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1. DESCRIPTION *and* CORRELATION of the BOURNEMOUTH BEDS. Part  
II. LOWER *or* FRESHWATER SERIES. By J. STARKIE GARDNER,  
Esq., F.G.S. (Read June 8, 1881.)

ABOUT two years ago I had the honour of laying before this Society a description of the marine beds of the Middle Bagshot, exposed between Highcliff and Bournemouth\*. In continuation of my former paper, I now propose completing the description of the Eocene cliffs of this part of Hampshire, as far as Poole Harbour.

These are of freshwater origin, and chiefly interesting on account of the fossil flora recently obtained from them. This appears to be the most extensive and varied yet brought to light from the Tertiary formations; and its study, even now, promises to modify the views held as to the age of very many of the similar fossil floras described from other parts of the world. The Palæontographical Society has undertaken to publish the entire British Eocene flora; and the first parts, comprising the ferns, have already appeared. To illustrate the relative importance of the flora of Bournemouth, I may mention that there are 19 species of ferns described from it, and that only 10 have been met with in all the other British Eocenes and Oligocenes, including Bovey Tracey, and three of these are also found at Bournemouth. Notwithstanding this, few plant-remains are obtained by collectors; for their distribution at Bournemouth is extremely local, and no detailed description of the cliffs containing them has yet been published. A principal object in bringing the present paper before the Society is therefore to indicate the exact position of the fossil-bearing

\* Quart. Journ. Geol. Soc. vol. xxxv. p. 209.

ing beds. The literature of the subject is not extensive, no writer previous to 1827 having even referred to the cliffs of Poole Bay, although the Bagshot beds of Alum Bay, Studland, and Corfe had frequently, since 1800, been described or alluded to.

In 1827, Sir Charles Lyell noticed them, as stated in my former paper\*. The Rev. P. B. Brodie seems to have been the first, in 1842, to call attention to the occurrence of distinct fossil plants in clay to the east of Bournemouth†, referring them to Lauraceæ, Amentaceæ, and Characeæ. Mantell‡, in 1844, adopted Brodie's views, and again, in 1847§, mentioned the occurrence at Bournemouth of "the same species of plants as those found at Alum Bay." In 1847 also Prof. Prestwich|| connected the Bournemouth and Alum-Bay sands and clays with the Bagshot of the London basin; and in 1849¶ he determined the position of the Bournemouth leaf-bed to be from 300 to 400 feet higher in the series than that of Alum Bay. The fossil leaves are referred to, but this time from the west of Bournemouth; and, owing to a local patch only having been examined, the species were thought to be few. In 1851, Mantell\*\* introduced some notes on the "foliage of Dicotyledonous trees," from "thin layers of sandy clay in the cliffs west of Bournemouth;" and in another work†† there is a footnote upon the temperate character of the flora compared with that from Sheppey. In 1855 Trimmer‡‡ used the term "Bournemouth sands and clays" in correlating them with beds of the New Forest. In 1856 De la Harpe§§ recognized 22 species of plants from Bournemouth, 13 of which he supposed to be common to Alum Bay; and in 1859||| we find that Heer was acquainted with the fact of the occurrence of leaves there and elsewhere in the Hampshire basin.

In 1862, in the 'Memoir on the Isle of Wight' by the Geological Survey, it is said that the fossil floras of Bournemouth, Corfe, and Alum Bay are "identical," although we now know that few of the characteristic forms are common to these localities. They are said to be "on exactly the same horizon" without reference to Prof. Prestwich's statement that from 300 to 400 feet of strata intervene. During 1865-69, Mr. W. S. Mitchell was engaged, with the assistance of a committee appointed by the British Association, in collecting specimens and information respecting the fossil leaves; and brief notices were read by him at the meeting of the British Association in 1866. His attention was principally directed to the Alum-Bay beds. The first illustration of a fossil leaf from Bournemouth ever published was of a *Gleichenia* by Mr. A. Wanklyn¶¶ in 1869, or

\* Quart. Journ. Geol. Soc. vol. xxxv. p. 209.

† Proc. Geol. Soc. vol. iii. p. 592.

‡ Medals of Creation, vol. i. p. 193.

§ Geol. Isle of Wight, p. 169.

|| Quart. Journ. Geol. Soc. vol. iii.

¶ Quart. Journ. Geol. Soc. vol. v. p. 43.

\*\* Geological Excursion round the Isle of Wight, 2nd edition. Supplement.

†† Fossils of the British Museum, 1851, p. 51.

‡‡ Journ. Roy. Agric. Soc. vol. xvi. p. 125.

§§ Bull. de la Société Vaudoise des Sciences Naturelles, 1856.

||| Flora Tertiaria Helvetia, vol. iii. p. 314.

¶¶ Ann. and Mag. Nat. Hist. ser. 4, vol. iii. p. 10, pl. i.

fifteen years after Edward Forbes \*, in his Anniversary Address to this Society, had called attention to the necessity of doing something with these floras, and suggested that the Palæontographical Society should direct their attention to them. In 1870 Mr. Mansel-Pleydell, in the 'Flora of Dorset,' alludes to the plant-remains from Bournemouth.

From that time nothing has been written upon the subject, except my own observations, referred to in the first twenty pages of the Palæontographical Society's Memoir on the Eocene flora.

The cliffs which comprise the Bournemouth freshwater series extend from Poole harbour to beyond Bournemouth, and present escarpments averaging nearly 100 feet in height, cut up by many chînes. They are composed of yellow, white, and brownish sands and clays possessing hardly any of the bright-red colouring so conspicuous at Alum and Studland Bays; yet in the sunlight and after heavy rains their ever varying shades of buff and yellow, orange and black, with their crown of dark pine woods, present effects not seen on any other British coast. Looked at in the summer, when baked by the sun and incrustated with blown sand, they appear monotonous, and for years were supposed to be unfossiliferous and on the same plane, much of them being jealously guarded private property.

The freshwater Middle Bagshot series is represented at Alum Bay by the unfossiliferous beds 19 to 24 of Prof. Prestwich's section†, 240 feet thick. It has not been separated, if really present, from the Lower Bagshot beds in the London basin. Besides the cliff exposure at Bournemouth, sections are visible inland in many neighbouring pits and railway-cuttings; in all probability also the extensive deposits of Bovey Tracey are of approximately the same age. These beds cannot be correlated, except palæontologically, with the continental Eocenes, the only beds with similar matrix containing leaves being, I believe, found at Aix-la-Chapelle.

I have placed the Bournemouth series in the Middle Bagshots, drawing the line between these and the Lower Bagshots at the pipe-clays of Corfe, Studland, and Alum Bay, on account of the great dissimilarity of the floras contained in them. The Bournemouth flora is distinct from the older floras, and passes upward into the Oligocene flora without any perceptible break, but does not pass downward into the Alum-Bay series. The two series are, in addition to this, lithologically distinct—the older being characterized by thicker and purer clay deposits and coarser and often deeply stained sands, the newer by black or sandy clay beds of small extent and fine yellow sands. Pipe-clays are everywhere dug from the one, and brick-earths mainly from the other. No flints or stones are ever found in these deposits; and the coarser material is quartz grit.

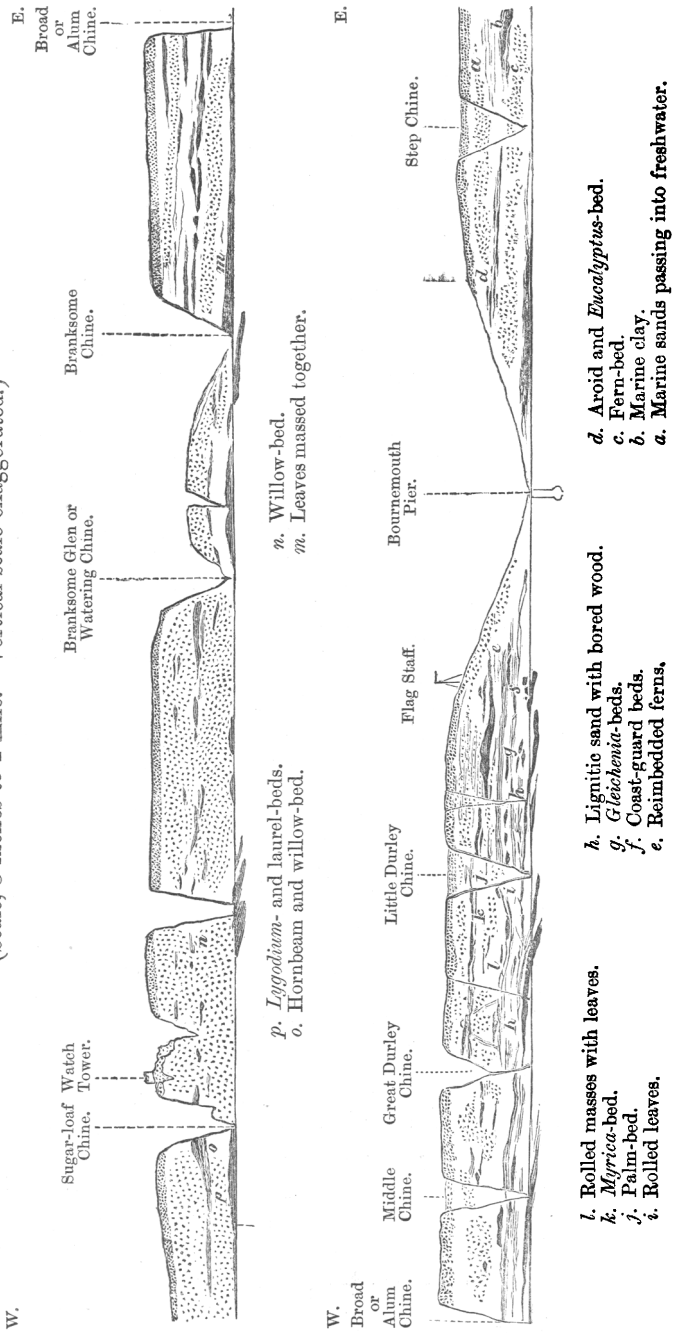
#### *Description of the Beds.*

In describing the beds of this part of the Bournemouth section, I find it most convenient to take what are presumably the oldest first.

\* Quart. Journ. Geol. Soc. vol. x. p. 56.

† Ibid. vol. xxxv. p. 226, fig. 6.

Fig. 1.—View of Cliffs between Poole Harbour and Boscombe, showing position of Plant-beds, &c.  
(Scale, 5 inches to 1 mile. Vertical scale exaggerated.)



## CORRELATION OF THE BOURNEMOUTH BEDS.

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The sequence of beds deposited by river-action is, it is well known, rather horizontal than vertical, the sediments nearest the head of any valley that has been silted up being usually the oldest. To take a familiar instance, the plains of the Rhone above Lake Lemán, were doubtless once a portion of the lake progressively filled in; and if sections through them were now visible, these would present many miles of horizontal stratification, only cut through and disturbed near the surface by the subsequent shifts in the course of the river: yet though continuous and horizontal, the sediments in the upper part of the valley are, of course, enormously older than those forming at the present outfall of the river into the lake. There are many indications that the Eocene river which deposited the Bournemouth strata flowed from a westerly point; and therefore the western extremity of the cliff-section is inferred to be the oldest. Moreover close examination reveals that the clays, sands, and grits, which do not appear at first traceable for more than a few yards, are really often in parallel zones of some extent, and repose at an angle which exposes at least 400 feet of their thickness.

It is scarcely necessary to describe the somewhat complicated formation of the cliffs in minute detail. Their general appearance seaward is that of a confused mass of lenticular patches, now of sand, and now of light- or dark-coloured clay, suggesting forcibly a transverse or oblique section across an old river-valley. The sections up the chines do not present the same lens-shaped patches, but more continuous beds; and it may therefore be assumed that they are somewhat more in the direction of the former channels.

The cliffs fronting the sea may be divided into three groups, which are not difficult to distinguish when unobscured by blown sand or débris.

From Poole Harbour to Bateman's Chine there are masses of dark clay enclosed in the sands. The principal mass is 1100 feet long and about 35 feet above high water. It consists of a continuous band, 4 feet thick, of yellowish sandy clay, overlain by darker clay of varying thickness, and attaining 40 feet at its eastern end. It terminates in the chine, and is barely traceable across to the other side. At the base of this dark clay there are in several places lighter clay patches containing leaves, the most important being situated at about 100 yards to the west of the chine just mentioned. The exact section is:—

	ft.	in.
Gravel, a few feet		
Cross-bedded coarse sands with rolled pipe-clay.....	12	0
Marly white clays, unstratified, with a layer of bright yellow sand	4	0
Slate-coloured clay, with frequent layers of pyrites towards the base. ....	11	0
Black clay with leaves .....	0	6
Shading to fawn-coloured clay with leaves .....	0	6
Regularly stratified yellowish and white sand alternating with pinkish sandy clay. (This bed is continuous for 1100 feet.)...	4	0
White and buff sands. ....	25	0
Black clays, often obliquely, sometimes vertically bedded, usually concealed by débris.		

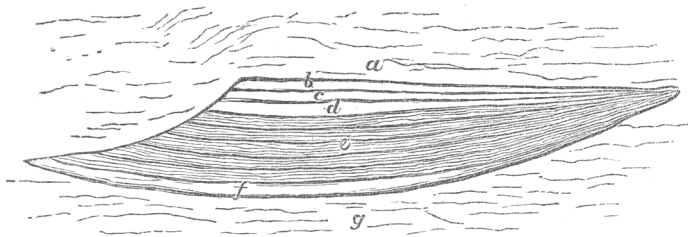
The prevailing leaves are simple and either laurel-like or willow-like, and frequently attached in numbers to the twigs. A large

pinnatifid leaf of the form of *Stenocarpus* is, together with a compound *Acacia*-like leaf, entirely confined to this patch. Other characteristic leaves are a small oval *Smilax* with a thin twining stem, a *Glyptostrobus* (?), and a *Lygodium*. The only fossil feather yet found, so far as I am aware, in England was obtained in this bed. Another patch at the angle of the chine has only single detached leaves, smoothly spread between the surfaces of laminated sandy clay, and is characterized by the great preponderance of a large hornbeam-like leaf and the very large stipules and serrate leaves of, apparently, a willow. Nearer Poole Harbour one or two small patches of clay occur; yet these sometimes contain leaves quite peculiar to them.

Unlike the rest of the cliffs eastward, the longest sections of the clays up to this point face the sea and do not extend far in the up-chine sections.

The second group extends from Sugar-loaf Chine to Watering Chine (fig. 1); and the cliffs are somewhat differently composed. The black clays are almost unrepresented; and in their place are observed numerous small and always lenticular patches of light-coloured clay, not arranged in any horizontal series, but sometimes three or four overlying one another at one spot. They are either composed of pinkish laminated sandy clay, hard white sandy marl, or pure white pipe-clay. The first variety has sometimes faintly marked impressions of leaves, while the latter are unstratified and without fossils. Only one considerable patch in this group, occurring about 100 yards to the east of the Branksome watch-tower, has yielded well-preserved fossils. It is 25 feet across, composed of white and drab and pinkish clay, overlying black sandy clay; and it contains remains of insects, flowers, leguminous pods, small detached willow-like leaves with smooth or serrated margins, stipules, laurel and *Diospyros* leaves. When leaves occur in it that are met with elsewhere on this coast, they are small and stunted. This lenticular patch is composed as follows (fig. 2):—

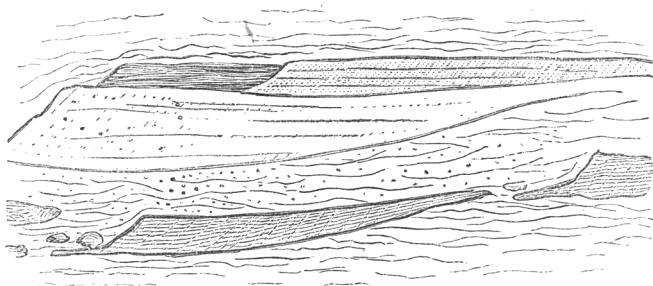
Fig. 2.—Section of Willow-bed, East of Sugar-loaf Chine.



a. Buff quartzose sand	ft.	in.
b. Coarse red iron sand with iron layer at base	0	4
c. White clay, stained slightly yellow in places, with leaves	0	6
d. Cinnamon-coloured clay, with leaves	0	8
e. Blackish clay in layers	7	0
f. Yellowish sandy clay	1	0
White sand	0	1½
Coarse red sand	0	4
g. Quartzose sand to beach.		

The lenticular patches, both of clay and sand, are frequently cut through their steep face to the west, and redeposited, the clays being rolled into small boulders and pellets (fig. 3).

Fig. 3.—*Example of Clay and Sand Beds, imbedded in loose Sands presenting Escarpments to the West, East of Sugar-loaf Chine.*



Under the leaf-bed just described five reefs of pyrites\* are visible at low water, running south-east with a W.S.W. dip. These are succeeded by dark clay dipping E., about 1 in 50, in which I observed a palm trunk *in situ* and numerous spines, and a bed of hard lignite, from 6 inches to a foot thick, underlain by brown clay with roots and covered by pyrites†. Rocks of pyrites again occur opposite Watering Chine, although they are never quite uncovered by the sea; and by means of a diver I was able to trace them two miles seawards towards Alum Bay.

In the third section of the cliffs, from Watering Chine to the Bourne valley (fig. 1), several distinct horizons can again be traced. At the base there are (1) black clays, obliquely bedded, recalling those at the base of the fossiliferous series nearer Poole. Then, in ascending order, interrupted and often separated from each other by sands, (2) black sandy clay, (3) ironstone, (4) small patches of pipe-clay or lightish sandy clay imbedded in sand. Tracing these from bluff to bluff, the dark-sandy-clay (2) and the ironstone (3) horizons are the most distinct, and dip some  $3^{\circ}$  E.; but the pipe-clays (4) are for some distance only represented by an irregular line of small lumps. Up the chine these horizons seem to rise  $4^{\circ}$  or  $5^{\circ}$  N.W. About half-way towards Bournemouth the dip brings in, at first close to the top of the cliff, a new horizon of sandy clay (5), with indistinct leaf-impressions at the angle of Broad Chine. The lower bed of dark sandy clay (2) can be traced across Broad and Middle Chines, until at its western angle it is carried below the beach; and soon after the ironstone horizon (3) also dips out of sight. The horizon can, however,

\* Many beds charged with iron or lignite, though friable in the cliffs, become indurated by sea-water.

† Since writing this description, a very extensive bed of lignite was left exposed, just west of Watering Chine, for a few hours by a violent easterly gale and spring tides.



be traced for several hundred yards along the beach, after easterly gales, and is seen to consist of several layers of ironstone, separated by clays and sands charged with lignitic and vegetable matter, and full of *Teredo*-bored wood. In the meantime the line of light-clay patches (4) becomes more defined; and although the clays are often merely rolled boulders, they assume importance from the beauty and rarity of the fossils which even the smaller isolated fragments contain\*. These boulders indicate how many leaf-patches were broken up and swept away after they had become indurated. The upper dark-clay zone also becomes of great importance; for it contains well-preserved fossils in at least two places, the one being characterized by the abundance of a *Myrica*-like leaf, the other by a large pinnate palm.

The last bluff on the west side of the Bourne, however, is by far the most important palæontologically. It is traversed by the upper dark-clay zone (5), with fossils which are comparatively not well preserved; but the light-clay patches (4) below are large and actually crowded with leaves. Towards the western end of the bluff the two horizons are widely separated by an immense wedge of indurated and laminated sands; but under the Highcliff mansions they approach to within about a dozen feet of each other, a mass only 10 or 12 feet thick of orange sand and ironstone separating them. The lenticular clay basin below this sand appears to have been known for several years as a spot for collecting; and it is regrettable that some systematic care was not bestowed upon it; for its margin is now almost reached, and scarcely any further specimens can now be obtained. It was characterized by an abundance of *Gleichenia*, which seems to have grown in a marly bed still pierced by rootlets, and also by what appears to be a distinct conifer, a *Godoya*, and *Iriarteia*, all these being very rarely, if ever, met with elsewhere. The cliff-section exactly under the flagstaff of the Coast Guard station is as follows:

		ft.	in.
	Light to yellow sand.....	10	0
	Black sand.....	1	0
	White sand .....	5	0
Upper horizon of clays.	Black clay .....	3	0
	Orange clay .....	1	0
	Black clay .....	12	0
	Light clay with leaves .....	2	0
	Light sand with lignitic grains .....	2	0
	Hard white sand .....	2	0
	Drab-and-white mottled clayey sand, passing to white sand .....	18	0
Lower horizon	Although no clay is present here, there are patches of clays. a few yards east and west abounding in leaves.		
The rest of the cliff is composed of grits and sands containing iron, with white sand containing lignitic matter near the sea-level.			

Twelve yards further on, the mottled sandy clay contains débris of palms, ferns, rushes, &c. Below this a few yards to the east occur by far

\* From one of these a large part of a pinna, the spathe, and fruit-stalks of a date-palm were obtained.



the richest fossil-bearing beds. The details are:—first a layer of quite decomposed *Teredo*-bored wood; then compact blackish clay in a wedge-shaped mass, 36 yards long, 10 feet thick, with a water-worn and uneven upper surface, laminated, highly pyritous, containing between some of its layers detached pinnules of *Osmunda lignitum*, twigs of *Sequoia Couttsiae*, spines, a small leguminous pod, and other fruits or seeds\*. [The leaves &c. are black and lustrous, but very difficult to preserve. The large frond of *Chrysodium*, figured pl. i. 'British Eocene Flora,' and leaves of palm are from this bed.]

The black clay passes into a cinnamon-coloured clay containing abundant and exquisitely preserved leaves, even the commonest of which are as yet undetermined.

The cinnamon clay rests upon a band of ironstone 1 foot thick, and this upon 5 feet of coarse angular grit; and then follows a patch about 1 foot thick of light drab and very tenacious clay, full of a small, variable and peculiar although as yet undetermined leaf, and of a *Smilax*. Below this, and separated from it by 30 inches of whitish and orange, more or less lignitic sand, are two beds, 4 or 5 inches thick, of sandy clay, finely laminated and full of leaves, becoming, in fact, towards the base a mere mass of decayed vegetable matter. The leaves contained in them are much handsomer, larger, and in far greater variety than those of any other of the beds. From this point to the pier no fossiliferous beds are exposed; but in excavating the foundations of the club-house, which is in their direct line of dip, it is stated that leaves were met with.

At 390 paces east of the pier, where the cliffs again rise, and some 40 feet above high water, I find that a bed of dark clay comes in, underlain for about 100 yards by light-coloured sands, filled with angular blocks of clay. These blocks are mostly of small size; but they contain a flora differing markedly from that of any of the lower beds to the west. Most abundant are fragments, and even perfect leaves, of a large aroïdeous plant, of an *Araucaria* and a *Eucalyptus*; and it is remarkable that while the *Araucaria* especially has never been met with west of the pier, it is the prevailing fossil in all beds east of it. Hence to the next chine, 350 yards distant, the cliffs are almost all grit and sand, though in places near their base there is much *Teredo*-bored wood, some stems measuring 12 feet long. Beyond the chine the clays and sands are much mixed; and 300 yards beyond the chine the last beds having the appearance of fresh water origin are seen. These are a series of thin, sharply defined beds of different composition, brightly coloured, overlain by black marine sandy clay and resting upon hard white sand. They contain in several places layers of ferns, principally those with reticulated venation, belonging to *Polypodium* and *Acrostichum*. Beyond this there is a mass of sands containing broken-up leaf-beds and lignitic matter, and then the more regular sequence of the marine series. The most eastern section of the freshwater series is as follows:—

\* Palæontogr. Soc. 1879, Gardner & Ettingshausen, Brit. Eocene Flora.

	ft.	in.
White sand		
Pale and dark yellow sands and whitish clay .....	4	6
Dark sandy clay with marine shells .....	6	6
Dark and bright sands .....	20	0
Stiff black clay .....	1	0
Sandy laminated clays with ferns .....	2	6
Mottled yellow-and-white sand .....	3	0
Hard white sand .....	about 25	0

The cliff-sections, looked at broadly, show that the prevailing arrangement of the material is seldom departed from. Interest chiefly centres in the clays, on account of the plant-remains they contain. These may be divided by their fossils into three groups—those at the western extremity of the section mostly characterized by the presence of *Salix* and absence of palm, the central group by abundance of palms and ferns, the eastern group by *Araucaria*, net-veined ferns, and *Eucalyptus*. These differences might either be due to changes in the physical condition of the land, brought about by lapse of time between the deposition of each, or to the dissimilarity of the stations whence the respective floras were derived, or in part to both causes. The western series, as we have seen, is separated from the central group\* by more than a mile of grits and clays, which cannot be traced in horizons like those east and west of it. The absence of dark clays and, indeed, of large clay patches and of distinct fossils, the coarseness and quantity of the sand and grit, the want of regularity, and the frequency with which sands and clays have been cut through and redeposited, seem to show that this was the filling-in of the former actual main channel of the river. The lenticular forms of the sands and clays in the face of the cliff show that the section must be a transverse or obliquely transverse one; and the fact that the patches which have been cut through invariably present the steep side to the west, points to the direction of the set of the stream. Thus the clays in the horizons of leaf-patches, both east and west of that which is supposed to have been at times the main channel, are seen to be much smaller and more frequently broken up and rolled into boulders as this is approached, and to be larger and therefore, at the time of deposition, more free from violent river-action as the central channel is quitted. If this was really at any time the main channel and all occupied at one time, the river must have been more than a mile in width, and the width of its valley subject to floods cannot have been less than 9 miles, and was possibly even 16 miles. The total absence of boulders and the fineness of the silt show that it flowed over a comparatively flat area; and the absence of lignite throughout a great part of its thickness, that probably there were lakes or catchment basins in its course to intercept drifting timber. Possibly the Bovey Tracey lignite basins, only 80 miles distant, which are undoubtedly of about the same age, may be relics of these. The complete absence of any material derived from flint or chalk shows that no chalk ranges were cut through by it; and the quartzose and granitic sand, and pipe-clay, that its sediment must

\* Sugar-loaf to Watering Chine.

have been mainly derived from an old rock area. There are no indications of the proximity of salt water, beyond the occurrence of bored wood; and although this is met with in existing rivers even 300 miles from the sea, its presence must imply that this region was towards the lower part of the course of the river, although little influenced, I believe, by tides.

If this were admitted to be the filling-in of the main channel, the remainder of the cliff-section would have been formed in a valley not continuously subjected to the action of running water. The clay patches would mark pools or slackwater creeks; and while it is quite possible that those without fossils, and especially those that are not laminated, may have been deposited in depressions at the bottom of the river itself, it is certain that those with an abundance of leaves smoothly deposited must have been formed away from the influence of strong currents, and in sidings of, or pools left by, the river. The clays are of all shades, from white to black, the more considerable masses being always dark. The pure sediments of the river and its sands were white; and we therefore cannot but infer that the staining-matter of the dark masses was iron and carbon, derived from decaying vegetation. In the case of the leaf-beds the dark clays always have lighter layers between them and the sands which surround them, and these contain the best-preserved leaves. I have seen no instance of the dark clays enclosing lighter layers, nor of their ever, when undisturbed, coming into direct contact with the sands or grits\*. The presence of leaves in the lighter beds shows at least that vegetable matter reached the pools in some abundance, and their absence in the blacker clays that they had decomposed into staining-matter. The section of the beds just west of the pier presents at its base fine river-sand, becoming carbonaceous as the current diminished, then choked with the fallen leaves, and then a nearly stagnant pool. The deposition of mud was abruptly ended by an influx of coarse grit several feet in depth. The same process was repeated in the second leaf-bed; but the third pool was formed more suddenly; for the clay rests immediately on clean grit and is not discoloured, though leaf-impressions abound in it. It is margined, like a few other leaf-beds here, with a white marl penetrated by rootlets. The succeeding 5 feet of coarse granitic grit mark the passage of a considerable body of water, and of some swiftness, and the ironstone a period of stagnation. The white clay shows that water again trickled in, charged with enough sediment to bury the leaves before they decayed. This passes gradually into the black clay, small light patches with actually skeletonized leaves in them (one has yielded a unique *Cecropia* leaf, and another a fern, *Adiantum* (*Hewardia*) *regia*) penetrating the black stagnant clay, which is dark with decomposed vegetation and charged with sulphide of iron. In some layers ferns and seeds can still be traced; but in most the vegetable matter is thoroughly decayed. Layers of compact clay are separated by what are now films of carbonaceous matter, to the number of hundreds, each layer indicating possibly only

\* Dark-clay masses sometimes contain galls of the finest pipe-clay, due, I believe, to segregation.

a year. Over this is lighter clay, as if the water again began to trickle in more freely; and then once more follows the sudden change to grit. The reimbedded lumps of clay above show that many such sequences may have been broken up and swept away; indeed it is more likely that a violent flood would have this action than a preservative one.

The general dip of these strata is difficult to ascertain, owing to the absence of continuous beds\*. It does not seem so uniform as in the marine series; and I am therefore only able to make a rough estimate that the western flora may be, probably, at least 200 feet vertically below the central flora. The central flora and the eastern flora must be separated by at least another 100 feet of strata, and the fern beds at the extreme east from the latter by 50 feet more. I should therefore estimate the total thickness of the freshwater beds seen in the cliff from Poole Harbour to the Meyrick Road in Bournemouth at not less than 400 feet. Nor is this the entire thickness of the group; for it seems likely, judging from the beds along its margin, that a mass of clay and sand, perhaps another 100 feet in thickness, has been denuded by the Ware in the formation of Poole Harbour. The clays in this lower part are in more extensive patches, and rarely, if ever, contain leaves, although unbored trunks of trees are not uncommon. They are evidently on a lower horizon and can be well examined in the numerous brick-pits which are worked into the hills encircling Poole Harbour from Parkestone to Upton. A well sunk at Longfleet Union Workhouse† close to Poole, penetrated 250 feet before pipe-clay was reached; but at Branksea it is much nearer the surface.

### *The Flora.*

None of the prevailing types familiar to workers at Alum Bay are found at Bournemouth; nor are any of the well-known Bournemouth types found at Alum Bay. On the other hand, they seem to pass upward through the Marine series to the Hordwell and the Bembridge strata. They are, in many respects, identical with the types of the Bovey flora; and their affinities are completely with the floras ascribed in France to the Oligocene. The facies of the flora seems, from what is at present known of it, to be chiefly Australian and tropical American; and its forests were so varied and rich in species, that they can only be compared, among existing botanical regions, to those of Atlantic America and Manchuria. It is difficult to reconcile the prevalence of distinct leaves in each separate pool, except upon the supposition that they fell from not far distant clumps of trees. Yet we have no evidence of the close proximity of forest growths, except occasional butts of palms imbedded in clay; and the remains must have been floated down, though probably from short distances, unless, indeed, it can be supposed that they were thus separated by the different powers of flotation of the leaves.

\* The dip can sometimes be seen very clearly at low water, when the beach has been removed by easterly gales.

† Proc. Geol. Soc. 1840, p. 413.

I have elsewhere endeavoured to show that there was a river of large size, bringing deposits from the westward, throughout the whole of our Eocenes. The Bournemouth Cliffs, I have long believed, present a section across its bed, and were formed during a continued period of subsidence. The sudden changes from fine to coarse sediment and the thickness of the deposit cannot be explained by the floods and freshets incidental to changing seasons, nor by the natural meanderings of a river over a wide valley, but are such as would occur whenever subsidence exceeded, in however trifling a degree, the silting-up power of the river.

A question of importance which must be raised by the floras found in these Bournemouth beds when they are studied, is whether the ages of the continental floras similar to ours have been correctly determined. While all the strata that have yielded dicotyledonous leaves or fruits in England below the Headon series are universally admitted to be Eocene, scarcely any of the beds on the continent resembling them are ascribed to that age\*.

Yet the British Eocenes, exclusive of the Upper Eocenes, or Oligocenes, are known to be about 1500 feet thick, besides the great gaps in them, of which there is abundant evidence; and almost the whole of this thickness is an alternation of estuarine and fluvatile beds, rich in plant-remains from the highest deposit to the lowest.

Until recently nearly every isolated patch containing a dicotyledonous flora was supposed to be Miocene. This was due to the accidental circumstance of the Miocene formation of Eningen and other localities in Central Europe having early attracted attention and been described. As all Eocene floras approximate more or less to Miocene, it was easy, in the absence of stratigraphical evidence, to assume that all isolated patches with dicotyledons belonged to the latter period. This classification was greatly favoured by the fact that the Middle Eocene floras differ strikingly from the older ones, owing, it would seem, to the incoming of a large proportion of plants resembling existing tropical American species. The great differences seen between the older Eocene floras that were partially known (such as those of Monte Bolca, Sézanne, Sheppey, Alum Bay) and the Miocene floras further supported these views; and we accordingly find that even our own outlying patch of the Middle Bagshot series at Bovey Tracey is described as Miocene. In consequence of the position assigned to it remaining apparently undisputed, very many other formations containing similar floras have been placed in the Miocene; and had the stratigraphical evidence at Bournemouth been inconclusive, the whole of that Eocene formation must also, upon plant-evidence, have been classified as Miocene.

In the same manner the true age of the so-called Miocene forma-

\* In 1874 Schimper enumerated the following ferns from beds containing dicotyledons:—

Upper Cretaceous (principally Aix-la-Chapelle) .....	46
Pal-eocene (Sézanne) .....	14
Eocene .....	8
Oligocene .....	19
Miocene .....	69

tions in the Arctic regions is extremely doubtful. I have long believed most of them to be Eocene; and this view is held by Dawson, Lesquereux, Saporta, Marcou, and others, all well qualified to judge. The plant-evidence is at present negative, in one sense; for although a proportion has, apparently, been identified by Heer with those of the Miocene of Switzerland, the true age of part of which is itself doubtful, another portion is identified by Dawson and Lesquereux with the undoubtedly Eocene, or even older Lower Lignitic of America. On the other hand it appears to me that the fact of there being a similarity in these floras to those of the Miocene is against their being of that age; for no two floras, so much alike and assimilating so closely to those of the present day could have grown contemporaneously in such widely separated latitudes—that is, if they grew at the same level, as is commonly assumed.

Apart from this, we have the following arguments in favour of some among the floras described being of Eocene age:—(1) the fact that the supposed Miocenes generally rest directly on the supposed Cretaceous rocks; (2) the absence of any explanation of the immense gap which Heer's grouping implies, and of which there is no stratigraphical evidence; (3) the Eocene climate may have permitted the growth of the floras, and that of the Miocene could not; (4) the probability that plants must have existed in Eocene times in the area (for there is ample evidence that it was then land), and there being no marine deposits of Eocene age there; (5) the improbability that Eocene remains can have alone escaped observation in a series of apparently consecutive deposits of immense extent and thickness, abounding in plants, and continuous, it is supposed, from the Middle Cretaceous to the Miocene.

Whether these are still called Cretaceous or Miocene, it is certain that in the various scattered dicotyledonous floras of Europe and America we have a great sequence of floras, each linked to the other by numerous plants contained in common, which there is the utmost difficulty in classifying under the existing divisions of Eocene and Miocene. Even the introduction of a Pal-eocene division and the recognition of an Oligocene formation have not lessened the difficulty. The Oligocene commences in England, as recently brought under our notice by Prof. Judd, at the base of the Headon series; but this line, unfortunately, severs in two a flora which is homogeneous, from the base of the Bournemouth beds to the Bembridge marls, and separates the lower and most important part from the congeneric and closely identical floras of France, which have all been placed in the Oligocene. Again the Lower Eocene brings together in one formation the floras of Bromley, Reading and Newhaven, and the almost perfectly distinct floras of Sheppey and Alum Bay. The Miocene, so far as its plant-beds are concerned, embraces, according to some authors, the whole Middle Eocene and up to the Pliocene, while opinions still diverge as to what are the characters by which a Cretaceous dicotyledonous flora should be recognized.

The existing divisions of the Tertiary were based, as we all know, solely upon their marine Mollusca. It would be inconvenient at

present to alter them, even were there any chance of such a proposal finding favour; but I would submit, as well worthy the consideration of this Society, whether, as the very existence of these vast series of plant-remains was unknown when the present classification was established, the time has not almost arrived to introduce a separate classification for plant-remains, which the impossibility of applying the present one to them seems to render necessary. The classification for terrestrial conditions and for marine conditions may with advantage be kept distinct until our knowledge is sufficient to enable us to correlate them satisfactorily. Otherwise it may be a very long time before confusion ceases; for I may venture to say that the flora at Bournemouth, which stratigraphical evidence of the most unequivocal description compels us to place at the very base of what is known as our Middle Eocene, would have been, if inference is permissible from their published work, regarded by Prof. Heer as Lower Miocene, by the Marquis of Saprota as Oligocene, by Baron von Ettingshausen and Prof. Lesquereux as Eocene, and, perhaps, by Prof. Newberry as Cretaceous. With less known, more isolated, and less distinctive floras the divergence of opinion would, doubtless, be greater. We have only to realize the vast difference, not only stratigraphically, but in the conditions of life upon the earth, which this discrepancy implies, to see the great inconvenience that must be caused to science through it.

#### DISCUSSION.

Mr. KOCH stated that the Mull beds contained leaves which very closely resembled some of Mr. Gardner's drawings.

Prof. JUDD remarked that Mr. Gardner's researches pointed to the necessity for distinct classifications based on terrestrial and on marine forms respectively.

Prof. HUGHES pointed out that in the case of some of the beds referred to there could be no comparison such as that suggested by Prof. Judd, as some contained remains of plants only, and no marine testaceous mollusca.

Mr. GARDNER thought that the greatest separation in the Eocene formation existed between the Bracklesham and Barton series rather than between the Barton and the later series; but he thought this change was a purely local one in the British area.