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## The Lignite of Bovey Tracey

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*Phil. Trans. R. Soc. Lond. B* 1911 **201**, 161-178  
doi: 10.1098/rstb.1911.0004

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IV. *The Lignite of Bovey Tracey.*By CLEMENT REID, *F.R.S.*, and ELEANOR M. REID, *B.Sc.*

(Received May 30,—Read June 16, 1910.)

[PLATES 15–16.]

THE lignite of Bovey Tracey, in Devon, was fully described by OSWALD HEER\* and PENGELLY† in these ‘Transactions,’ and there is no need to repeat their description. The conclusion HEER came to, from the study of the fossil plants (except a single beetle there were no other fossils), was that the deposit “must be referred to the Lower Miocene division and to the Aquitanian stage of it,” or as we should now put it, the strata were Upper Oligocene or, perhaps, Lower Miocene. HEER also considered it to be equivalent to the Hamstead Beds of the Isle of Wight, which we now know are somewhat earlier than the Aquitanian and are of Middle Oligocene date.

Doubt has since been thrown on these conclusions by Mr. STARKIE GARDNER‡, who considered that the flora collected by HEER and PENGELLY is identical with that of the Bournemouth Beds (Middle Eocene). Mr. GARDNER appears to have made no collections at Bovey, and in his Bournemouth collections (now in the Museum of Natural History) we can find nothing to justify this statement. Perhaps this extreme view is somewhat modified by later changes in the identification of some of the plants.

Notwithstanding the want of evidence, there has been a general tendency in Britain to accept GARDNER’s correction of HEER’s work, and to wait for this evidence to appear in forthcoming parts of the Monograph on the Eocene Flora. In accordance with this tendency the Bovey Beds have appeared in recent geological manuals, and on the later editions of the maps of the Geological Survey, as equivalent to the Bournemouth or Middle Bagshot Beds.

Recently it became necessary to visit the Bovey Basin for the purposes of the colour-printed edition of the New Series 1-inch Map of the Geological Survey and of the explanatory Memoir. During this visit it became apparent that there was much original botanical work waiting to be done, which lay outside the ordinary duties of the geological surveyor, and which could not be adequately dealt with in a sheet Memoir. We therefore undertook a special examination of the botanical evidence, which promised to throw light on the age of the lignite. It was useless to wait

\* HEER, 1863.

† PENGELLY, 1863.

‡ GARDNER, ‘Monograph,’ 1879, vol. 1, pp. 18, 19.

longer for a continuation of the Monograph of the Eocene Flora,\* nothing having been published since 1886. We started this examination with little doubt that Mr. GARDNER'S view would prove to be correct, but soon we found we were obtaining a flora unlike what we expected. It was a flora almost identical with that of the lignites of the Wetterau.† These lignites are now generally accepted as of Upper Oligocene age, and to this period we must therefore refer the Bovey lignites, unless the German authorities are mistaken as to the stratigraphical position of their equivalent deposits in the Rhine Valley. As the Rhine lignites occur in latitudes almost identical with that of Bovey, and the physical conditions and surroundings were very similar, we should expect to find the contemporaneous floras almost identical, except for endemic species. It is not surprising, however, that there is comparatively little resemblance between the Bovey flora and that of the Aquitanian stage of France. The difference of latitude is considerable, and the soils on which the plants grew must also have been different; we are therefore scarcely in a position to compare the floras.

Unfortunately the mode of occurrence of these plant-beds, occupying as they commonly do isolated basins, with different climatic conditions and amid different surroundings, makes exact correlation very difficult in the absence of any associated fauna. There seems, however, no doubt as to the close relationship between the lignites of Bovey and those of the Wetterau. If we are right in this conclusion, the Bovey lignite fills a gap in the British geological sequence, for latterly the general opinion has been that all strata between Middle Oligocene and Lower Pliocene were missing in Britain. We cannot yet find in Britain true Miocene deposits, but the Bovey plants show that we have representatives of the very top of the Oligocene. Indeed, some French authorities‡ would class such deposits as Miocene, but this does not seem to be the general opinion.

In another way the Bovey flora is of interest, for it shows the gradual dying out of the tropical or warm-temperate plants and the incoming of a few northern genera, probably washed down from the surrounding uplands of Dartmoor.

Since HEER and PENGELLY wrote, a boring has been carried down to a depth of 526 feet below the surface at Bovey Heathfield without reaching the base of the Tertiary deposits.§ No scientific examination had been made of the cores, and this seemed a good opportunity for clearing up two points: firstly, Did all the deposits in this considerable thickness of strata belong to one geological period? and, secondly, Were any of the lower strata of marine origin, or did they belong to the same enclosed fresh-water lake?

\* GARDNER, 1879—1885.

† WEBER, 1852; LUDWIG, 1857—1860.

‡ SCHIMPER, 1870—1874; SAPORTA, 1879, 1891—1892; DE LAPPARENT, 'Traité de Géologie,' 1906, 5th edit., vol. 3, chap. 3.

§ WOODWARD, 1900; JUKES-BROWNE, 1909.

It may be remarked that our method of boiling down the clays with soda is peculiarly adapted for the treatment of the broken material brought up by the boring-tool. The smallest seeds, twigs, or fragments of leaves can be extracted uninjured. If they are in a good state of preservation we can in this way obtain evidence which no ordinary macroscopic examination would render available.

Thanks to Messrs. CANDY and Co., the Geological Survey obtained portions of all the borings from known depths. They were a good deal broken up by the boring tool, and unfortunately in process of time the enclosed plant-remains have greatly decayed, but the lower beds contained enough seeds in fair preservation to show that the whole thick mass belonged to a single deposit. Several seeds and twigs of *Sequoia couttsia* were obtained, as well as two or three seeds belonging to *Carpolithes boveyanus*, and one of vine. They seem to indicate that the beds near the surface at Bovey are the same as those found near the bottom of the boring at Heathfield. As this boring was made to test the thickness and quality of the pottery clays, few samples were preserved of the thick masses of lignite noted as passed through, and the seeds all occurred in beds of clay mixed with lignite, just as most of the seeds are found in similar beds in the open pit at Bovey. The pieces of lignite found in the lower part of the boring look like Sequoia wood, but they are now in too fragile a state to be cut into sections.

Circumstances did not permit of our making extensive collections in the field as we should have wished. The "coal-pit" which PENGELLY and HEER described is flooded, and the upper part is a good deal overgrown. Their best plant-beds are now either beneath the water-level, or are so much weathered by long exposure to the air that it is difficult to obtain leaves in good preservation. We decided therefore to devote ourselves to the study of the fruits and seeds which could be obtained by boiling down with soda large quantities of the carbonaceous clay from the upper beds in this pit, and from a newer pit a mile and a-half away at Heathfield.

Where only fragmentary material is available we prefer to use fruits and seeds, rather than leaves, for specific determinations. HEER's work had been mainly on leaves, and on such large seeds as could be picked out on the spot; we hoped to supplement his work, instead of going over the same ground. In this we have been fairly successful, but it is unfortunate that we cannot examine the more prolific beds which PENGELLY and HEER studied.

The beds we have examined, though supposed not to be prolific, have yielded a considerable number of unrecorded species, some of them new to science, others already known from the lignite of the Wetterau. At the same time the use of new methods has enabled us to obtain better material for the study of the plants already recorded. This new material, combined with a re-examination of HEER's types, makes us inclined to reduce several of his supposed endemic forms to well-known Rhine Valley species. Others, only represented by bad specimens, must also, we believe, ultimately disappear from the lists. The whole of this work tends, therefore,

to reduce the supposed endemic element in the Bovey flora, and greatly to increase its resemblance to the flora of the Wetterau lignite. No doubt, as our illustrations show, we have added various plants, unknown except at Bovey, but the discovery of these is due to the application of methods of collecting not yet applied to the Continental deposits. It may be that there is a considerable endemic element in the Bovey flora, but all the geological evidence suggests that we are dealing with a continental area, not with an island.

Before proceeding to the description of the plants, a word must be said as to the physical geography of the district and the conditions under which the plants grew. The Bovey basin, in which the lignite and pottery clay were deposited, is a tectonic rock-basin\* surrounded on every side by steep bluffs, which immediately to the north-west slope upwards into the heights of Dartmoor. The composition of the gravel and sand, and of the thick beds of pottery clay deposited in this basin, leave no doubt that we are dealing with strata consisting essentially of flood-deposits washed from Dartmoor. This accounts for the singular poverty of the flora along certain lines; a granite flora is always a poor one, and we are dealing mainly with the plants swept out of a narrow valley or gorge in the granite. Mingled with these are a few water-plants; but so few species that we are forced to conclude that then, as now, the water heavily laden with china clay was inimical to aquatic vegetation. One species of *Potamogeton* is abundant both at Bovey and Heathfield. Marsh plants are exceedingly rare; *Taxodium distichum* is represented by a single scale of a cone; we found also one seed belonging to *Alismaceæ*, and a few of *Calla*. The flora we find perhaps suggests dense jungle with many climbers, surrounding and overhanging the lake, the shores of which plunged so steeply that there was little room for either marsh plants or for rooted aquatic forms. The meadow flora is missing.

Of the two pits to which we have devoted our attention, the northern one is directly opposite and close to the mouth of the narrow valley leading into Dartmoor; it yields therefore in profusion remains of the *Sequoia couttsiæ* and ferns, which probably grew in the ravines. The other pit, a mile and a-half to the south-east, is nearer the middle of the lake; it yields scarcely any *Sequoia*, but abundance of fruits of several species commonly referred to *Nyssa*. *Nyssa* is a genus of trees, mainly American, the existing species of which grow overhanging water.

We came across no animal remains except galls, and an unknown and somewhat doubtful egg-capsule; but as the deposits seem to have lost any lime they may once have possessed this is not surprising; we could find no hard nodules, such as might preserve impressions of mollusca.

At the time of writing, preparations are again being made to pump out the Bovey coal-pit and work the lignite for producer-gas making. This may make it possible in a few years to make large collections of the plants; but there have been so many

\* JUKES-BROWNE, 1909.



delays that it seems best to publish the new botanical evidence rather than wait before making a correction which geologists will be glad to know of.

The already published species left without comment were determined by HEER, and as we have no better material to work on, and the preservation of many of his specimens is not good, we cannot examine them critically. In a few cases better material has led us to dissent from certain of HEER's identifications; but there seems no good reason to question his determination of leaves with which he was thoroughly familiar in Switzerland.

Certain of the undescribed plants will be of considerable interest to botanists, and these are now figured and named. We have found also various well-marked fruits and seeds, which at present we are quite unable to refer to their proper genus or even order, though specifically they are quite determinable. These we have thought it advisable to figure, as an aid to future workers; for the same species will probably be discovered in other parts of Europe, and will then act as zone fossils, even if their proper botanical position is still unknown. We considered whether it was desirable to follow the old custom, place these unknown but well characterised forms under the indefinite genus "*Carpolithes*" and give them specific names for purposes of reference. We came to the conclusion, however, that the advantage was not great, and that it would be more fair to future workers to figure them, leaving the naming to whatever botanist succeeds in referring them to their correct botanical position. We must thank the officers at Kew and the British Museum for much assistance, and for permission to dissect recent specimens where necessary for comparison.

#### NOTES ON THE PLANTS.

*Magnolia attenuata*, WEBER\* (Plate 15, figs. 1, 2), Heathfield, 1909.

Seed elongate, ovate truncate or slightly cordate at base, sides nearly parallel, narrowed above into an acute apex, somewhat rugose. Length, 7 mm.; breadth, 4.5 mm.

The seeds agree with those found abundantly in the Rhine lignite, and referred by WEBER to his *Magnolia attenuata*; but as the type of this species is a leaf, and another species occurs in the same deposit, it is not certain that the seed and the leaf belong to the same plant. The species is now first recorded from Britain; but no *Magnolia* leaves have yet been found in the Bovey Beds.

*Vitis hookeri*, HEER† (Plate 15, fig. 3), Heathfield and Bovey, 1909.

The genus is represented by seeds of three well-marked species, which we obtained by washing the clays. We found one good specimen of *Vitis hookeri* at Heathfield,

\* WEBER, 1852; LUDWIG, 1859—1860, p. 122.

† HEER, 1863.

and it corresponds closely with HEER's description and figure of the seed of this species, obtained at Bovey. It seems closely allied to the living *Vitis vinifera*, especially to the Pliocene form found at Tegelen and figured by us.\*

*Vitis ludwigi*, AL. BRAUN† (Plate 15, fig. 4), Bovey, 1909.

A single seed. Ovate-acuminate, gradually narrowed into the attenuate strongly tubercled beak, inner face faceted, smooth, deeply pitted, outer face curved with an oval chalaza, margins sparsely tubercled, length 4 mm.

*Vitis teutonica*, AL. BRAUN‡ (Plate 15, figs. 5, 6), Bovey, 1900.

Seed ovate-acuminate, gradually narrowed into the beak, granulate all over, inner face with long shallow pits, outer convex longitudinally sulcate with a narrow pyriform chalaza, length 4 mm. These seeds seem to correspond exactly with UNGER's description of seeds from the German lignite found associated with the leaves named by BRAUN *Vitis teutonica*. UNGER's description is *seminibus parvis 3-5 mm. longis ovato-acuminatis rugulosis, externe convexis longitudinaliter sulcatis, interne lateribus compressis*.

This species has not before been recorded in Britain, but HEER's type specimens of *V. britannica*§ appear to be nothing but badly compressed seeds of this vine, though his figures are scarcely recognisable.

*Cornus?* (Plate 15, figs. 7, 8), Heathfield, 1909.

Stone, thick, bony, globose (crushed obliquely), base somewhat prominent, with a small circular depression, and eight radiating grooves apparent, reduced to two at the apex. Length, 4 mm.

Only a single specimen has been found; we cannot therefore examine the internal structure to see whether the stone is two-celled as in *Cornus*. The genus has not before been recorded from the Bovey Beds.

*Mastixia*, n. sp. (Plate 16, figs. 73, 74), Heathfield, 1909.

After we had completed our plates we discovered that two fragments of fruits belonged to this genus of Cornaceæ. The living species of *Mastixia* are mountain plants in Further India and Malaya. The drupe is distinguished from other Cornaceæ by the infolding of the bony endocarp, which forms a strong internal rib, making the cavity horse-shoe shaped in cross-section. (See text-fig. 1, *M. euonymoides*, PRAIN). These characters are well seen in our fossils, which, however, are much narrower and probably smaller than any living species of the genus. We have no complete

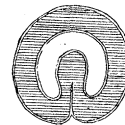
\* 'Verhand. Kon. Akad. Wetensch. Amsterdam' (Tweede Sectie), 1907, Deel 13, No. 6, figs. 30, 31,

† 'Sitzungs Protokoll d. geol. Gesellsch.,' Berlin, April, 1857,

‡ UNGER, 1860, p. 23.

§ HEER, 1863, p. 53.

specimen, so cannot give a full description. It is thick-walled, strongly ribbed externally, and mucronate, greatly resembling some of the so-called Nyssas. These possibly, when similar broken specimens have been discovered, may be found to belong to the same genus. It may be remarked in this connexion that complete seeds or fruits in lignite are so compressed that the walls close together and obliterate the cavity, making it almost impossible to examine the anatomy. If, however, the seed has germinated, or has been bitten in half by a bird, the silt gets in and prevents the walls from closing. In this way broken specimens may be exceedingly valuable, as affording the only satisfactory material for botanical study.



TEXT-FIG. 1.

### *Nyssa.*

Various large seeds or stones from the Rhine lignites and from Bovey have been described as belonging to species of *Nyssa*, and we can now add three more of the Rhine species to the Bovey list. The fossils require thorough revision and a study of the leaves and other parts of the plant, which, however, have not yet been found in the Bovey Beds. There is a good deal of doubt as to the correctness of the reference of these various fossil forms to *Nyssa*, though some of them suggest a close affinity to *Cornus*. It is, however, perfectly clear that at least four species of these fossil seeds are common to the Rhine lignite and to Bovey.

HEER'S seeds of *Nyssa* came from a bed now below the water-level at Bovey. Ours were found mainly in the upper beds at Heathfield.

*Nyssa europæa*, UNGER (Plate 15, fig. 9), Bovey and Heathfield.

Many specimens from Bovey are in the Museum of Practical Geology; but we are unable to identify HEER'S figured specimens. We obtained from Heathfield specimens agreeing with HEER'S, figs. 16 and 17. The seeds of this species vary a good deal; they are very abundant in Germany.

*Nyssa lævigata*, HEER,\* Bovey.

From an examination of the types now in the Museum of Practical Geology, we doubt whether this species will stand. The three specimens so named by HEER are too badly preserved for photographing, and they may be unripe or abortive. We found nothing that could be referred to *N. lævigata* either at Bovey or Heathfield, and the species has not been found in any of the Continental deposits.

*Nyssa microsperma*, HEER,\* Bovey.

The type (HEER, Plate XVIII, fig. 24) is in a small tube containing two specimens, the larger of which is the one figured. A second tube (also in the Museum of Practical

\* HEER, 1863.



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Geology) is labelled in HEER'S writing as *Nyssa microsperma*; it contains two of these seeds, one of *Sequoia*, and three apparently allied to *Taxus*. We did not find this form either at Bovey or Heathfield, and it is unknown on the Continent, or perhaps is there taken to be merely a small form of *N. europæa*.

*Nyssa obovata*, O. WEBER\* (Plate 15, fig. 10), Bovey.

Three seeds found by us seem to belong to this species. They correspond with WEBER'S description in size and shape, and are all somewhat oblique. We cannot recognise what is meant by "*costis striis 6 longitudinalibus*," as the surface markings seem to be very irregular. WEBER'S figure is not good.

*Nyssa ornithobroma*, UNGER† (Plate 15, fig. 11), Heathfield, 1909.

These seeds form considerable masses of the lignite of Wetterau, and were described and figured by UNGER in 1861 and 1866. His description is "*putamine subosseo, 15 mm. longo, 7-10 mm. lato, subcompresso ovato, elliptico striis longitudinalibus notato*," and in his latest figure (Plate XXIII, fig. 12), the seed shows a curious "capped" termination at each end, as in our fossil. We have only one perfect specimen and three fragments, but there seems no doubt as to the determination. The species is new to Britain.

*Nyssa striolata*, HEER,‡ Bovey.

HEER'S types of this curious species are in the Museum of Practical Geology, and we have seen no others. His figs. 20, 21, 22 of Plate XVIII represent it, but the same tube contains some *Nyssa vertumni*, and fig. 23 seems to show a group of *N. vertumni*, which HEER did not recognise as a Bovey species. His comparison of *N. striolata* to one of UNGER'S figures of *N. ornithobroma* is puzzling, as we see no resemblance between the two species and doubt their belonging to the same genus. Unfortunately, HEER'S types of *Nyssa striolata* are now in too bad a state for photographing, and they do not greatly resemble his figures.

*Nyssa vertumni*, UNGER§ (Plate 15, fig. 12). Abundant at Heathfield, rare at Bovey.

This species, also common in the Rhine lignite, has not previously been recorded from this country, though, as already observed, there are some poor specimens of it in the same tube as HEER'S types of *N. striolata*. We found it abundant at

\* WEBER, 1852, p. 184.

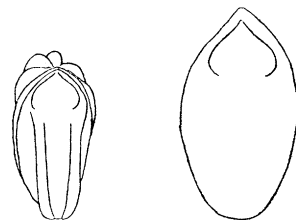
† UNGER, 1860—1866.

‡ HEER, 1863.

§ UNGER, 1860—1866.

Heathfield and rare at Bovey. UNGER's description is "*putamine subosseo, 12-15 mm. longo, 7 mm. lato, subcompresso, obovato apiculato, striis longitudinalibus sulcato.*" Heathfield specimens are large, obovate, compressed dorsally, strongly sulcate, except near the pointed base, rounded and mucronate above, length about 12 mm., breadth about 6 mm. The strong laterally compressed ribs make this very unlike the other species.

We have several broken specimens of this fruit, showing the interior; it is one-celled, with no internal rib like that characteristic of *Mastixia*. The outside shows a large somewhat triangular depression near the micropylar end, and this depressed area tends to open, apparently on germination (fig. 2). An exactly similar valve is seen in the recent *Nyssa sessiliflora* (fig. 3). *Nyssa vertumni* at any rate appears to be a true *Nyssa*.



TEXT-FIG. 2.

TEXT-FIG. 3.

*Rubus microspermus*, n. sp. (Plate 15, figs. 13-17), Heathfield (fairly abundant), Bovey (less common).

Endocarpium parvum, compressum, lateraliter semilunare vel semiovatum, margine ventrali arrectissimo in apicem obtusum nequaquam recurvum transeunte, basi rotundatum leviter recurvum, 2.5 mm. longum, 1.5-1.8 mm. latum.

Stone small, compressed, laterally semilunar or semiovate, apex terminating the very straight ventral margin and neither prominent nor recurved, base rounded, slightly incurved, length 2.5 mm., breadth variable, 1.5 to 1.8 mm.

Sculpture closely resembles some forms of *Rubus fruticosus*, from which our fossil is principally distinguished by its small size and very straight ventral margin. Prickles (of which only three were found) small and strongly recurved, so that the tip is almost parallel to the branch, base much compressed laterally. These prickles almost certainly belong to the same plant; they are scarcely distinguishable from extreme forms of *R. fruticosus*.

#### *Boragineæ.*

*Calvarinus reticulatus*, n. gen. and sp. (Plate 1, figs. 18-20), Heathfield and Bovey.

Nucula erecta, magna, obovata, rotundata, sursum eximie reticulata, inter retis maculas lævis, arcola basilari gynobasi affixa. Inferne costis angustis eminentibus, superne in rete transeuntibus, percursa; facie interiori angulata. Nucula 5 mm. longa, 4.5 mm. lata.

Nutlet erect, large, obovate, rounded and inflated above, like a human skull, strongly reticulate with smooth interspaces, attachment basal as in *Lithospermum*. Narrow, sharp ribs radiate from the base and pass upwards into a coarse network of

similar ribs covering the upper half and rounded top. The inner face is angled. Length 5 mm., breadth 4.5 mm.

One inflated specimen, somewhat damaged at the base, has apparently germinated, thus allowing mud to enter the cavity and save the nutlet from compression. Another better preserved specimen has not opened, and has therefore been compressed obliquely. Both these were found at Heathfield. At Bovey we found one badly-preserved fragment of the same species.

It is doubtful if our fossil can be referred to any of the sub-tribes founded on recent genera of *Boragineæ*. It corresponds fairly well in its attachment, erectness, rounded shape, and thick wall with the *Lithospermeæ*, but its surface sculpture is very different. It does not seem to be near any existing genus.

Little is yet known as to the geological history of this order, though leaves described vaguely as "*Boraginites*" have been recorded from Tertiary deposits.

Labiata (Plate 15, fig. 21).

Labiates are so rare in Oligocene strata that we have figured the only nutlet we found. Unfortunately it is not sufficiently well preserved for either specific or generic determination.

*Taxodium distichum*, L. C. RICH (Plate 15, fig. 22), Bovey.

We have obtained a single characteristic scale of the cone of this tree at Bovey. It is strange that remains of a swamp tree should be so rare in a deposit of this sort. It was not found by HEER and PENGELLY, and we found no foliage belonging to *Taxodium*.

*Sequoia couttsia*, HEER\* (Plate 15, figs. 23-37). Abundant at Bovey, rare at Heathfield.

This conifer appears to be confined to the Bovey basin, for though cones and foliage from other localities have been referred to the same species, Mr. STARKIE GARDNER has now separated them, referring certain of them to the genus *Athrotaxis*. With regard to the Bovey tree, which is the type of the species, it seemed important to make a thorough examination of the new material we had obtained, for Mr. GARDNER had only HEER'S figures and specimens to examine, and these specimens were not in good condition. The result of our examination is to show that *Sequoia couttsia* is a true *Sequoia* and close to the living *S. sempervirens* and *S. gigantea*.

The cones of *S. couttsia* are broadly oval and abruptly narrowed into the stalk, or somewhat cordate; at the base are a few small recurved wedged-shaped barren scales; these are succeeded by peltate scales, the lower ones having their stalks strongly reflexed, the middle ones with stalks at right angles to the axis; at the

\* HEER, 1863.

apex is a rosette of a few almost sessile barren scales; the arrangement of the scales is distinctly spiral. It is not easy to count the number of the scales, as none of the cones we found were perfect. There would seem to be 20–24 fully developed scales, besides a few undeveloped round the apex and base.

The scales are broader than long; the outer face quadrilateral, or passing into an irregular pentagon or hexagon, rugose, with lines radiating from a central umbo. The scales vary in shape according to their relation to the axis; they may be either wedged-shaped or umbrella-shaped, and detached scales of both shapes occur in profusion.

The seeds are pendant beneath the thickened involute margin of the scale on its upper side, and are pressed against its stalk, upon which the impression of the seed is frequently seen. We have several specimens showing the seeds *in situ*; one isolated and somewhat distorted scale shows five seeds pendant as described. The winged seeds vary greatly in size and shape.

The cone and seed therefore correspond with the recent *Sequoia*. *Athrotaxis* has imbricate (not peltate) scales, the stalks broadening gradually into the blade, which is bent at an angle to it and produced upwards into a thin almost membranous apex; it has no umbo.

Preparations were made of the epidermis of the leaves of the extinct *S. couttsia*, and also of the two living species, and of *Athrotaxis*.\* In all three species of *Sequoia*, stomata occur irregularly scattered in bands showing a most characteristic arrangement of cells. The cells are approximately oblong, with the longer axes parallel to the mid-rib. The stomata are somewhat quadrilateral and surrounded by four or occasionally five long narrow cells placed end to end and forming a ring round the stoma.

In *Athrotaxis* the cuticle is formed of irregularly triangular cells, and the stomata are surrounded by rings, usually of six wedged-shaped cells. The stomata are distributed so uniformly and closely that the same cuticle cell may touch two or even three of them.

In both cone and leaf therefore the Bovey fossil corresponds with *Sequoia* and is unlike *Athrotaxis*.

*Taxus baccata*, Linn. (Plate 16, figs. 42 and 43), Heathfield, 1909.

A single seed, crushed vertically but otherwise perfect.

Globose, mucronate at apex, rugose, wrinkled towards the base, trace of fine striæ, but surface cells obscure. Attachment of moderate size, but forming a very deep conspicuous irregularly circular pit with raised margin and a central boss. Width 5.5 mm. (perhaps slightly widened by crushing).

Much larger than *Taxus ? nitens*, testa thinner and like recent *Taxus*, with which

\* We must thank the Director of Kew Gardens and Dr. AUGUSTINE HENRY for recent material.



it agrees closely, except that the fine surface sculpture is obscure. We have not yet been able to compare it with LUDWIG'S\* *Taxus margaritifera*, which occurs in the Rhine lignite, but that species is described as having a polished surface, and is therefore quite unlike our fossil.

*Taxus ? nitens* (HEER).† “Very frequent in the coal of the 46th bed” (HEER). Bovey.

Seed globose, testa very thick, attachment triangular, round or irregular as in *Taxus*, surface polished, with close-set fine striæ most conspicuous towards the base, sculpture resembling *Taxus*, but cells smaller. Length 5 mm.

This seed, called *Carpolithes nitens* by HEER, closely resembles *Taxus*, except for the great thickness of the testa, fineness of the sculpture, and polished surface. In its polished surface it agrees with *Taxus margaritifera*, but LUDWIG figures that species as having a thin testa.

*Stratiotes websteri* (A. BRONG).

*Carpolithes websteri*, now referred to the living genus *Stratiotes*, is abundant in certain beds at Bovey. It has a great range in time, and may include more than one species.

*Palmacites daemonorops* (UNGER) (Plate 16, figs. 44-49), Bovey and Heathfield.

Prickles belonging to this palm have been well figured by HEER,‡ who states also that PENGELLY found a fruit at Bovey probably belonging to the same plant (a rotang palm), but that he himself had only seen a drawing of it, reproduced on his Plate 9, fig. 50, which is said to be natural size. We have found several fruits belonging to *Calamus* or *Dæmonorops*, but they are very minute, and we cannot help thinking that HEER'S illustration is enlarged two diameters, instead of being, as he thought, of natural size.

We have the fruit in various stages. The young form is still enveloped in the peculiar striate bracts; the full-grown specimens show well the characteristic recurved scales, and from the tip of riper ones projects the nut. The length of our full-grown specimens is 6 or 7 mm., not 13 mm. as HEER records. Possibly his specimen represents a second species, but the prickles seem all to belong to one form. Fig. 49 represents a minute fragment of an inflorescence such as was formerly referred to *Leptomeria*. These are considered by Saporta to belong to palms.§

*Calla cf. palustris*, Linn. (Plate 16, figs. 50, 51), Heathfield, 1909.

Some irregular globose seeds, sometimes slightly stipitate, with granular surfaces,

\* LUDWIG, 1859—1860, p. 73.

† HEER, 1863.

‡ HEER, 1863; GARDNER for a time referred these prickles to Cactus.

§ SAPORTA, 1889.

are so like the living *Calla palustris* that they would be difficult to separate, were it not for their flattening and smaller size. These differences are only such as we should expect in a crushed and carbonized seed.

*Sagittaria* ? n. sp. (Plate 16, fig. 52), Heathfield, 1909.

A single well-preserved carpel probably represents a new species of *Sagittaria*, or some closely allied genus of Alismaceæ. Without more material we do not care to give it a name.

*Potamogeton tenuicarpus*, n. sp. (Plate 16, figs. 53, 54).

Endocarpium tenue, coriaceum, subtiliter granulatum, parenchymate bene aspectabili, oblate obovatum, margine dorsali semicirculari, ventrali superne rotundato, inferne emarginato, carina elevata carunculas laterales gignente ad  $\frac{2}{3}$  circumferentiæ cinctum. Stylus terminalis. 1.5 mm. longum; 1.2 mm. latum.

Endocarp minute, thin, coriaceous, finely granulate and showing conspicuous cell-structure, flattened obovate, dorsal margin semicircular, ventral margin rounded above, notched below, detachable keel occupying two-thirds of the circumference, with sharp central ridge and lateral flanges, style terminal. Length 1.5 mm.; breadth 1.2 mm.

Abundant at Bovey and Heathfield. Most of the fruits have germinated; germinating fruits with embryo attached and loose embryos are also not uncommon. The fruits are very uniform in size and shape, and no trace of any other species of *Potamogeton* has yet been found in the deposit.

The minute size of the fruit and its thin coriaceous endocarp with conspicuous granulation and cell-structure make this very unlike any living *Potamogeton*. Many fossil *Potamogetons* have been described, mainly from specimens without fruit; but where fruits are described or figured they seem to be thick-walled like the recent forms. *Potamogeton tenuicarpus* may have to be placed in a new section of the genus; but we see no reason for making it a new genus.

#### *Incerta Sedes.*

Figs. 55 and 56 show the back and front view of a peculiar flat-winged seed or scale which we cannot identify. Length 7 mm. Bovey. As we have only a single specimen we cannot examine the internal structure.

Fig. 57 suggests a spadix of an aroid, but the specimen is less than 2 mm. long. Bovey.

Figs. 58, 59, 60, show three specimens of an irregularly angular hard fruit with central girdle, and apparently five ribs above and about double the number below. Length 2 mm. or 3 mm. Heathfield.

Figs. 61, 62. Several specimens of a compressed winged seed with marginal notch have been found at Bovey and Heathfield; but we can offer no suggestion as to their

relationship. The sculpture consists of prominent concentric and radial striæ, through the intersection of which the whole wing is covered by rectangular pits. Length 1·8 mm.

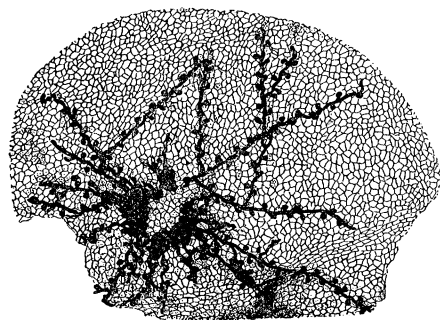
Fig. 63 appears to be an inferior fruit with five prominent ribs and persistent calyx. Length 2·3 mm. Heathfield.

Figs. 64–66. Curious cups with much wrinkled outer skin, suggesting the shrivelled remains of a fleshy calyx, occur fairly frequently both at Bovey and at Heathfield. Out of one of these cups dropped a seed, but unfortunately it fell among others and could not be identified. Possibly these cups should be associated with *Carpolithes boveyanus*, HEER, which also is abundant at both localities. Length of longest specimen about 3·75 mm.

Figs. 67, 68. Two erect seeds, triangular in section and greatly resembling beech, but very small, have been found at Bovey. They probably belong to *Cupulifera*; but we have no means of associating them with any of the leaves. Length 4·5 mm.

Figs. 69, 70. Several specimens of these laterally compressed, hard, smooth seeds have occurred at Heathfield. The interior shows an arched recess in the thick wall. This is probably the chalaza. The seed is quite determinable; but, at present, we can offer no suggestion as to its affinities. Length 5·5 mm.

Fig. 71. A single specimen only of this beautiful seed has been found at Heathfield, and we therefore can say nothing as to its internal structure. It seems to have been somewhat inflated and attached by the thin ventral margin. The testa is of moderate thickness, and covered all over by fine wrinkles which radiate from the hilum. Length 4·8 mm. Breadth 2·65 mm.



TEXT-FIG. 4.

We have not attempted any study of the associated cryptogams; but among the small leaf-fragments obtained by boiling the clays with soda we found the specimen shown in the text-figure 4 (magnified 50 diameters). We illustrate it in order that botanists may see the kind of material

that may be obtained in this way. Mr. MASSEE, to whom we submitted it, writes: "The small organism obviously belongs to the Hepaticæ, and most nearly agrees—so far as general appearance goes—with *Lezeunea minutissima*, HOOKER, but cannot be referred to any recent species."

## EXPLANATION OF THE PLATES.

All figures are from untouched photographs. The figured specimens have been placed in the Museum of Practical Geology.

## Plate 15.

- Figs. 1, 2.—*Magnolia attenuata*, WEBER. Two seeds. Heathfield, 1909. ( $\times 3$ .)  
 Fig. 3.—*Vitis hookeri*, HEER. Heathfield, 1909. ( $\times 6$ .)  
 Figs. 4, 5.—*Vitis teutonica*, AL. BRAUN. Two specimens, showing dorsal and ventral view; fig. 4 is somewhat crushed. Bovey, 1909. ( $\times 6$ .)  
 Fig. 6.—*Vitis ludwigi*, AL. BRAUN. Bovey, 1909. ( $\times 6$ .)  
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 Fig. 29.—*Sequoia couttsiæ*, HEER. Axis of cone, showing at the apex the sessile scales in place, and below the erect or reverted stalks of peltate scales. Bovey, 1909. ( $\times 3$ .) (The exterior of the cone has been figured by HEER.)



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- Fig. 32.—*Sequoia couttsia*, HEER. A peltate scale of the cone, with seeds still attached under the revolute margin. Bovey, 1909. ( $\times 6$ .)
- Figs. 33, 34, 35.—*Sequoia couttsia*, HEER. Three winged seeds, showing extent of the variation. Bovey, 1909. ( $\times 3$ .)
- Fig. 36.—*Sequoia couttsia*, HEER. Preparation of cuticle (boiled with  $\text{KClO}_3$  and  $\text{HNO}_3$ ), showing distribution of the stomata. Bovey, 1909. ( $\times 50$ .)
- Fig. 37.—*Sequoia couttsia*, HEER. Enlargement of part of fig. 36, showing structure of the stomata (the guard-cells tend to disappear under this treatment, both in the fossil and recent *Sequoia*). ( $\times 160$ .)
- Fig. 38.—*Sequoia sempervirens*.—Preparation of cuticle (boiled with  $\text{KClO}_3$  and  $\text{HNO}_3$ , and cleared with ammonia), from an imbricate scale-leaf. Recent. ( $\times 50$ .)
- Fig. 39.—*Sequoia sempervirens*. Enlargement of part of fig. 38, showing structure of the stomata and their close agreement with *S. couttsia*. ( $\times 160$ .)
- Fig. 40.—*Athrotaxis cupressoides*. Preparation of cuticle (boiled with  $\text{KClO}_3$  and  $\text{HNO}_3$ ), showing distribution of stomata. Recent. ( $\times 50$ .)
- Fig. 41.—*Athrotaxis cupressoides*. Enlargement of part of fig. 40, showing structure of stomata. ( $\times 160$ .)

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- Figs. 53, 54.—*Potamogeton tenuicarpus*, n. sp. Two fruits. Heathfield, 1909. ( $\times 12$ .)







42

x6



43

x6



44

x12



45

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46

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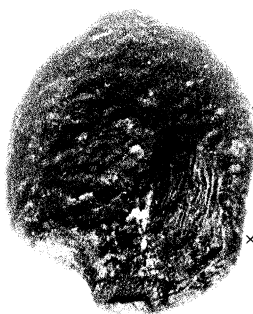
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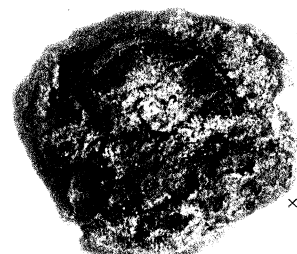
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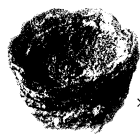
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69

x3



70

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71

x3



72

x6

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- Figs. 73, 74.—*Mastixia*. Two fragments. Heathfield, 1909. ( $\times 3$ .)

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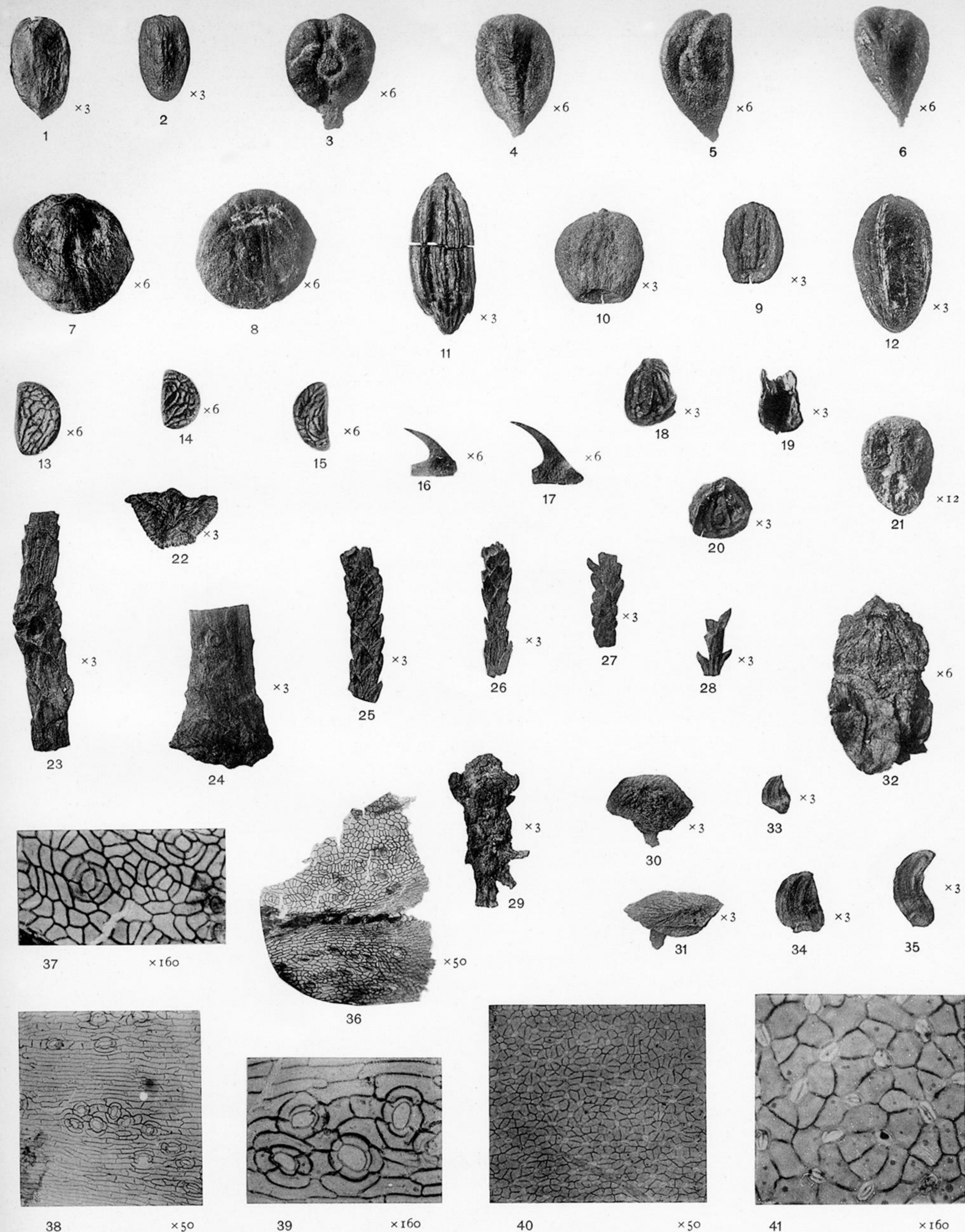


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