speakers, at which the following resolution was passed: "That this meeting of the inhabitants of Chelsea, having heard that there is a probability of the old physic garden on the Chelsea Embankment being no longer kept up by the Apothecaries' Company, considers that every effort should be made to preserve it for the public as an open space." Under these circumstances we wish to put in a plea that the claims of the London students of systematic botany and materia medica should not be overlooked, or the scantiness of their opportunities for the study of living plants forgotten.

THE SEARCH FOR COAL IN THE SOUTH OF ENGLAND.[1]

(1) THE bare facts of the recent discovery of coal-measures at Shakespeare Cliff, near Dover, have been published in the press, and the full account cannot be written till the completion of the inquiry which is now going on. It is, however, not unfitting that the bearing of the discovery on the general question of the existence of workable coal-fields in Southern England should be discussed within these walls, not merely on account of its general interest, but because it naturally follows the paper read by Mr. Godwin-Austen before the Royal Institution, in 1858, "On the Probability of Coal beneath the South-Eastern parts of England." In 1855 he had placed before the Geological Society of London the possibility of the existence of coal in South-Eastern England at a workable depth. In the two years which had elapsed, "the possibility" had grown in his mind into the "probability," and in the thirty-two years which have passed between the date of the paper before this Institution and the present time, "the probability" has been converted into a certainty by the recent discovery at Dover. In this communication, the lines of the inquiry laid down by Godwin-Austen will be strictly followed. We must first examine the conditions under which the coal-measures were accumulated.

(2) The seams of coal are proved, by the surface-soil traversed by roots and rootlets, to which in some cases the trunks are still attached, to have been formed *in situ* by the growth and decay of innumerable generations of plants (*Lepidodendra*, *Sigillaria*, *Calamites*), pines (*Trigonocarpa*, *Dadoxylon*, *Sternbergia*) allied to *Salisburia*, and a vast undergrowth of ferns, all of which contributed to form a peat-like morass. Each seam represents an accumulation on a land-surface, just as the sandstones and shales above it point to a period of depression during which sand-banks and mud-banks were deposited by water. The fact also that the coal-seams in a given sinking are parallel, or nearly parallel, implies that they were formed on horizontal tracts of alluvium, while the marine and fresh-water shells in the associated sandstones and shales prove that they were near the level of the sea, or within reach of a mighty river. This tract of forest-clad marsh-lands, as Godwin-Austen and Prestwich have pointed out, occupied the greater part of the British Isles, from the Highlands of Scotland southwards as far as Brittany, and eastwards far away into the valley of the Rhine, and westwards over the greater part of Ireland. It swept round the hills of South Scotland and the Lake district and the region of Cornwall. It occupied a delta like that of the Mississippi, in which the forest-growths were from time to time depressed beneath the water-line, until the whole thickness of the coal-measures (7200 feet thick in Lancashire, 7600 in South Wales, and 8400 in Somersetshire) was built up. After each depression the forest spread again over the sand and mud of the submerged parts, and another peat-layer of vegetable matter was slowly accumulated above that buried beneath the sand and mud. The great extent of this delta implies the existence of a large river draining a large continent, of which the Highlands of Scotland and the Scandinavian peninsula formed parts, and which I have described before the Royal Institution under the name of Archaia.

(3) At the close of the Carboniferous age, this vast tract of alluvium was thrown into a series of folds by earth-movements. These have left their mark in the south of England and the adjacent parts of France, in the anticline of the English Channel, the syncline of Devonshire, the anticline of the Mendip Hills and of the lower Severn, and the syncline of the South Wales coal-fields. These great east and west folds have been traced from the south of Ireland on the west, through 35 degrees of latitude, through North France and Belgium, as far as the region of Westphalia. Next, the upper portions of the folds were attacked by the subaërial and marine agents of denudation over the whole of the Carboniferous area, leaving the lower parts to form the existing coal-fields which lie scattered over the surface of the British Isles, and are isolated from each other by exposures of older rocks; and a broad east and west ridge was carved out of the folded and broken Carboniferous and older rocks, extending from the anticline of the Mendip Hills eastward through Artois into Germany, and constituting the ridge or axis of Artois of Godwin-Austen.

The next stage in the history of the folded Carboniferous and older rocks is marked by the deposition of the Permian and Secondary rocks on their eroded and water-worn edges, by which they were partially concealed or wholly buried, and these newer strata thin off as they approach the ridge of Artois. This barrier, also, of folded Carboniferous and older rocks sank gradually beneath the sea in the Triassic, Liassic, Oolitic, and Cretaceous ages, and against it the strata of the first three named ages thin off, while in France and Belgium the Cretaceous deposits rest immediately upon the water-worn older rocks.

From these general considerations it is clear that the coal-measures which formerly extended over nearly the whole of Southern England can now only be met with in isolated basins under the newer rocks, and that these are thinnest along the line of the above-mentioned barrier.

(4) The exposed coal-fields in Britain, and on the Continent also, Godwin-Austen pointed out, along this line, are of the same mineral character, and the pre-Carboniferous rocks are the same. This ridge or barrier also, where it is concealed by the newer rocks, is marked by the arch-like fold (anticlinal) of the chalk of Wiltshire, and by the line of the North Downs in Surrey and Kent. Godwin-Austen finally concluded that there are coal-fields beneath the Oolitic and Cretaceous rocks in the south of England, and that they are near enough to the surface along the line of the ridge to be capable of being worked. He mentioned the Thames Valley and the Weald of Kent and Sussex as possible places where they might be discovered.

These strikingly original views gradually made their way, and in the next eleven years became part of the general body of geological theory. They were, however, not accepted by Sir Roderick Murchison, the then head of the Geological Survey, who maintained to the last that there were no valuable coal-fields in Southern England.

(5) The next important step in the direction of their verification was that taken by the Coal Commission of 1866-67, by whom Mr. Godwin-Austen was examined at length, and the results of the inquiry embodied in the Report by Mr. Prestwich. In the Report Mr. Godwin-Austen's views are accepted, and fortified by a vast number of details relating both to the coal-fields of Somersetshire and of France and Belgium. Mr. Prestwich also calls special attention to the physical identity of the coals of these two regions, and to the fact that the Carboniferous and older rocks in both are similarly dis-

[1] Friday Evening Lecture delivered at the Royal Institution on June 6, by Prof. W. Boyd Dawkins, F.R.S.

turbed. He concludes, further, that the coal-fields which now lie buried beneath the newer rocks are probably equal in value and in extent to those which are exposed in Somerset and South Wales on the west, and in Belgium and France on the east.

We will now proceed to test these theoretical conclusions by the light of recent observations.

(6) The coal-fields of Somerset and Gloucester were proved by the labours of Prof. Prestwich and the Coal Commission of 1866–67 to be small fractions of the great coal-basin which lies buried beneath the Triassic, Liassic, and Oolitic rocks, from the Mendip Hills northwards past Bristol to Wickwar. On the west also three small isolated coal-basins occur—those of Nailsea and Portishead, which are partially, and that of Aust, which is wholly, concealed by the newer rocks. The coal-measures are folded and broken, and traversed by great "overthrust" faults, which at Kingswood give the same series of coals twice over in the sinkings of one colliery. Their southern boundary is the line of the Mendip Hills. They also probably occur at a depth which remains to be proved, still further to the south, in the valley of the Axe and the district of Glastonbury, the most southern boundary being the mountain limestone of Cannington, near Bridgwater. The great Somerset and Gloucester field may extend to the east under the newer rocks, between Freshford and Beckington, in the district south of Bath.

The value of the evidence of the coal-fields of the west of England on the general question consists in the fact that they may be taken as fair samples of those which lie concealed along the line of the buried ridge through South-Eastern England in the direction of France, Belgium, and Germany.

(7) One of these concealed coal-fields has been struck in a deep boring at Burford, near Witney, in Oxfordshire, at a depth of 1184 feet, under the following rocks :—

	Feet.
Oolites	148
Lias	598
Rhætic	10
Triassic rocks	428

The sandstones and shales of the coal-measures were penetrated to a depth of 225 feet (De Rance, Manch. Geol. Soc., March 26, 1878).

These coal-measure rocks form, as suggested by Hull, one of the same series of coal-basins as those of South Wales and the Forest of Dean, and probably mark the line of the continuation of the South Wales syncline in the direction of Harwich, where Carboniferous shale has been struck at a depth of 1052 feet from the surface.

This boring proves not merely the presence of coal-measures at a workable depth in Oxfordshire, but also the important fact that the Triassic rocks, which are of great thickness further north, have dwindled down to an unimportant thickness in their range southwards and eastwards. Further, that south, in the London area, these rocks are wholly absent; and farther to the east, at Harwich, the Liassic and Oolitic strata and Lower Greensand are absent, and the Gault rests on the eroded Lower Carboniferous rocks, inclined at a high angle.

(8) The water-worn surface of the folded rocks, which are older than the Carboniferous, has been repeatedly struck in deep borings for water in the neighbourhood of London, at depths ranging from 839 feet at Ware to 1239 feet at Richmond. They consist of Silurian strata in the north at Ware, and of Old Red Sandstone or Devonian rocks in the other localities. From their high angle of dip, as in the case of similar rocks underlying the coal-fields of Somerset and Northern France and Belgium, it may be inferred that coal-fields lie in the synclinal folds in the neighbouring areas.

From the fact of the Silurian rocks being in the north, while all the rest of the borings to the south terminate in the Devonian or Old Red rocks, it may be inferred that the chalk of the North Downs probably conceals the coal-measures. It must also be noted that there are no Wealden rocks in the London area, and no Lower Greensands, and that the Lower Oolites at their thickest are only 87 feet. The secondary rocks, which are of great thickness in the midland and northern counties, thin off as they pass southwards towards London, against the ridge of older rocks, as both Austen and Prestwich have pointed out.

It is therefore in the area south of London, rather than in that immediately to the north, that the coal-measures are to be looked for at a workable depth beneath the surface, and underneath the chalk of the North Downs. It must, however, be noted that the line of the South Wales syncline through Burford passes to the north of Ware, and that there may be coal-measures in the northern parts of Essex and of Hertfordshire at a workable depth.

(9) The Report of the Coal Commission was published in 1871, and in the following year the Sub-Wealden Exploration Committee was organized by Mr. Henry Willett, to test the question of the existence of the Carboniferous and pre-Carboniferous rocks in the Wealden area by an experimental boring. The site chosen was Netherfield, about 3 miles south of Battle, in Sussex, where the lowest rocks of the Wealden formation constitute the bottom of the valley. The rocks penetrated were as follows :—

Section of Netherfield.

	Feet.
Purbeck strata...	200
Portland strata	57
Kimmeridge clay	1073
Corallian strata	515
Oxford clay	60
	1905

This boring showed that the coal-measures and older rocks are, in that region, more than 1900 feet from the surface of the ground. We may also infer, from the fact of the bottom of the bore-hole being in the Oxford clay, and from the known thickness of the Bath Oolitic strata in the nearest places, that it lies buried beneath considerably more than 2000 feet of newer rocks. With this valuable, though negative result, the Sub-Wealden exploration came to an end. It was a purely scientific inquiry, paid for by subscription, and largely supported by those who had no pecuniary interest in the result.

The experience of the boring at Netherfield showed that the search for the coal-measures and older rocks of Godwin-Austen's ridge would have to be carried out at some spot further to the north, in the direction of the North Downs. In the district of Battle the Oolitic rocks were proved to be more than 1700 feet thick, and the great and increasing thickness of the successive rocks of the Wealden formation above them, which form the surface of the ground between Netherfield and the North Downs, rendered it undesirable to repeat the experiment within the Wealden area proper, where the Wealden rocks presented a total thickness of more than 1000 feet, in addition to that of the Oolites. My attention, therefore, was directed to the line along the North Downs, where Godwin-Austen believed that the Wealden beds abruptly terminated against the ridge of coal-measures and older rocks, and where, therefore, there would be a greater chance of success.

(10) The evidence, also, of the French, Belgian, and Westphalian coal-fields pointed in the direction of the North Downs.

The Carboniferous and older rocks, which we have hitherto traced only as far as the area of London from their western outcrops in Somerset, Gloucestershire, and South Wales, reappear at the surface in Northern France,

Belgium, and Westphalia, and contain most valuable coal-fields, which are long, narrow, and deep. These extend from the district of the Ruhr on the east, through Aachen, Liége, Namur, Charleroi, Mons, and Valenciennes. The enormous value of the last field led, during the last hundred years, to numerous borings through the newer rocks, which have extended the western range of the coal-measures upwards of 95 miles away from its disappearance under the Oolites and chalk, as far as Flechinelle, south of Aire, or to within 30 miles of Calais. It occupies throughout this distance a narrow trough or syncline, 11 miles across at Douchy, and about half a mile at its western termination. It is represented still further to the west by the faulted and folded coal-fields of Hardinghen and Marquise, which are within about 12 miles of Calais. The coal-measure shales and sandstones found in a boring at Calais, at a depth of 1104 feet from the surface, in 1850,[1] reveal the existence of another coal-field in the same general line of strike, and making for Dover and the North Downs.

(11) We have seen that the range of the coal-measures has been pushed farther and farther to the west by experimental borings, until they have been proved to exist underneath Calais. The opposite shores of the Straits of Dover, therefore, presented the best locality for a trial still further to the west. In choosing a site, the Channel Tunnel works, close to Shakespeare Cliff, Dover, appeared to me to present great advantages, which I embodied in a report to Sir Edward W. Watkin, in 1886. The site is within view of Calais, and not more than 6 miles to the south of a spot where about 4 cwt. of bituminous material was found embedded in the chalk in making a tunnel, which, according to Godwin-Austen, had been probably derived from the coal-measures below.

Prestwich also had pointed out, in 1873, in dealing with the question of a tunnel between England and France, that the older rocks were within such easy reach at Dover, that they could be utilized for the making of a submarine tunnel. Sir Edward Watkin acted with his usual energy, and the work was begun in 1886, and has been carried on down to the present time, under my advice, and at the expense of the Channel Tunnel Company. The boring operations have been under the direction of Mr. F. Brady, the Chief Engineer of the South-Eastern Railway, to whose ability we owe the completion of the work to its present point, under circumstances of great difficulty. A

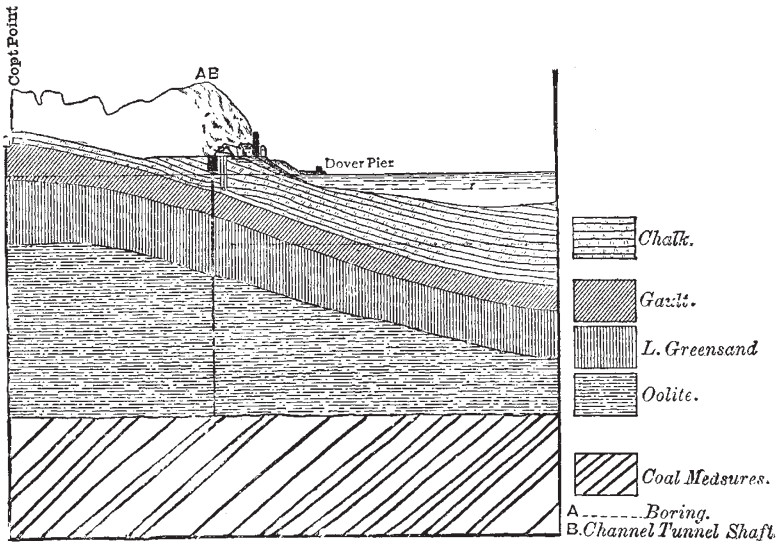

Fig. 1.—Boring at Shakespeare Cliff.

shaft has been sunk (A, Fig. 1) on the west side of the Shakespeare Cliff, close to the shaft of the Channel Tunnel (B) to a depth of 44 feet, and from this a bore-hole has been made to a depth of 1180 feet.

Section at Shakespeare Cliff, Dover.

	Feet.
Lower grey chalk, and chalk marl	
Glauconite marl	500
Gault	
Neocomian	
Portlandian	
Kimmeridgian	
Corallian	660
Oxfordian...	
Callovian	
Bathonian	
Coal-measures, sandstones, and shale sand clays, with one seam of coal	70

The coal-measures were struck at a depth of 1204 feet from the surface, or 1160 feet from the top of the bore-hole, and a seam of good blazing coal was met with 20 feet lower.

(12) This discovery proves up to the hilt the truth of Godwin-Austen's views as to the range of the coal-measures along the line of the North Downs, and as to the thinning off of the Oolitic and Wealden strata against the buried ridge. The former are less than one-third of their thickness at Netherfield, and the latter are wholly unrepresented. It establishes the existence of a coal-field in South-Eastern England, at a depth well within the limits of working at a profit. The principal coal-pits in this country are worked at depths ranging from over 1000 to 2800 feet, and one at Charleroi, in Belgium, is worked to a depth of 3412 feet.

The Dover coal-field probably forms part of the same narrow trough as the Calais measures, prolonged westward under the Channel further to the south than Godwin-Austen drew it in 1858. Whether it is a trough similar to that which extends through Northern France for more than 100 miles from east to west, as Godwin-Austen has drawn it in the diagram on the wall, reaching as far to the west as Reading, or whether it is a small, faulted, insignificant fragment of a field, such as that of Marquise and Hardinghen, remains to be proved. It is,

[1] This fact is doubted by Gosselet. I am, however, informed by Prestwich that both he and Elie de Beaumont identified them as coal-measures at the time, and I see no reason for doubting the accuracy of those two eminent observers. The cores were, unfortunately, lost in the first Paris Exhibition.

however, one of a chain of coal-fields which will, in my opinion, ultimately be proved to extend under the newer rocks between Dover and Somerset, along the line of the North Downs, in long narrow east and west troughs. It is probably a continuation beneath the Straits of Dover of the coal-measures struck at Calais (see Fig. 2).

The further question as to the value of these fields may be answered by the amount of coal in the fields which are now being worked in Westphalia, Belgium, France, and Somersetshire. The Westphalian coal-field contains 294 feet of workable coal, distributed in 117 seams; that of Mons, 250 feet, in 110 seams; and that of Somerset, 98 feet, in 55 seams. The North French coal-field in 1887 yielded 7,119,633 tons, and gave employment at the pits to 29,000 men, and is rapidly increasing its output.

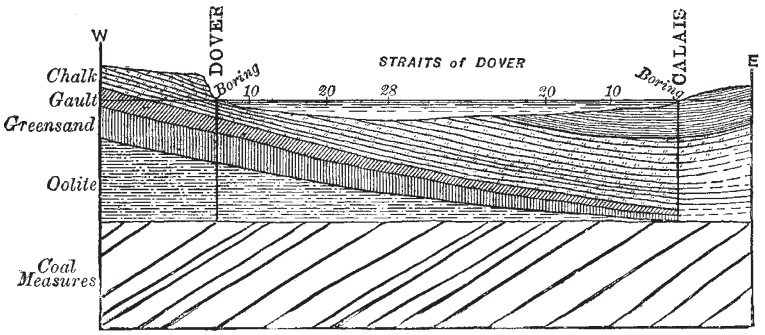

FIG. 2.—Probable Range of Coal-measures between Dover and Calais.

It may be inferred that the buried coal-fields which await the explorer in the North Downs are in all probability not inferior to these. Godwin-Austen, in his memorable paper before the Geological Society, in 1855, said that if one of these buried fields were once struck in South-Eastern England, their exploration would be an easy matter. It has been struck at Dover, and the necessary base is laid down for further discoveries, which in all probability will restore to South-Eastern England the manufactures which have long since fled away to the coal districts of the west and north, and which will put off by many years the evil day when the energy stored up in the shape of coal in these islands shall have been spent.

RECENT ADDITIONS TO THE LITERATURE OF INSULAR FLORAS.

THE LACCADIVES.

THESE small islands, fourteen in number, are situated between 10° and 14° N. lat., and at 120 to 180 miles from the Malabar coast of India. They are of coral formation, almost without exception portions of atoll rings, and nowhere elevated more than twenty feet above the sea, so that storm-waves sometimes sweep completely over them. In 1847 such a wave destroyed 1000 of the small population, and there have been equally disastrous cyclones in much more recent times. Indeed, according to Hunter's Imperial Gazetteer of India, the islands, which have an area of two to three square miles, are nowhere more than ten or fifteen feet above the level of the sea. In 1871 the population was estimated at about 13,500, and the almost sole cultivation is the coco-nut palm. It is supposed that the abundance of this palm may have attracted the first settlers, but as that event occurred more than 350 years ago—how much more it is impossible to say—this point must remain uncertain. The total annual value of the exports, consisting almost entirely of the products of the coco-nut palm, is said to be about £17,000. From the physical character of the group, it was not expected that the flora contained any endemic element, but until quite recently there was no published account of the vegetation, beyond broad generalizations. Dr. D. Prain, Curator of the Calcutta Herbarium, has supplied the want in the "Memoirs by Medical Officers of the Army of India," Part V., where he gives an enumeration and analysis of all the plants hitherto known by him to have been collected in the islands, and he has since communicated to the writer a list of some twenty additional species. Briefly, the vegetation consists, apart from cultivation, of very widely dispersed plants—whose wide area is due to ocean currents, birds, or winds—plus a number of weeds of tropical cultivation. Dr. Prain has not visited any of the islands himself, and collectors have not concerned themselves with the question of colonization of plants from drift-seeds or from seeds conveyed to the islands by carpophagous birds; hence his deductions are mainly based on probabilities, which he discusses in considerable detail, followed by a table giving the full distribution of all the plants then known to him from the islands. These number eighty, including seventeen purely cultivated plants. It is interesting to know what is cultivated, of course; but it is undesirable to encumber the distributional tables with plants of this category. Dr. Prain estimates that the presence of eleven species is certainly due to the sea, seventeen probably so, and twenty-two possibly so; whilst birds are regarded as the agents in two, three, and five instances respectively. The two ferns collected in the island of Anderut are set down with certainty to the wind, and two or three other plants probably to the same agency. The rarity of ferns seems to be accounted for, in part at least, by the extreme flatness of the islands rather than by unfavourable conditions, for Dr. Treub found eleven species of ferns on the elevated part of Krakatão only three years after the great eruption, which absolutely destroyed all the vegetation previously existing, and covered the island with a volcanic deposit of intense heat from one to sixty yards in thickness.

One common tree in the vegetation of many islands of the Indian Ocean we miss in Dr. Prain's list, and that is *Cordia subcordata*, the iron-wood of the Keeling Islands.

THE KURILES.

Mr. Kingo Miyabe, lately appointed Professor of Botany at the Agricultural College, Sapporo, Japan, and formerly a student at Harvard, U.S., and for a short time in this country, is the author of a "Flora of the Kurile Islands," which is published in the Memoirs of the Boston [U.S.] Society of Natural History, vol. iv., No. 7.