the present species, though winged seeds of a somewhat similar type have been recorded from earlier Mesozoic rocks in various parts of the world. It is difficult to be certain of the true nature of the apparent wing, which might be the impression of a sarcotesta, and it is impossible to express any opinion as to the affinites of this seed except that it is probably gymnospermous.

Dicotyledonous Wood.—In addition to the fragments in the nodule mentioned above, a small stem from Bull's Point, about 1 cm. in diameter, was sectioned, but the preservation was too poor for description or identification.

Phyllites sp.

There are several small fragments of dicotyledonous leaves; one of these occurs on the same block as the *Sphenopteris*. A collodion imprint was obtained which showed only the upper surface of a leaf without stomata. A larger fragment, from Bull's Point, shows venation details very clearly, but in the absence of base, apex, and margin it is impossible to attempt identification. Collodion imprints again showed no stomatal details.

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