exhaustiveness such as amply to establish his title to them. No man, it may be added, was ever more anxious than Jevons to do justice to the labours of his predecessors, and he was ever ready to welcome in the most generous fashion any indication of an anticipation of some favourite thought. His work was good enough, and he knew it was good enough, to stand upon its own merits.

In logic the system of formal or mechanical reference which Jevons worked out in great detail, was founded upon the antecedent researches of Boole. The processes, however, were presented by Jevons in such a fashion, the principles were so simplified and the capabilities of the method so ingeniously developed that his work has a secure place of its own alongside that of Boole. This is not the place for discussing the permanent worth of the new analysis of inference, but it may be said that hardly sufficient justice has yet been done to many of the speculations into which Jevons was naturally led in the development of his analysis. His treatment of the relations of logical and numerical quantity, and his attempt to deal with induction apart from all quasi metaphysical principles are bold and subtle contributions to logical theory and, in connection with his other work in this department they sufficiently establish his place as an original and thoughtful logician.

For philosophical speculation, in the wider sense, Jevons had little inclination, and possibly from the character of his intellect, little ability. Dealing with ultimate logical and economical questions he was often driven to the verge of inquiries such as fall under the designation of philosophy, to problems of the theory of knowledge and of ethics, but he never crossed the boundary, and indeed seemed somewhat impatient of the existence of a land beyond the formal relations of logical terms or the quantitative variations of pleasure and pain. This lack of interest in problems going to the root of logical and economical theory makes itself apparent in almost all his works, and probably, for many reasons, deprives them of some of their value. It is impossible to say, however, what genuine contribution to English philosophising might not heve been made had so original and well endowed a mind been spared longer to us.

THE BRITISH ASSOCIATION

ALTHOUGH the numbers at the Southampton meeting have little exceeded 1200, still so far as the essential work of the Association is concerned, it has been up to a fair average. The New Forest excursion was an especially enjoyable one, though that to the Isle of Wight was most interesting from a scientific point of view.

During the meeting the reception rooms and the rooms in which the Sections have met have been connected by telephones. In each room was a board on which were painted in a line the letters indicating the Sections. Below each letter there was space for a figure to be inserted to indicate the number of the paper in the day's programme that was under discussion; if it were No. 3 in Geology, the attendant there sent the number to the reception room. Here the attendant marked the board, and then sent the information to all the other Sections, so that it could be known in all the rooms what was the subject under discussion in each Section.

There was a sharp discussion on the question whether the Association should meet in Canada next year, seeing that Oxford has withdrawn its invitation, but the meeting decided on Southport, with Prof. Cayley as President. Canada (Montreal) was, however, selected for 1884.

There is a very strong feeling that the vote of the General Committee binding the Association to go to Canada in 1884, was not a representative one. The first vote taken was adverse to crossing the Atlantic, though it was felt that if this were done it would be specially desirable to do so while the Marquis of Lorne is President, as he has done much in founding the most important scientific institutions in Canada, and his tenure of office terminates next year. When Southport gained the majority the larger number of the Committee left the room, not being aware that the place of meeting for the following year, 1884, was going also to be determined, and the supporters of the Canada invitation, led by an able tactician, Capt. Bedford Pim, secured an easy victory. It is worthy of note that the Members of the General Committee, who contributed to this result, with few exceptions, did not include Presidents and Secretaries of Sections, or indeed many of the working members of the Association, and it is therefore greatly feared that should the proposed visit be made, the meeting will not be a representative one.

It is satisfactory to learn that the Council are taking steps to learn the real wishes of the Members, by asking every Sectional Committee to send up three or four representatives to constitute a committee to confer with the Council as to the means of carrying out the proposal, if found to be feasible. It is worthy of note that previous to the meeting at Southampton, the Council sent out a notice to the whole of the General Committee, inquiring their views on the subject, and that the replies obtained from a far larger portion of the Committee than that attending the meeting was distinctly adverse to leaving the British Isles. It was felt that the proposed departure would be unfair to Life Members, who had purchased a right to attend meetings in that area, and would prevent the greater number of sectional officers and working members from attending, their movements being controlled by considerations of time and expense.

The following is the list of grants voted for next year :—

A—Mathematics and Physics

Scott, Mr. R. H.—Synoptic Chart of Indian Ocean ...	£50
Darwin, Mr. G. H.—Harmonic Analysis of Tidal Observations ...	50
Brown, Crum—Meteorological Observations on Ben Nevis	50

B—Chemistry

Tilden, Prof. W. A.—Investigating Isometric Naphthalene Derivatives ...	15
Odling, Prof.—Photographing the Ultra-Violet Spark Spectra ...	20
Pye-Smith, Dr.—Elimination of Nitrogen ...	30

C—Geology

Etheridge, Mr. R.—Earthquake Phenomena of Japan ...	50
Williamson, Prof. W. C.—Fossil Plants of Halifax... ...	20
Sorby, Dr. H. C.—British Fossil Polyzoa ...	10
Etheridge, Mr. R.—Fossil Phyllopoda of the Palæozoic Rocks ...	25
Hawkshaw, Sir John—Erosion of the Sea Coasts of England and Wales ...	10
Hull, Prof. E.—Circulation of Underground Waters ...	15
Evans, Dr. J.—Geological Record ...	50
Ball, Prof. V.—Carboniferous Limestone Caves in the South of Ireland ...	20
Etheridge, Mr. R.—Llandovery Rocks of Central Wales ...	10

D—Biology

Pitt-Rivers, General—Photographs of the Races and principal Crosses in the British Isles ...	10
Stainton, Mr.—Record of Zoological Literature	100
Cordeaux, Mr. J.—Migration of Birds ...	20
Lankester, Prof. Ray—Table at the Zoological Station at Naples ...	80
Pye-Smith, Dr.—Scottish Zoological Stations ...	25
Hooker, Sir J.—Exploring Kilimandjaro and the adjoining Mountains of Eastern Equatorial Africa ...	500
Meldola, Mr. R.—Investigation of Loughton Camp ...	10
Sclater, Mr. P. L.—Natural History of Timor-Laut ...	50

G—Mechanics

Bramwell, Sir F. J.—Relation between the Pressure at different Points of a Structure on which Water and Air impinge	£25
Whitworth, Sir Joseph—Screw Gauges	20
Bramwell, Sir F. J.—Patent Legislation	5

SECTION C

GEOLOGY

OPENING ADDRESS BY ROBERT ETHERIDGE, F.R.S., F.G.S., PRESIDENT OF THE SECTION.

FOR some years it has been the rule or practice that the Presidents should open the sectional meetings with an address, selecting any subject which may seem to them best adapted to the occasion. This custom I believe had its origin in this Section, when the Association met at Aberdeen, and was due to Sir C. Lyell, who was the first to deliver an opening address. He selected for his theme the discoveries of M. Boucher de Perthes, chiefly with relation to the occurrence and association of flint weapons with the bones of extinct animals in the gravels of the valley of the Somme.

The Geological Section, over which during the present meeting I have the honour to preside, embraces a wide field of research, and therefore allows selection from a large range of subjects, so large indeed that it would be difficult to choose an original one that would be acceptable and useful to those members of the Association who may be present. It is thirty-six years since the British Association last met in Southampton, and probably not half-a-dozen members who attended the meeting of 1846 are now present, if living. We are, however, fortunate in having with us to-day one or two who contributed papers to this Section thirty-six years ago.

The Geological Section may be congratulated on its place of meeting this year. Hampshire presents a wide range and field of research to the practical, as well as the less advanced student in geology. Truly may it be said that this area is classic ground. No less than six distinct formations, with their subdivisions, occur in the immediate neighbourhood and within reach of those members who have honoured the Association with their presence this year. Be it remembered that it is thirty-six years since the British Association met in this city. Since then, or the year 1846, geology has indeed advanced with strides unsurpassed by any other science. The Tertiary rocks of the Hampshire basin alone have received from the hands of private and learned physicists, as well as the long-continued labour of the Geological Survey, the most careful and detailed research. It may well be said that this rich field has not wanted competent labourers, earliest and foremost of whom must be named Webster, Sedgwick, Prestwich, and Edward Forbes, who with Mr. Bristow mapped out with so much care and accuracy the intricate structure of the Isle of Wight. To these must be added, through later research, the names of Searles Wood, Wright, Fisher, Tawney, Keeping, Judd, and others. Other portions of Hampshire and Sussex bearing upon the question of the Anglo-French Tertiary basin, have been elaborately treated upon by Dixon, Godwin-Austen, Sir C. Lyell, and others.

It may be a fitting preliminary to local communication which will most probably come in, during the course of this meeting, that I should summarise what has been done in this area. This may be familiar to many, but there are others who may wish to examine certain geological localities, the mention of which may induce them to visit spots of much interest. It is scarcely the duty of the president of this Section to devote the time allowed to an opening address to the discussion of any original subject, while work of unusual local interest has transpired during the past year to justify him in drawing attention to a subject of much importance connected with the stratigraphical position of certain beds in the Eocene strata of the Isle of Wight; a question of local geologist interest, as well as bearing upon the correlation of the Tertiary rocks of Hampshire with those of France, Belgium, and Germany. Instead, therefore, of offering to the Geological Section an address on some special subject or branch of general geology, I have deemed it more interesting, and certainly more useful, to lay before you an outline of certain physical features occurring within the immediate neighbourhood, and district in which we are now assembled.

I purpose therefore to call attention to the local geology of this area, especially as regards the Tertiary deposits of Hampshire and Sussex, as forming or constituting the northern portion of a vast series of deposits once continuous to Northern France, the area now covered by the English Channel and the Solent, and lying in the depression of jurassic and cretaceous series. The relation also of the Hampshire and Anglo-French basin and its tertiary fauna to that of the London or Anglo-Belgian area will receive notice, as being part of the history of one great period, the strata comprising the two areas being also once continuous, much of it being subsequently removed or denuded away from those areas now occupied by the English Channel and German Ocean.

Before especially noticing the Isle of Wight and the neighbouring coasts, I must state that by laborious search over both old and new ground, and through the very careful examination of collected specimens during the past twenty years, great light has been thrown on the geological structure of many local areas hitherto obscure from want of critical palœontological knowledge being brought to bear upon the fossil fauna or flora characterising the various marine and freshwater deposits with which the surrounding district abounds. Greater precision has of late been arrived at in the chronological arrangement of the cretaceous and tertiary strata which occur both in the Isle of Wight and on the mainland.

Doubtless you are all aware that the strictest investigation as to the distribution and organic contents of the Fluvio-marine Tertiaries of the Isle of Wight, was undertaken by Professor Edward Forbes, when attached to the Geological Survey from the years 1848-56, and subsequently Mr. H. W. Bristow, F.R.S. completed all the older tertiaries and cretaceous rocks of the island, thus producing a complete geological guide to this portion of the Hampshire basin. The structure of the opposite coast to the east, or that embracing Bracklesham Bay, Selsea, and Bognor, was critically treated by Mr. Frederick Dixon in the year 1850, ("The Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex." By F. Dixon, 1850, 1st ed., 2nd ed 18.) who was most ably assisted in his palæontological researches by the most distinguished naturalists then living, each faunal group receiving critical supervision and description. A second edition of this valuable work appeared in 1878, wherein much new geological and palæontological matter is added; both the Cretaceous and Tertiary reptiles were figured and described by Professors Owen and Bell, the fishes by Sir Philip Egerton, the Cretaceous echinodermata, by Professor Forbes. Mr. Sowerby described the mollusca, and the large crustacea were described by Professor Bell, and the corals by Lonsdale.

SELSEA.

I now draw your attention to a locality of extreme interest both to the geologist and archæologist, and where cause and effect are manifested in both investigations, the historical portion being based upon physical causes and changes that have long been, and are still going on, to modify the form, extent, and structure of the Sussex coast, from the mouth of Chichester Harbour to Littlehampton and Bognor. In the year 1855 Mr. Robert Godwin-Austen, F.R.S. and G.S., read before the Geological Society an elaborate paper upon the "Newer Tertiary Deposits of the Sussex Coast," in which he also noticed some peculiar features in the parts of the Isle of Wight and South Hants bordering the Solent.

From Beachy Head to Selsea Bill, the coast line lies east and west, so that there intervenes a tract between the chalk range and the sea which ultimately acquires a width of ten miles, as from Lavant to Selsea. This tract is low and level, presenting a series of superficial accumulations, remnants of a definite Tertiary period, of which at no other place in England is there any such record, and to which I ask your attention should any journey to inspect the phenomena exposed along the shore of Bracklesham Bay, or between Wittering and Pagham Harbour, or Bognor be proposed. Espeoially may I refer to interesting evidence as to local conditions during the glacial period. It may not be known to many, or all present, that the peninsula of Selsea is celebrated in English history as one of the places where Christianity was first taught in this country. It was one of the most ancient Saxon establishments. This peninsula was granted by Edilwalch, King of the South Saxons, to Wilfred the exiled Bishop of York, about the year 680. At that time it is stated to have contained 5,220 acres of land, with 85 families and 250 slaves. The parish now contains only 2,880 acres; 2,340 having been slowly denuded away by the action and encroachment of the sea. This encroachment and destruction during the past 800 years has been very extensive.

The creek called Pagham Harbour, on the south-east side of the Bill or peninsula, was due to an irruption before the year 1345, when 2,700 acres of land were destroyed. The site of the ancient cathedral and episcopal palace of Selsea, believed to have been situated to the south-east of the present church of Pagham, is no longer to be determined, but there is no reason to doubt but that it stood nearly a mile out in what is now sea. Camden, in his "Britannia," states that "in this isle remaineth only the dead carcase as it were, of that ancient little citie (where those bishops (of Selsea) had their seat), hidden quite with water at every tide, but at low water evident and plain to be seen."

The Bishop's Park, as the shore and sands are still called, extended for many acres on the south-east coast, and the remaining fragment has still the name of Park Coppice. The sea has gained more than a mile on this coast since the see and cathedral of Selsea was established, A.D. 680; Wilfred was the first Bishop of Selsea in that year, and Stigand was the first Bishop of Chichester, A.D. 1070. No less than twenty-two Bishops had occupied the episcopal chair of Selsea, and resided there, before the removal to Chichester. The parish that divides Selsea from Bognor is called Pagham, and the extensive estuary, which is a mile long and broad in places, Pagham Harbour. The remarkable church is dedicated to St. Thomas à Becket, and the ruins of the archiepiscopal palace are still visible south-east of the church. Archbishop Becket resided here with a large retinue, and his interference with a manor within his lordship, gave rise to his dissension with Henry II. which terminated in his assassination. That part of the coast marked "the Park," now covered by the sea, was part of the prelate's extensive estate, and is still visible at low water. The houses of the village are built of an arenaceous limestone almost entirely made up of microscopical shells, of the genera *Miliola* and *Alveolina*. This stone was formerly procured abundantly from an extensive range or ledge of rocks (calls the Clibs and Mixen) south of Selsea Bill, and extending some distance east and west. In 1830 the removal of this bed of stone was forbidden, forming as it did and does, a barrier to the encroachment of the sea.

This digression and somewhat archæological dissertation is necessary for my purpose, when drawing your attention to those recent geological changes that have taken place along that coast almost within modern times.

Thorney, Ham, and Medmeney marches, behind Bracklesham Bay, and between Bracklesham and Selsea, are of marine or estuarine origin, separating Selsea from the mainland, making it what its name expresses, an island, "Seles-eu," or "Island of the Sea-calf." We are thus led to believe that when Selsea became known to the English nation it was an island, and that in Bede's time the process of silting up the estuary must have commenced, and the completion of this process would seem to have been before the Conquest. The action of the tides on this coast carries the sand and shingle from west to east, therefore the gradual wasting which has taken place on the shore of Bracklesham Bay has served to supply a large portion of the material of which these marshes are formed.

The ground on which Selsea, Bognor, Littlehampton, Worthing, and other places on the Sussex coast westward of Brighton are built, is of very recent formation, being composed of gravels, sands, and loam belonging to the post-Pleiocene or Pleistocene series. These superficial post-Pleiocene beds overlie the well-known Eocene series in patches, and contain a large fauna. No less than 66 genera and 142 species, chiefly mollusca, occur here. The remains of the *mammoth* or *elephant* (*E. primigenius*, or *antiquus*) occur in the muddy deposits [*mud-deposit*]. With these are associated marine shells of existing species, but some not known now as such on the Sussex coast. East of Bognor, at low tides we have the remains of a sunken forest, and west of Selsea the trunks and roots of trees, &c., may be examined at low water. These trees in both areas are not fossilized, but evidently destroyed by the encroachment of the sea, probably since the time when "the Park" existed. In July, 1877, Mr. H. Willett, of Brighton, obtained from the beach below high-water mark, near East Wittering, a large number of bones of rhinoceros associated with several species of land and freshwater shells of existing species. The bones lay in the midst of decayed trees in a peaty deposit beneath the glacial beds of Selsea. An almost perfect skeleton of the *Elephas antiquus* is in the Museum at Chichester, which was obtained from the "mud beds" or "mud deposit" off Selsea Bill; multitudes of the shell *Pholas crispata*, occur in the same bed. Teeth of the mammoth have occurred in the "mud deposits" of Bognor, Littlehampton, and Worthing; and we have again the well-known "Elephant bed" at Brighton, doubtless of the same age.

At the British Association meeting in 1851, Mr. Godwin-Austen, F.R.S., then president of the Geological Section, called attention to the evidence of repeated oscillations of level of no very remote date which were to be observed in parts of the coast of Cornwall, Devon, the Channel Islands, and the Cotentin, an area comprising the western opening of the English Channel. As before stated, the same distinguished physicist, four years later, in his paper "On the newer Tertiary Deposits of the Sussex Coast," exhaustively described the phenomena of the later movements of the land, and interchanges between the sea and the coast. The oldest of the newer-Tertiary deposits of the Sussex levels in ascending order is to be seen only at extreme low-water in Bracklesham Bay; thence eastward round Selsea Bill, as far as the entrance into Pagham Harbour.

This portion of the Sussex series forms the "mud-deposit" of Mr. Dixon. Its character and composition distinguish it from the beds above. Is is composed of an extremely fine tenacious dark grey sandy mud, which resists the action of the sea; it rests upon the well-known Eocene Nummulitic strata.

The thickness of this Lutraria clay or "mud-deposit," can only be estimated at low-water spring tides; in places it is from 18 to 20 feet thick; it increases seawards and passes away beneath the sea-bed. On the coast near Medmeney (west side of the Bill) the surface of this clay is occupied by the remains of a colony of *Pholas crispata*, which has burrowed into it. This species attains here to great dimensions, and from its restricted range and littoral habit serves to determine the level of the tidal waters at the *commencement of the Selsea deposits*. The relative age of this old estuarine deposit of Selsea is determined by its mammalian remains. Those of *Elephas primigenins* are tolerably abundant, and the interest attached to them is enhanced by the fact that they do not occur here as single and detached teeth, or portions of tusks (as occurs on the higher gravels), but so many parts have been found together as to leave no doubt but that entire skeletons still lie embedded in this deposit. The head with the teeth and tusks and numerous bones have been found in close juxtaposition, and are now placed in the Chichester Museum. No less than sixty-six genera and 151 species of mollusca have been found here, or thirty-three genera and eighty-nine species of gasteropoda, and thirty-three genera and sixty-two species of pelycipoda, have been obtained from the Lutraria clay or "mud-bed." I may mention, among so many, the rarer shells that occur.

Cerithium reticulatum, da Costa. = C lima Brug.—A Spanish, Portuguese, and Mediterranean shell, comparatively recent within our area.

Fusus turricula (Pleurotoma).—A boreal Atlantic species, occurs in the Red crag. Scarce in the Faluns and Bridlington.

Pecten polymorphus, Bronn.—Lisbon, Mediterranean, very rare fossil in Italian and Sicilian beds.

Tapes decussata, ranges south but not north of British Islands. Common in the Mediterranean.

Lutraria rugosa.—Algeria and Morocco (living), also Canaries. South of Spain and Portugal.

Syndosma Boysii (Amphidesma).—Atlantic; rare; ranges to coast of Spain.

Pholas crispata Linn.—Rare on south coast of England, a Scandinavian species, and is found in the Crag.

From "the assemblage of mollusca, and the patch of *Pholas crispata* in conjunction with conditions of the deposit, we may infer that the relation of the land to sea-level was then much what it is now, or that these ledges of mud-beds in which this shell is found, then lay between tides." Many of the bivalve mollusca (Peylicipoda) lived in and on this mud, which is evident from the position in which the shells are now found, especially the *Myæ*, *Lutrariæ*, and *Pullastra* (Tapes)." "This area," according to the views of Mr. Godwin-Austen, "must have been an enclosed salt-water lagoon. The list of shells must be considered a special one, the result of local conditions subordinate to, but indicative of a much larger marine fauna which had its full development in some adjacent sea," and this fauna as a whole differed as much from that of the present Channel waters, as the fossil contents of the Selsea mud-deposits do from the mollusca now inhabiting the series of large creeks and lagoons extending from Fareham to Pagham." As regards the molluscan fauna of Selsea, some of which, now found on the Sussex coast, are essentially southern and western, do not range further north, or into the German Ocean area, and this southern relation of the fauna of the Lower Selsea deposit (*Lutraria mud-deposit*) is still further strikingly illustrated by the presence of the before-mentioned two remarkable species, *Pecten polymorphus* and *Lutraria rugosa*, neither of which are now known to range further north than Lisbon. "We therefore have indications of a warmer condition of the waters of the English Channel, which allowed southern forms to range to a more northern latitude than now, and then a limitation of these forms to the area where now found, or in the Sussex deposits." The inference drawn by Mr. Godwin-Austen as to the manner in which the elephant's remains occur in this Lutraria clay is an obvious and an interesting one, as it enables us to arrive at a relative geological date, showing that the lower estuarine beds of Selsea and of the Sussex levels generally were contemporary with what is known as the period of the large mammalian fauna.

Overlying this Lutraria or mud deposit, there occurs a tough, calcareous, sandy clay; with chalk, and chalk flints—waterworn and of large size. This Yellow Drift clay is of marine origin, determined by the associated mollusca; Littorina and Mytilus being disseminated through the mass. This deposit occurs over the whole of the Selsea peninsula, and extends inland beneath the Sussex levels. Besides the large masses of flints and materials from the chalk, oolitic rocks, and chert-sandstone from the Upper Greensand, resembling that occurring at Lyme and Charmouth, there are other rocks which, from their "ages, composition, origin, size, and condition," render the mode of accumulation a problem of great geological interest. "The rocks in question consist of grey porphyritic granites, red syenites, syenite, hornblendic greenstones, micha-schists, green fissile slates, masses of quartz from veins, siliceous sandstones," such as occur in the Palæozoic series (Lower Silurian) of Normandy, micaceous sandstone with orthides, probably from the Devonian beds, and blocks of compact limestone, whether from the Devonian series of Devon or the Cotentin (France), is uncertain."

In size these older rocks range from coarse shingle up to masses of 20 tons weight, the granitic rocks being the most numerous and of the largest dimensions. A mass of porphyritic rock was exposed near Pagham by coast-line denudation, measuring 27 feet in circumference. Whence came they, and how brought, or what the transporting agent beyond that of floating ice, we know not. I must refer you to Mr. R. Godwin-Austen's original paper for matter of the highest interest relative to the original history of the yellow clay and the conglomerate bed, and later deposits in Sussex, as well as other phenomena bearing upon the present aspect of this singular area—a description of the complex nature of the structure of which would here be out of place. "What was the condition of the English channel as to its coast-line when certain marginal accumulations were being formed?" To answer this demands a profound acquaintance with the *old physical geography* of the district both of Northern France and Southern England.

The Brick-earth.—Above the yellow clay and mammalian gravels, the highest or uppermost deposit on the coast, there occurs a uniform bed of dark chocolate coloured unstratified clay, averaging about 3 feet in thickness. This clay forms part of that great layer of earthy matter which overlies all the gravel and other beds of the Sussex levels, and is extensively used for brickmaking. This brick-earth is a subaërial deposit, probably occurring as the wash of a terrestrial surface under a greater rainfall than we have now. This deposit is conspicuously shown along the shore, and forms the low cliffs of Bracklesham Bay. To this period Mr. Godwin-Austen refers the "*Combe rock*" of Selsea. He then refers to the condition of the English Channel area, at the period of the Crag-deposits of the German Ocean. The author is disposed to the belief that this Channel area was mostly in the condition of dry land at the time that the area of the German Ocean was occupied by the Crag sea. The peculiar molluscan fauna of the Sussex deposits point to a limitation of a *marine province* in that direction, whilst their habits indicate at the same time shallow water and marginal conditions. The temperature of the water of the English Channel during the period of the *Elephas primigenius*, and its associates, was such as now occurs 12 degrees or nearly 800 miles further south. In 1871 Mr. Alfred Bell examined with great care the fossil contents of the Lutraria clay or mud-deposit; he has added materially to the hitherto published lists of contents of this deposit. The result proves it to be unique as regards the fauna. "Of the 144 species of shells Mr. Bell states that 30 do not exist nearer than the West of England, the Channel Islands, north of Spain, 8 or 10 not passing this side or north of Gibraltar, all being littoral (or sub-littoral) species. As British Quaternary fossils 45 are peculiar to Selsea, and 20 others probably find here their earliest place in British geological history." Numerically the contents of this mud deposit are as follows: mammalia, 5 genera and 6 species; mollusca (bivalves), 33 genera and 62 species; univalves, 32 genera and 80 species; polyzoa, 2 species; crustacea, 8 genera, and 10 species; echinodermata, 2 genera and 2 species; foraminifefa, 9 genera and 10 species. Most of the fossils occur opposite Thorney coastguard station, where the Lutraria clay rises at intervals in low hummocks. The elephant remains appear to be those of *E. antiquus*. The tooth of *E. meridionalis* has also occurred here, an association resembling the Forest-bed of Cromer. In the Chichester Museum there exists the greater portion of a fine skeleton *E. antiquus* obtained from this mud deposit.

I have thus dwelt at some length upon these post-Pleiocene or Pleistocene beds at Selsea, owing to their local interest, and hope by so doing to induce any present who may be interested in the Quaternary geology of the British Islands, especially that of Sussex, to visit Bracklesham Bay and Selsea, near to which we are now assembled.

The Eocene Formations of Selsea and Bracklesham Bay.

It is impossible to pass unnoticed the Eocene tertiaries that occur in Bracklesham Bay, the stratigraphical position of which has long been settled, comprising the middle portion or fossiliferous division of the Bagshot Series. The Bracklesham beds take their name from the Bay in which they are so characteristically developed, yet difficult to clearly understand. The main divisions extend from Wittering, on the west, to the Barn Rocks, east of Selsea Bill, a distance of seven miles.

The Hampshire basin alone, in England, contains the nummulitic series, no fossiliferous representative being known in the London basin.

About a mile to the east of Selsea Bill is situated the "Park bed." This Park bed is analogous or equivalent to the "Calcaire grossier" of Grignon, in the Paris basin.[1] It contains thousands of Nummulina lævigata associated with Pernæ, Bullæ, Cypræa, Solens, besides the well-known coral Litharea Websteri. The Park bed is situated close to the shore, and is accessible at low water. It is here at low spring tides that the very recent post-Pleiocene beds may be seen overlying the Eocene deposits. At the Bill the Eocene beds are shown at low water in large detached portions called the "Clibs," the larger portion lying to the south-west, and the so-called "Mixen Rocks," marked by the "Mixen Pole," trend about a mile out into the sea. From these rocks, which extend a mile and a half east and west, and varying from 200 to 400 yards wide, is procured the Alveolina or foraminiferal limestone; the "Clibs" rock contains scarcely any other fossil remains. The *Houngate* Rocks, the same as the *Mixen*, are situated opposite Old Thorney Station House, and are visible at low water; they are nearly a mile in extent, and vary from 50 to 60 yards in width. Certain fossils have given names to the beds that range through the bay. The remarkable shells *Cypræa Coombii*, the great *Ceritheum* (*C. giganteum*), and *C. cornucopiæ*, *Venericardia planicosta Turritella terebellata Conus diadema*, &c., amongst many others, aid us to determine the beds stratigraphically—locally the "Barn bed," "Palate bed," "Venericardia bed," the "Park," &c, serve to mark horizons of importance.

Opposite the New Thorney Station are the Scrobicularia or Lutraria clays or mud deposits from which the elephant remains were obtained.

The Rev Osmond Fisher, in his description of the "Bracklesham beds" of the Isle of Wight basin, restricts the name to a group of strata rich in organic remains, the greater part of which are displayed at low water upon the shore at Bracklesham Bay in Sussex. He also includes under that name higher beds than any seen at Bracklesham Bay that occur at Stubbington and the New Forest. He groups certain strata which appear to intervene between the base of the Barton series and the highest beds at Bracklesham Bay on account of their containing an assemblage

[1] Four hundred species of Mollusca have been found in the French deposits.

of fossils more akin to the fauna of the Bracklesham than the Barton.

"No marine fossiliferous beds are known *below the lowest* at Bracklesham Bay, until we reach the Bognor Rock of the London clay—at Bognor—except it be a thin stratum of clay at the very base of the Bracklesham series at the Whitecliff Bay. The following shells range through the Brackle-ham group, and are confined to it, viz., *Venericardia planicosta*, *Sauguinolaria Hollowaysii*, *Solenobliquus*, *Ctherea suberycinoides*, *Voluta cithara*, *Turritella sulcifera*, and *Pecten corneus;* the last-named species occurs in the High Cliff beds." The Rev. O. Fisher, through the confined range of certain species, has divided the whole series into four principal groups. Vide *Quarterly Journal of the Geological Society*, vol. xviii. pp. 66—75.

Group A The upper, abounding in gasteropoda, and has *one of its fossil beds* in the eastern part of its range full of *Nummulina variolaria.*

Group B is more sandy in its general condltion, and distinguished by the presence of the large gasteropoda. *Cerithium giganteum*, *Nummularia variolaria*, occurs in this member at Whitecliff Bay.

Group C Sandy like the last, but its chief fossil-bearing bed is profusely crowded with *Nummulina lævigata.*

Group D embraces the lowest fossiliferous sands of Bracklesham Bay the distinctive shells are *Cardita acuticosta*, and *Cypræa tuberculosa.*

Bracklesham beds at Whitecliff Bay.—These beds rest on the Lower Bagshot sands, and agree with bed No. 6 of Professor Prestwich's section, their base being distinguished by a bed of rolled flint pebbles about one foot in thickness.

Reading in descending order Mr. Fisher's group A. including the beds xix., xviii., xvii., xvi., xv., xiv., and xiii., correspond with the beds numbered 17, 16, 15, and 14 in Professor Prestwich's; together they measure 254 feet. The position of the beds here renders them easily accessible at Bracklesham Bay, but they are nearly horizontal, and consequently must be paced to be understood. Beds No. xvii. and xiv, of Group A are the most fossiliferous, and both contain *Nummulina variolaria.*

Mr. Fisher's Group B includes beds xii., xi., x,. and ix., or Professor Prestwich's No. 13. No. ix. of Fisher and 13 of Prestwich is the chief fossilliferous bed. *Nummulina variolaria*, *Voluta nodosa*, and *Sanguinolaria Hollowaysii*, are the chief fossils in this bed, the thickness of the group is only 27 feet.

Group C with beds viii., vii., and vi., correspond to Professor Prestwich's Nos. 2 and 11. No. vii. contains the distinctive and characteristic nummulite, *N. lævigata*, also equally abundant at Bracklesham Bay with *Sanguinolaria Hollowaysii*, bed No. vi. of Fisher, and No 1 of Prestwich is very fossiliferous. These three beds measure 123 feet.

Group D is composed of beds No. v., iv., iii., ii., and i., or Nos. 10, 9, 8, 7, and 6 of Prestwich. The only fossiliferous bed in this group is No. iv. of Fisher, and 9 of Prestwich, in which the great *Venericardia planicosta* abounds, as at Bracklesham Bay, the fine shell *Cypræa tuberculosa* not occurring at Whitecliff Bay. The beds comprising this group are 251 feet thick; in all, the Bracklesham beds at Whitecliff Bay measure 653 feet. I have deemed it important to partly particularize this remarkable section at Whitecliff Bay by way of comparison with the fine section shown at low water in Bracklesham Bay, where the beds occupy the shallow shore for three and a half to four miles, and are nearly horizontal, or dip S. by E., with a strike of W. by S. and E. by. N. So nearly level are the beds, that there is no oqportunity given to measure the dip or thickness with accuracy. Mr. Fisher, in his excellent section, has given the order of succession of the beds, and the distances between the outcrops. The beds exposed towards, or near Selsea Bill, belong to the upper members, and their strike is nearly tangential to the shore, consequently we continue our walk upon the same outcrop for a long distance in step-like planes. I give the Rev. O. Fisher's section and sequence round Selsea Bill, as he observed them, as a guide to those who may visit the area. Vide *Quarterly Journal of the Geological Society, loc. cit.*

Commencing at a spit of gravel seen at low water off "the Bill," brought together by the meeting of the tides from the "Park" and Bracklesham Bay, and going westward or towards Wittering, we have the following ascending section: [1]—

	Paces
"Beds then covered with sea sand	600
Outcrop of septaria, on sandy clay weathered green beds covered with sea sand	127
Hard dark grey, sandy bed, nummulitic in upper part (nummulites abundant at 216 paces, concretions at 226 paces)	420
Nummulina variolaria, and other foraminifera in clay	324

"Taking up this last-named bed again as being *the highest distinguishable* at this place, we then have the general descending series along nearly three miles of the shore" westwards.

Descending Section of Bracklesham Beds at Bracklesham Bay

Group	No.	Beds	Paces
A.	22.	Clay.—*Nummulina variolaria*, *Alveolina sabulosa Quinqueloculina*, *Hawerina*, *Biloculina ringens*, *Rotalia obscura*, *Turbinolia sulcata*, &c.	324
	21.	Hard calc. sand; "HARD BED" foraminifera, *Tellinæ*	140
	20.	Greyish clay with *Corbulæ* and *Nummulinæ*	120
	19.	(*d*). Dark clay (Cypræa bed, Dixon)	460
	18.	Sandy clay containing same shells as 19 (*d*)	66
	17.	,, ,, green foss. in upper part	194
		Pleistocene mud [1]	112
		Green sandy clay	300
B.	16.	(*e*). Sands full of casts, bivalves	218
		Pleistocene mud [1]	80
	15.	Hard sand, weathered green	70
	14.	Shelly sand, greenish-brown, full of fossils, *Cerithea* and *Cytherea striatula* (Little bed)	29
	13.	Dark sandy clay with *Turritella imbricata*	240
		Pleistocene clay, laminated *Ostrea edulis*, &c.[1]	124
	12.	(*f*). Dark Clayey sand with numerous *Cerithium giganteum*, *Pectunculus pulvinatus*, &c., &c.	163
	11.	*Septaria*, resting on shelly sand with black flint pebbles	150
	10.	Laminated liver-coloured clays, sandy towards the bottom	246
	9.	*Ostrea tenera* bed, 18 inches thick	52
	8.	Dark green sand, full of broken shells, *Pectunculus pulvinatus*, *Lucina*, *Bulla Edwardsii* Towards upper part (79 paces less) Shelly in the middle (48) abounding in *Turritella terebellata* at the base	175
	7.	Soft laminated dark-coloured clay	177
		Pleistocene mud, out of which places protrudes a clay weathered green [1]	288
C.	6.	(*g*). *Nummulina lævigata* bed, with numerous fossils (Little Park bed)	40
	5.	Sandy clay, weathered green	107
		Beds covered partly with sea-sand and partly with Pleistocene mud	105
	4.	(*h*). Dark mottled clay, shells and scattered nummulites, *fish* and *serpent* remains ("Palate Bed")	134
		Covered with sea sand	96
	3.	Dark sandy clay	53
		,, ,, ,, with broken shells	111
		Covered	30
D.	2.	Turritella bed, *T. imbricataria* and *T. sulcifera*	92
	1.	Septaria containing shells and occasionally *Rostellaria ampla* (68 paces), resting on a mass of *Venericardia planicosta* and *C. acutirostra;* the lower part of the bed is Greensand crowded with shells, among which immediately beaeath the *Carditæ*, the *Cypræa tuberculosa* occurs. The bed then become less fossiliferous, and passes into a dark grey laminated clay, broken up and re-arranged, mixed with dark sand and black pebbles ("Barn bed," Dixon)	330
			5,016

[1] Every yard of this bay and its extended beds were measured and paced and the map constructed by Mr. Bristow and myself, and the fossils observed in the numerous thin beds comprising the section.

[1] These clay beds are nearly modern in age, and cover up unconformably the underlying Bracklesham beds.

Below this no fossils found.

The Park on East side of Selsea and the Mixen Rocks.

On the east side of the Selsea peninsula, the highest bed seen is the *Nümmulina lævigata* bed, rich in fossil. All the succeeding beds down to the *Venericardia planicosta* bed are usually exposed at "the *Park*."

Mixen Rocks.—A ledge, one mile south of Selsea Bill, composed of a *Miliola* and an *Alveolina*, continuation of No. 22(*b*) only more calcareous.

Bournemouth Area.

The geology of this remarkable area has received attention from several explorers. Sir Charles Lyell in 1826, Professor Prestwich in 1848, the Rev. O. Fisher in 1861, and in the year 1878 Mr. John Starkie Gardner prepared and read an able paper on the "Description and Correlation of the Bournemouth Beds." Part I., the Upper Marine Series (*Quarterly Journal of the Geological Society*, vol. xxxv. pp. 202-228. 1879.), treating of the coast section between Bournemouth and Highcliff; and a second paper, Part II., on the lower or Freshwater series (*Quarterly Journal of the Geological Society*, vol. xxxviii, pp. 1-15.). He states his reason for differing from the previous writers upon the succession of the beds and their correlation with other localities. Mr. Gardner's researches endeavour to show that the celebrated Bournemouth leaf-beds immediately underlie the true Bracklesham series, and are, unlike those of Alum Bay, of *Middle* and not of *Lower Bagshot* period, hitherto the received view as to their age. The author has also ascertained that a great portion of the cliffs between Hengistbury Head and Bournemouth are of marine origin, and highly fossiliferous. These marine beds comprise two distinct characters, which the author traces across to Alum Bay in the Isle of Wight. Mr. Gardner also differs from the Geological Survey in believing "that the so-called Upper Bagshot beds of the London basin do not belong to that series, but are the equivalents of his Boscombe sands, these sands, and the marine Bournemouth beds being, according to his researches, the western equivalents, or extreme shore-condition of the Bracklesham sea."

At Highcliff, nearly under Rothsay Castle, both the Barton and the Bracklesham series are exposed, the Barton being not more than 10 feet in thickness, and the subjacent Bracklesham 40 feet. The section is revealed to the sea-level, and therefore highly instructive. The Highcliff sands conformably underlie the Barton and Hordwell series at an angle of 2° to the E. The remarkable promontory of Hengistbury Head is mainly composed of strata contemporaneous with the Bracklesham series; and which Mr. Gardner would for convenience call the Bournemouth beds. Hengistbury promontory in shape resembles a parallelogram obliquely truncated at its northern extremity. The cliffs facing the sea on the south are about 50 feet high, increasing to 100 feet on the north, both presenting bold escarpments to the sea. "The succession of the strata at Hengistbury Head, reading upwards, comprises, 1, the Boscombe sands; 2, a lower series of sand with green grains, and an upper bed with ironstone; and 3, the white Highcliff sand. The white sands at Highcliff are 30 feet thick, being 12 feet thinner than the equivalent beds at Alum Bay, where they measure about 42 feet." The lowest series in the cliffs at the headland Mr. Gardner terms the "Boscombe sands," which without any doubt represents the chief mass of brilliantly coloured sands, about 750 feet thick, at Alum Bay, known to all explorers of the island. These coloured sands are numbered 25 and 26 in Professor Prestwich's section of the vertical beds in Alum Bay (Vide *Quarterly Journal of the Geological Society*, vol. ii.). Mr. Gardner also notices another hill similar in contour to that of Hengistbury, about three miles to the north of the Head. This, St. Catherine's Hill, possesses, like the headland, similar physical features, being flat-topped and having abrupt escarpments on all sides, and 160 feet high. Both the Highcliff sand and the Hengistbury beds occur in this hill, showing their connection and continuity inland with the coast section. "The correlation of the Hengistbury Head series on the mainland with those of Alum Bay across the Solent admits of little doubt, and they would appear to be represented at Alum Bay by the *Highcliff sands*, 25 feet in thickness, and equivalent to bed No. 28 in Prof. Prestwich's section. The Hengistbury Head beds appear to be the equivalents of bed No. 27 in the Alum Bay section. The Boscombe sands represent beds No. 26 and 25 of Prestwich in Alum Bay, where they are 150 feet thick. It can be conclusively seen from examination of the cliffs in the Bay from Hengistbury to Bournemouth that there is a general sequence, and that the strata have an amount of dip or inclination, sufficient in so extended a distance to expose two complete series of beds, the upper series, being the continuation of the Boscombe estuarine sands, 100 feet thick, and the lower series of sands and clays, of marine origin, which Mr. Gardner has provisionally termed the Bournemouth marine beds." With Mr. Gardner's paper in hand the most minute details of the coast may be followed (*Loc. cit.* 217-226.), from the Head towards Bournemouth. These, both for physical and palæontological details, I must therefore refer to you, as giving step by step an analysis of the structure of the cliffs, and the flora contained in the clays and sandy series of which they are composed. This flora of the Bournemouth bed marine may be referred to the Middle Bagshot series, and the Bracklesham division, possibly representing the same stage in the London basin, and it would appear from careful consideration of the Middle and Upper Bagshots that no Eocene beds younger than the Bracklesham are met with in the London area, a geological fact of much significance as compared with the complete succession of the Eocene series as developed in the Hampshire basin, and that of their equivalents in the basin of Paris. Mr. Gardner believes that "the fossil plant remains of the Bournemouth beds, especially those in the marine series, are of the same age as those in the Bovey Tracey deposits, which have been wrongly assigned to the Miocene period, believing, in fact, that they are simply an outlier of the Bournemouth series, now 80 miles to the west," but formerly and originally connected as a western extension of the Bournemouth deposits.

Comparison of the flora of the two areas shows a close affinity, if not identity of species, *Osmunda lignata*, *Lastrœa Bunburyi*, *Palmacites dæmonorops*, the fruit, conifers, and dicotyledons being not only specifically identical, but occur in the same combinations and manner of preservation," *loc. cit.* pp. 227, 228. *Polypodium*, *Chrysodium*, *Pteris*, and *Osmunda*, amongst the ferns; *Eucalyptus*, branches of Sequoia, pods and leaves of the Leguminosæ, *Nipadites*, *Dryandra Cacti*, *Anona*, *Hightea*, &c., occur in the beds constituting the western termination of the Bournemouth marine series. The fauna testifies to its marine derivation: the genus *Ostrea*, *Arca*, *Modiola*, *Tellina*, *Calyptrœa*, *Phorus*, *Natica*, and *Cerithium*. The crustacea, through Callianassa, and a shore crab, with Bryozoa (Flustra), needs no other comment. The changing physical characters of the beds of the Bournemouth series, both horizontally and vertically, the marshy character of the flora, "as represented by the ferns, aroids, Eucalyptus, &c., the patches of clay, in which the water-plants, ferns, &c., may have rooted, the local patches of ironstone, the intercalated marine beds and their fauna mingled with unios, clearly shows that this was the debateable ground between sea and river, beyond which to the west it would appear the sea never then penetrated." In February of the present year, Mr. Gardner communicated to the Geological Society his second paper on these Bournemouth beds, being a continuation of his former notice, but in this his researches are confined to the history of the "Lower or Freshwater Series" (*Quarterly Journal of the Geological Society*, vol. xxxviii.) of the Bournemouth area. The author describes the geological structure of the Eocene cliffs as far as Poole harbour. All the strata between Bournemouth and Poole harbour are of freshwater origin, and are highly interesting on account of the fossil flora recently obtained from them by Mr. Gardner—undoubtedly the most extensive, richest, and most varied hitherto discovered or extracted from the Tertiary formations. No less than nineteen species of ferns have been described from these beds. Only ten species have been met with in all the other British Eocene deposits, including the famous Bovey Tracey beds, and three of these ten are also found at Bournemouth. Sir C. Lyell, in 1827, the Rev. P. B. Brodie, in 1842, Mantell, in 1844, Prof. Prestwich, in 1847, Trimmer, in 1855, De la Harpe, in 1856, and Heer, in 1859, have all written upon the flora and its associated conditions, origin, &c. In 1862, the Geological Survey, through the Memoir by Forbes and Bristow upon the Isle of Wight, held the view that the fossil flora of Bournemouth, Corfe, and Alum Bay, were identical, although few species were common to these localities. "The cliffs comprising the Bournemouth freshwater series extend from Poole harbour on the west, to beyond Bournemouth, and present escarpments averaging about 100 feet in height, composed of yellow, white, orange and black sands and clays, crowned with fir-trees or pine woods.

Mr. Gardner places these Bournemouth beds in the Middle Bagshots, drawing the line between these and the Lower Bagshots at the pipe-clay beds of Corfe, Studland, and Alum Bay in the Isle of Wight. This line of division is drawn on account of the great dissimilarity of the flora contained in each. The Bournemouth flora, which is distinct from the older, or Alum Bay series, passes up into the so-called Oligocene without any perceptible change or break; but few, or none of the same species pass down or occur with the Alum Bay beds.

These Middle Bagshots are represented in Alum Bay by the unfossiliferous beds marked 19 to 24 in Professor Prestwich's section, (*Quarterly Journal of the Geological Society*, vol. x. p. 56,) and are 240 feet thick. Palæontologically, these beds may be correlated with the continental Eocene, probably those of Aix-la-Chapelle. The cliffs fronting the sea may be divided into three groups. The first extends from Poole Harbour to Bateman's Chine, the second group extends from the Sugar-loaf Chine to Watering Chine, the third section or group extends from Watering Chine to the Bourne Valley.[1] The chief interest attached to the Bournemouth beds is the flora distributed chiefly through the *Lower or Freshwater Series*. None of the prevailing Alum Bay types are found at Bournemouth, nor are any of the well known Bouremouth types found at Alum Bay, and according to Mr. Gardner, their affinities are completely with the floras ascribed in France to the Oligocene, and the forms of flora as at present known, chiefly Australian and tropical American.

The author has endeavoured to show that "a great river existed throughout the whole of Eocene times, bringing deposits from the westward, and that the Bournemouth cliffs present a section across its bed, these deposits being formed during a continued period of subsidence." The sudden change observed in the beds from fine to coarse sediment, and the thickness of the deposit, cannot be explained by the floods and freshets incidental to changing seasons, but are such as would occur whenever subsidence exceeded, in however trifling a degree, the silting—up power of the river," *loc. cit.* p. 13.

It is a question of importance whether the continental floras similar to our own at Bournemouth have been correctly determined. "For while all the strata that have yielded dicotyledonous leaves or fruits below our Headen series are admitted to be Eocene, scarcely any of the beds on the Continent resembling them are ascribed to that age," but to the Miocene. "For as all Eocene floras approximate more or less to Miocene, it has been a kind of rule in the absence of stratigraphical evidence, to assume that all isolated patches with dicotyledons, belonged to the latter period, and had the stratigraphical evidence at Bournemouth been inconclusive, the whole of that Eocene formation must also upon plant evidence (for we have no other) have been classed as Miocene.

The *Lower Freshwater series* are seen in the neighbourhood of Corfe and some parts of the cliffs at Studland. It is characterised by abundance of pipe-clays, and is about 200 feet thick.

The *Middle Freshwater series* also occurs at Cofe and Studland, and form the whole thickness of the cliffs between Poole Harbour and Bournemouth, thus constituting a fine section, 4 miles long and 100 feet in height,

The next series is marine, and about 400 to 500 feet thick. This marine group occupies the cliffs between Boscombe and High Cliff.

The Bournemouth flora appears to consist principally of trees or hardwood shrubs, few remains of herbaceous plants being preserved. The ferns are rare in the lower part of the series, but become more abundant, almost to the exclusion of other vegetation, towards the close of the middle period.

The prevailing group appears to be that of Acrostichum, of which there were many species. *Angiopteris*, *Neprodium*, *Gleichenia*, and *Lygodium*, and other undescribed forms occur.

Among the *Coniferæ*, *Cupressus*, *Taxodium*, and *Dacridium*, with indications of pinus. The Cycadæ seem to have disappeared.

The monocotyledons are well represented by reeds and rushes. *Nipadites*, represents the screw pines. The palms are very abundant, especially in the lowermost beds of Corfe and Studland and the upper middle beds of Bournemouth; many *Flabellaria*, *Sabal*, and *Phœnicites*, occur; the Smilaceæ occur in all the fossiliferous beds, and are represented by five or six species.

The Apetalæ, illustrated by *Populus*, *Ulmus*, *Laurus*, *Quercus*, *Artocarpidium*, and *Daphnogena*, with *Carpinus*, *Fagus*, *Castanea*, *Salix*, and *Ficus*, and numerous Proteaceæ.

Elæodendron, *Rhamnus*, *Prunus*, *Juglans*, *Cluytia*, *Ceratopetalum*, with *Dodonœa*, *Celastrus*, *Eucalyptus*, and many *Leguminosæ*, illustrate and characterise the Polypetalæ.

Cactus and *Stenocarpus* are added for the first time to the Eocene dicotyledons.

Mr. Gardner believes that we have probably represented almost every genus descended from Continental floras.

The Eocene flora presents us with types peculiar to the Southern Hemisphere, and related to those of Australia and the adjacent islands. We have examples of this southern flora through the *Proteaceæ*, *Leguminosæ*, *Coniferæ*, and the *Myrtaceæ*, through *Eucalyptus*.[1]

Isle of Wight.

The present rhomboidal form or configuration of the Isle of Wight is due partly to the unequal action of the sea on its coast line, and partly to those disturbances or movements which have thrown some of its strata into the positions exhibited at Scratchell's Bay, Alum Bay, and Whitecliff Bay.

The rapid waste of the cliffs going on at Sandown and Freshwater Bays is due to the action of the sea, the Lower Greensand and Wealden strata there exposed being more easily destroyed than the chalk.

The leading physical feature in the structure of the Isle of Wight consists in the ridge of high and bare chalk downs near the centre of the island extending from the Needles on the west to Culver Cliff on the east. Another chalk range parallel to the former, but on the south of the island, extends from St. Catherine's Down on the west to Boniface Down on the east. In the space occupied between these two chalk ranges or upper cretaceous rocks, there occurs the complete succession of the lower cretaceous and lacustrine Wealden groups, comprising the Hastings sand and Weald clay exposed at Compton Bay and Rock Point on the west, and Sandown Bay on the eastern side. The central ridge is depressed and cut through by transverse valleys; such occur at Freshwater Gate, Shalcombe, Calbourn, and by the Carisbrook, Medina, and Brading valleys. "All these breaks may possibly be on lines of faults running or cutting through at right angles to the strike of the chalk."

The part of the Isle of Wight which lies to the north of the central chalk range is entirely composed of the older Tertiary or Eocene strata. The only fault of magnitude known in the island is that occurring along the line of the Medina valley. Those on the eastern side of the river are the Headon, Osborne, and St. Helen's series. The rocks at West Cowes, or west of the Medina, belong to the Bembridge marls or fluvio-marine series. "From the known thickness of the several groups the amount of displacement which takes place on the line of fault between East and West Cowes, or *along the line of the Medina*, cannot be less than 200 feet."

The longitudinal undulations affecting or disturbing the Tertiary strata north of the chalk ridges are less obvious than those above described. The chief flexures which are in immediate sequence with the chalk are exhibited both at Whitecliff and Alum Bays, where the Lower and Middle Tertiaries are inclined at very high angles.

The first set, or the east and west undulations, are connected with the movement that elevated the chalk vertically. The north and south undulations also affect the chalk, since each north and south valley formed by the synclinal curve or hollow of the roll, corresponds to the division between the two chalk downs, and each down to an anticlinal. All the Lower Tertiary strata, including the fluvio-marine beds, are affected by these movements.

The gravel beds, which rest upon the older Tertiary strata, whether the *oldest or higher* level gravels, or the newer, such as those which occupy the combes and transverse valleys, are *unaffected* by these movements, showing that their origin is subsequent to the disturbing forces which affected the Secondary and Tertiary rocks below them or on which they rest.

[1] For particulars of these three groups, see *Quarterly Journal of the Geological Society*, xxxviii. pp. 5-8.

[1] Mr. Gardner has been greatly aided in his floral researches by Constantin Baron Ettingshausen, Ph.D., who has brought to bear his great knowledge of fossil plants and their distribution through the higher Tertiaries. The joint monograph by Mr. Gardner and Ettingshausen on the "British Eocene Flora," in the Palæontographical Society's volumes for 1879 are of the highest value to Palæobotanical students.

LOWER TERTIARY STRATA OF THE ISLE OF WIGHT.

The Lower and Middle Eocene strata of the Isle of Wight, especially up to the base of the fluvio-marine series, may be better studied in the cliffs in Alum Bay and Whitecliff Bay than in any other part of the island.

In these remarkable sections the whole of the strata from the chalk to the fluvio-marine formation are displayed in unbroken succession.

PLASTIC CLAY.

"The lowest member of this group of strata in the Isle of Wight is the *Plastic Clay*, or Woolwich and Reading series of Mr. Prestwich." These beds are best examined in Whitecliff Bay and Alum Bay, especially the former, where the mottled beds are well exposed. No fossils have occurred in the plastic clay of the island. Seven beds have been recognised, the whole measuring 85 feet; they constitute a narrow belt striking across the island, resting on the chalk.

The *London clay* succeeds the plastic clay, and also forms a narrow belt extending across the island from the west coast at Alum Bay to the east at Whitecliff or Culver Cliff; its thickness is about 200 feet. A band of flint pebbles only 2 inches thick divides the plastic clay from the London clay, representing the basement bed of Mr. Prestwich. Nowhere in Britain can the London clay be so advantageously studied as at Whitecliff Bay, or where the characteristic fossils are better exposed. Twenty-five to thirty characteristic species may be collected here. Amongst others may be named *Pinna affinis*, *Pectunculus brevirostris*, *Pholodamya margaritacea*, *Panopea intermedia*, and *Modiola elegans*. The annelida *Ditrupa plana* belongs essentially to the London clay.

MIDDLE EOCENE.

Lower Bagshot Beds.

Joshua Trimmer, in 1850, first applied the term Bagshot to the whole series of strata in Alum Bay and Whitecliff Bay. dividing it into upper, middle, and lower, thus correlating it with the corresponding series in the London area which had been previously established by Mr. Prestwich.

The Lower Bagshot beds are greatly developed in the Isle of Wight, attaining a thickness in Alum Bay of 660 feet, the most important Geneva being Elæodendron, Taxites, Quercus, Juglans, Daphnogene, Laurus, Cæsalpina, Cassia, Ficus, Dryandra, Rhamnas and Sabal, &c. They comprise a series of variously-coloured unfossiliferous sands and clays, with accompanying iron sand-tone and clay. These last beds are in one place crowded with the leaves of sub-tropical land plants illustrating no less than 19 families, 26 genera, and about 50 species. The *Araliaceæ*, *Casuarinaceæ*, *Celastraceæ*, *Coniferæ*, *Cornaceæ*, *Cunoniaceæ*, *Cupuliferæ*, *Cycadæ*, *Ebenaceæ*, *Euphorbiaceæ*, *Juglandæ*, *Laurineæ*, *Leguminosæ*, *Moreæ*, *Palmæ*, *Proteaceæ*, *Rhamneæ*, *Sapindaceæ*, and *Tiliaceæ*. The same strata at Bournemouth and Corfe Castle in Dorsetshire exhibit an identical but also richer flora. Out of the great series found at Bournemouth through the researches of Mr. J. Gardner, fifteen or sixteen species occur in the pipe-clays of Alum Bay. As a whole they indicate a rather high temperature. The flora of the Lower Miocene beds, well known in Central Europe, has some affinities with that of our Hampshire basin.

The tropical or sub-tropical character of the London clay plants was long ago worked out by Dr. Bowerbank, but it was reserved for Dr. De la Harpe to carry his comparison into the Middle Eocene beds, and to show that there had been only a moderate decrease of temperature, so far as plants could show, in the time occupied by the deposition of the Bagshot or Bracklesham sands. The marine fauna of the same period fully bears out this conclusion, there being no essential difference between the fossils of the London clay and those of the Bagshot, or even the Barton beds, which would indi ate a marked change of climate.

The flora of the Alum Bay beds is especially distinguished by the number and variety of its Leguminosæ. The plant contents of the Lower Bagshot beds of Alum Bay approximate to that of the London clay by the predominance of plants of this family, forty-seven species of which were obtained by Mr. Bowerbank.

The junction between the London clay and the Lower Bagshot is clearly seen in Whitecliff Bay. The brown ferruginous clay representing the former, and the latter by pale grey or white sands about 40 feet thick. In the 640 feet of these Lower Bagshot beds at Alum Bay no other fossils are known than plants, and *about* 60 *species* occur.

MIDDLE BAGSHOT SERIES.

Bracklesham Beds.

The strata comprised between the sands at the base of Headon Hill, and the pipe-clay bearing sands and clays (Lower Bagshots), overlying the London clay, are subdivided into Barton clay and Bracklesham beds. The Bracklesham beds in Alum Bay are represented by clays and marls in the lower part, and by white, yellow, and crimson sands above. The lower beds are remarkable for the quantity of lignites, coaly or vegetable matter contained in them, constituting beds from 15 inches to 2 feet in thickness. The black and coal-like appearance of four of these beds are conspicuous and marked objects in the cliff, and determine the position of the Bracklesham series.

The uppermost beds of the series, or the yellow, white, and crimson sands, are totally devoid of organic remains, or are unfossiliferous. At Whitecliff Bay the lower part of the Bracklesham beds are green, clayey sands, containing *Venericardia planicosta*, *Turritella imbricataria*, *Nummulites lævigatus*. Six zones of fossils are there recognised. A hard bed of conglomerate composed of rounded flint pebbles in a ferruginous cement is also a marked feature in the cliffs at Alum Bay, defining the division between the Bracklesham and overlying Barton clay.

Barton Clay.

The Barton series, composed of sandy clays and sand with layers of septaria, is sufficiently shown in Alum Bay, where it attains a thickness of 300 feet, and is rich in fossil remains, the whole of which are marine, 48 genera; and 90 species of mollusca alone have occured at Alum Bay.

At Barton Cliff, on the mainland, or opposite coast of Hampshire, a rich and abundant marine molluscan fauna occurs. The lower beds at Alum Bay contain *Voluta luctatrix*, *Rimella*, (*Rostellaria*) *rimosa*, *Conus* or *Conorbis dormitor*, and *Fusus longævus*, with *Crassatella sulcata*, &c.

UPPER BAGSHOT SANDS.

These are the unfossiliferous sands below the Lower Headon beds, used extensively for glass-making, which may be 150 feet thick at Alum Bay. In Whitecliff Bay the junction between the Upper Bagshot sands and the Barton clay is sharp and well defined; a few casts of fossils occur here, but are in so friable a state that they cannot be removed.

Examination of the cliffs at Alum Bay will at once show that the strata from the chalk to the Upper Bagshots are highly inclined, caused by the force that produced the anticlinal axis which traverses the island east and west, and this axis brings to the surface the Wealden beds in Brixton and Sandown Bay, thus revealing the extent and continuity of the Wealden series, and determining its presence westward to the Isle of Purbeck along the same east and west line of elevation. Eastward of the Isle of Wight this axis is lost under the waters of the English Channel, and we have no visible proof of its influence towards Beachy Head; it may have aided in preparing a weakened line for the course of the Channel towards the Straits of Dover. These beds at Horwell Cliff have been the subject of a notice by Mr. Tawney in the "Proceedings of the Cambridge Philosophical Society," and will be referred to in the latter part of my address.

FLUVIO-MARINE SERIES.

Of the fluvio-marine strata of the Isle of Wight, the *Bembridge* series is by far the most constant in *lithological characters.* The lower part, calcareous (marine and freshwater.) The upper part (largest) consist of alternations of marls and laminated clays.

By far the larger portion of the Tertiary surface of the Isle of Wight is occupied by the Bembridge series, which *overlie the Headon beds, or Headon Hill group.* Stratigraphically, or in a scientific point of view, they possess high interest, being *representatives of extensive continental formations*, through which we are enabled to correlate or throw considerable light on the classification of foreign Tertiary strata.

Through these Bembridge strata we are also made acquainted with and acquire much information respecting the terrestrial fauna of our own area during the later portion of the Eocene epoch.

Palæontologically the Upper Bembridge marls are characterised by the abundance of *Melania turritissima* These marls are finely shown in Whitecliff Bay, on the shore at Hempstead, and at Thorness, containing *Cyrena pulchra*.

The upper beds of the second group are exposed in the clearest manner through fine sections at the same places, and also at, or near Brading harbour, below St. Helen's. Remains of *Trionyx*, or the fresh-water tortoise, large cerithia (*C. variabile*), and *Cyrena pulchra* characterise these beds.

The *third group*, or the Bembridge oyster beds, forms 'a narrow but constant band between the marls and the limestones. Marine conditions set in here, characterised by the abundance of *Ostrea vectensis*, *Nucula similis*, *Cytherea incrassata*, *Mytilus*, and *Cerithium*. These beds were long mistaken for the "upper marine" or Middle Headon strata. At Whitecliff Bay and Brading harbour this group may be advantageously studied.

The fourth subdivision, or Bembridge limestone, includes those beds exhibited at Binsted, Cowes, Calbourn, and Sconce (but not the limestones of the Headon series). It is important to remember this when correlating the British Upper Eocene deposits with those of the Continent.

This remarkable limestone in *Whitecliff Bay*, forms a conspicuous feature in the cliffs; it is also the marked feature at Bembridge ledge. When closely inspected it is found to be composed of a number of distinct beds or strata. In ascending order we readily recognise seven divisions, each characterised by freshwater mollusca and some few land plants.

Bed No. 1. Concretionary limestone containing the fresh-water plant *Chara tuberculata*, with *Lymnæa longiscata*.

,, 2. Greenish marly clay, *Lym. longiscata* and *Planorbis*.

,, 3. Compact creamy yellow limestone, *Lym. longiscata* and *Planorbis oligyratus*.

,, 4. Pale marly limestone, compact in places, full of *Paludina globuloides*, *Lym. longiscata*, *Hydrobia*, and *Cyclostoma mumia*.

,, 5. Greenish white limestone, concretionary and fossiliferous, containing *Lym. longiscata*. *Planorbis discus*. *P. rotundatus*, *P. Sowerbyii*, *P. obtusus*, *Helix occlusa*, *Helix labryrinthica*.

,, 6. Crumbly white marl, with globular concretions, *Chara tuberculata*, *Planorbis obtusus*.

,, 7. A similar bed to 6, with *Planorbis discus*. The whole about 25 feet thick.

The strata along the coast and section are in many places beautifully shown, and present peculiarities not elsewhere seen in the island.

The difference between the upper and lower portions of them is considerable, and may be separated—

1. The Upper, Forbes termed the St. Helen's Sands.
2. The Lower, the Nettlesome Grits.

The St. Helen's Beds, or Osborne and St. Helen's.

These lie between the Upper *Headon series* proper, containing *Potamomya* and the Bembridge limestones. These beds are of freshwater and brackish-water origin.

Paludinæ (*P. lenta*), *Melaniæ* (*M. costata*, *M. excavata*), *Melanopsis brevis* and *M. carinata*. *Chara Lyellii* is the Gyrogonite of this limestone band, which on the east side divides the Upper or Nettlestone beds from the Lower or St. Helen's sands.

Between the Bembridge limestone and the brackish-water beds with Potamomyæ, that terminate the Headon beds, a great series of strata intervenes, which on account of their mineralogical and palæontological peculiarities, deserve and hold an intermediate position between the middle and upper Eocene strata.

Osborne Series in Whitecliff Bay.

Thickness 100 feet.—Dark red clays and bright red and variegated clays occur. (*Helix occlusa*, *Planorbis discus*, and *Lymnæa longiscata*.)

Osborne Series between St. Helen's and Ryde.

Between Brading Harbour and Ryde sections occur, and on shore are seen the rocky ledges below Seafield, and from St. Helen's to Nettlestone. At Watchhouse Point, below St. Helen's, the Bembridge limestone forms an extensive arch.

Headon Series. 170 feet thick.

Best seen at Headon Hill, Colwell Bay, and at Whitecliff Bay, and their lowest divisions at Hordwell. Everywhere *Planorbis euomphalus* characterises the fresh-water bands.

Potamomya plana, and *Cerithium pseudocinctum* abound in the brackish-water beds. *Cytherea* (*Venus*) *incrassata*, accompanied by many shells, occur in the marine division.

The group may be divided into three sections, Upper, Middle, and Lower Headon.

Upper Headons.—These constitute the greater portion of the *Upper Freshwater* series. The mass of freshwater limestone in Headon Bill belongs to this section. Brackish in the upper part, abounding in *Potamomya* and *Cyrena obovata*, at Cliff End they contain a cyrena (like *C. pulchra*). *Cerithium trizonatum* occurs here abundantly, and *Bulimus politus* and *Melania muricata* abound.

Middle Headons. "*The Headon intermarine or Upper marine formation.*"—At Headon Hill these deposits were deposited under brackish-water conditions, for, although *Ostrea*, *Cytherea incrassata*, *Nucula deltoidea*, *Natica depressa*, *Buccinum labiatum*, and other sea shells are common, the upper and lower beds abound in *Cerithium ventricosum*, *Cerithium concavum*, *Cerithium pseudocinctum*, *Neritina concava*, *Nematura*, *&c.* which are brackish or estuarine. A short distance further north, in Colwell Bay, the upper and lower beds contain brackish-water shells; *but the central part assumes a distinctly marine character*. *Ostrea velata*, S. Wood, is a characteristic species with numerous marine genera, many of which are of Barton types. This central part is known as the "*Venus bed*," from the presence of *Cytherea incrassata*. The marine character of the *Middle Headon beds* is still more strongly marked at Whitecliff Bay (22 genera). The lower portion of this series at Whitecliff Bay contains many Brockenhurst species, but at Colwell Bay we *have no evidence of characteristic species from this horizon*, or in *the western side of the island*.

Lower Headons, fresh and brackish-water series.

These beds are 70 feet thick in Totland Bay, and 40 feet thick in Whitecliff Bay.

They consist of fresh and brackish-water beds abounding in fossils resembling those of the upper division. *Unio Solandri* and *Cyrena cycladiformis* occur here and are characteristic.

At Headon Hill the thick bed of limestone in the Upper Headon is conspicuous in the cliffs, but it thins out rapidly towards the north and disappears in an easterly direction. The Lower Headon contains a much less thick limestone at Headon Hill, and it is represented by the band forming How Ledge between Colwell and Totland Bays. 120 species have been obtained from the Headon series; 104 mollusca, 9 crustacea, 4 annelids, and three plants, land, freshwater; and marine the fossils of the Headon fluvio-marine series, are $\frac{23}{74}$ gasteropoda; $\frac{15}{25}$ pelycipoda; polycipes 1, balanus 1, crustacea $\frac{5}{9}$, plantæ $\frac{2}{2}$, fish $\frac{2}{2}$.

Professor Judd, in a paper communicated to the Geological Society in May, 1880, on the Oligocene strata of the Hampshire basin, having reference to the beds at Headon Hill and Colwell Bay, in the Isle of Wight, endeavoured to show that the Colwell Bay marine beds are not, as has been hitherto supposed, the equivalents of those of Headon Hill and Hordwell Cliff, but that they occupy a distinct and much higher horizon in the Eocene series. Assuming this to be the case, a new classification and nomenclature for the Upper Eocene series of Britain was proposed by the author (*Quarterly Journal of the Geological Society*, vol. xxxvi. 1880.)

Professor Judd traced the history of previous opinion upon the succession of the Tertiary strata down to the time of Professor Edward Forbes and the Geological Survey, with the subsequent labours of Mr. Bristow. Edward Forbes confirmed the previous determinations of Professor Prestwich in his elaborate researches in the Isle of Wight Tertiaries. Forbes's life, however, was not spared to enable him to complete his researches in this division of the British strata; his attention was chiefly confined to the four uppermost Eocene members, or the Hempstead, Bembridge, Osborne, and St. Helen's, and the Headon beds. These divisions were accepted and worked upon as a basis by the Geological Survey. With regard to these strata, Forbes maintained, as almost all previous observers had done, that the beds at Colwell and Totland bays are on the same horizon as those at the base of Headon Hill and at Hordwell Cliff.

Professor Judd's view has been questioned and refuted by Messrs. Tawney and Keeping, in an elaborate paper also read before the Geological Society in May, 1881, (*Quarterly Journal of the Geological Society*, vol. xxxvii. 1881.) and in a subsequent communication to the Cambridge Philosophical Society in the same year, "On the Beds at Headon Hill and Colwell Bay in the Isle of Wight."

The importance of a correct reading and classification of these Middle Eocene strata in the Isle of Wight, and their correlation with beds of the same age in France, Belgium, and Germany, cannot be overlooked or over-estimated, and often as it has been attempted, the papers by the two above-named authors have still greatly added to our knowledge of the stratigraphy of the Eocene series of the Isle of Wight. It is impossible to dispute the validity of their researches and value of their sections. The publication of Mr. Judd's paper disputing the correctness of Forbes's work and that of the Geological Survey, and the proposal of a fresh classification, drew immediate attention to the labours of the older authors, but especially that by the Geological Survey—which was answerable for the latest, indeed the only known extended and complete analysis of the Upper Eocene strata of the Isle of Wight.

We owe a debt of gratitude to the late Mr. F. Edwards and Mr. S. V. Wood, for their valuable additions to our knowledge of the palæontology of the fauna of the fluvio-marine beds of the Hampshire basin. Since the publication of Professor Forbes's memoir upon the Isle of Wight, the molluscan fauna alone is at least three times as great as noticed by him, and since which the remarkable fauna of Brockenhurst in the New Forest, discovered by Mr. Edwards, has been carefully studied by Von Könen for the mollusca, and Dr. Duncan for the corals. These naturalists have shown the relation and agreement of this fauna with that of the Lower Oligocene in North Germany. This Brockenhurst fauna is also identical with certain strata at the base of the Middle Headon beds at Whitecliff Bay, in the Isle of Wight.

Professor Judd in his paper describes the stratigraphical position of the Colwell Bay and Headon Hill beds, and their relation to each other, pointing out what *he believed to have been an error on Forbes's part*, relative to the correlation of the "Venus bed" at two places, in what is really a continuous section, Edward Forbes and the Geological Survey having carefully and correctly determined that *only one set of marine* strata occurred between the two brackish or estuarine and freshwater series. This fact has been again most carefully worked out by Messrs. Tawney and Keeping, *leaving no doubt* as to the interpretation and accuracy of the work of Forbes and the Survey, and establishing upon a firmer basis the continuity and equivalency of the Colwell Bay and Headon Hill marine series, through the "Venus bed," all being stratigraphically and palæontologically the same. Professor Judd insists upon 250 feet of strata intervening between the Bembridge limestone and the marine band of Headon Hill, but Forbes and the Geological Survey in their section show less than one half of that thickness. Recent research confirms this view. At pp. 148–150, the author also endeavours to how that palæontological evidence is in accordance with, and as complete as the stratigraphical. This of course is based upon the belief that both are read or interpreted rightly. The comparison is between the collective fauna of Whitecliff, Colwell Bay, and Brockenhurst on the one hand, and Headon Hill and Hordwell on the other hand, but Messrs. Keeping and Tawney have shown the illogical nature of conclusions drawn from such an admixture of beds. Each bed should be compared separately.

Professor Judd (on pp. 150-164) correlates the British fluvio-marine strata with that of the Continent, adding at p. 153 of this paper a list of his so-called Brockenhurst species from Whitecliff Bay, Colwell Bay, Brockenhurst, and Lyndhurst, with those species common to the Barton beds below and Hempstead series above. This so-called Brockenhurst, but really Middle Headon fauna, numbers 84 genera, and 187 species (65 are MS. names). Four of the 13 corals of the Brockenhurst beds also occur in, or are representatives of the Oligocene stra a of North Germany. This conclusion was arrived at by Dr. Duncan, independently of the work of Von Könen upon the mollusca in the same beds.[1] The author also prepared a list of the Hempstead or so-called Middle Oligocene fauna, in which no less than 40 genera and 101 species are named, 40 of these are manuscript names, by Mr. F. Edwards, thus reducing the described fauna to 61 species. The sub-division and nomenclature of the series is next given, and the author proposed to extend the "name of the Headon series, so as to embrace all the beds between the Barton and the Brockenhurst series, and to call all those strata said to belong to the zone of *Cerithium concavum* the Headon group," doing away with the smaller subdivision of Lower, Middle, and Upper. To all the beds between the Brockenhurst and Hempstead series Mr. Judd would apply the name Bembridge group; including the series both above and below the "Bembridge series of Edward Forbes, and also beds referred by him to the base of the Hempstead, the Osborne and St. Helen's, and to the Upper Headon." Such a proposal labours under the error of altogether failing to recognise the position which the Brockenhurst fauna occupies in this interesting series. Professor Judd in fact places the Brockenhurst beds not only above the Middle Headon, but above the Upper Headon and Osborne beds of Headon Hill. It occupies, however, in fact, a place at the base of the Middle Headon, as is well seen at Whitecliff Bay, and Brockenhurst itself.

This change in the nomenclature and classification has not met with approbation, and is strongly opposed by Messrs. Tawney and Keeping in their exhaustive paper, and by Mr. Lucas in his communication to the *Geological Magazine*, (*Geological Magazine*, decade ii. vol. ix.) Messrs. Keeping and Tawney elaborately defend the labours and views of the Geological Survey, giving a mass of evidence, both as to the order of the strata and the distribution of life forms, clearly showing that the relations of the whole group can be determined by examination of the continuity of the Colwell Bay and Headon Hill beds, and that the *brackish marine beds of Colwell Bay* correspond with the brackish marine beds of Headon Hill in every essential particular, being, in fact, one continuous and unbroken sequence, as laid down by the Geological Survey, and which the authors have again so clearly demonstrated in the text of their Memoir, and laid down in their clear and continuous section from Cliff End or Lynchen Chine to near Alum Bay Chine, and synthetically proved in their vertical sections.

The following general and condensed description or analysis of the Headon series of Holwell Bay and Headon Hill, as given by Messrs. Tawney and Keeping, will aid those wishing to examine the section, prior to reading or possessing themselves of the original paper in the *Quarterly Journal of the Geological Society*, vol. xxxvii. or that of Professor Judd, *loc. cit.*, Note 1.

Vertical Section at the North-east Corner of Headon Hill.—One hundred and ten feet of strata occur from the top of the Bembridge Limestone to the top of the Great Limestone (Upper Headon). The Brockenhurst series does not exist here. Not a single marine fossil occurs in that interval. Nor is there any bed having the least resemblance either lithologically or palæontologically to the Colwell Bay Venus bed.

The *Upper Headon* at Headon Hill measures 50 feet and contains the thick Lymnæan limestone (27 feet). The united or combined thickness of the Osborne and Upper Headon beds (Geological Survey) is 119 feet, *i.e.* adopting the top of the *Cerithium ventricosum* bed as the boundary. The Osborne beds at Headon Hill are below the Bembridge limestone and extend up to it, *so there is no room*.

The *Middle Headon.*—The uppermost and lower portions of the Middle Headon are brackish-water beds abounding in *Cerithium ventricosum*, *C. pseudocinctum*, *C. concavum*, *Neritina concava*, and *Nematuræ*. The beds or series in Headon Hill richest in *Cytherea incrassata* (Venus bed proper), exhibit identically the same fossils as at Colwell Bay.

Below the oyster band in grey sandy clays is the *Venus bed*, extremely rich in marine fossils. *Cytherea*, *Mya*, *Mactra*, *Corbicula*, *Nucula*, *Trigonocœlia*, *Fusus*, *Cancellaria*, *Voluta*, *Vicarra*, und *Natica*; *Mya angustata* and *Cytherea incrassata* scattered throughout and abundant. The Middle Headon of Headon Hill is 32 feet thick. The Survey vertical section gives 35 feet for the same boundaries. The height of the Middle Headon above the sea level at the north-east end is 72 feet, and not below the sea level, as seems required on Professor Judd's theory.

Lower Headon.—The first bed is a Lymnæa limestone, and is the same well-known bed which forms the top of the Lower Headon in Warden Cliff. It is traceable to How Ledge, where it disappears below the sea, and clearly shows by its course that it is the How Ledge bed of Warden Cliff. Although this limestone is denuded from the top of the anticlinal curve between Weston and Widdick Chines, some of the lower beds are traceable the whole distance; accordingly we can join on the section in Headon Cliff to that in Warden Cliff. This gives a continuous section and series of beds from the lowest seen of the Lower Headon, through the Middle and Upper Headon of Colwel Bay to the Bembridge limestone both north and south. There is therefore only one marine (*Middle Headon*) series lying between two freshwater series, or "the Lower and Upper Headon." The Rev. O. Fisher has discovered the Venus bed in the Totland Bay brickyard, some short distance above and

[1] A. von Könen on "The Correlation of the Oligocene Deposits of Belgium, Northern Germany, and the South of England," *Quarterly Journal of the Geological Society*, vol. xx. p. 97.

behind the top of the cliff, between the chines. This being the only part where it is missing from the cliff is proof of its continuity from Warden Cliff to the north-east corner of Headon Hill.

The authors describe in the most careful manner the Lower Headon beds of the cliffs between Weston and Widdick Chines, much of the space in which is hidden by grassy slopes, but the connection cannot be doubted.

The Lower Headon of Warden Cliff.—"The lowest beds of this series are seen below the Totland Bay Hotel at Weston Chine, and all are below the Venus bed. A remarkable feature in the lowest portion are five thin Lymnæan limestones, containing *chara* seeds. These five limestones at low water form five submarine ledges parallel to the great ledge at Warden cliff" (Warden ledge). Above these five beds and the sands containing *Potamoma* comes the concretionary calcareous sand rock which forms Warden Ledge. It crops out at the top of the cliff below the flagstaff of the coastguard station. Succeeding these is the Unio bed (*U. Solandri*) and associated with *Melania turritissima*. The How Ledge limestone succeeds and forms the summit of the Lower Headon series. This limestone is denuded away in the centre of Totland Bay, where we have evidence and may infer the summit of the anticlinal to be near the old wooden pier. The thickness of the Lower Headon in Warden cliff is 72 feet, and from that to 87 feet before reaching the yellow sands of the Upper Bagshot.

The whole of the cliffs between Weston and Widdick Chines are occupied solely and throughout by Lower Headon beds, and the Colwell Bay marine bed extends all through Warden point and cliff, where it rests upon, or is supported by the *How Ledge* limestone. Between Warden Battery and Weston Chine the Colwell Bay marine bed (Middle Headon) is maintained in all its integrity.

Middle Headon of Colwell Bay.—"The Neritina bed at the south-west end of the bay is well seen a little short of Colwell Chine. Above this comes the richest part of the 'Venus bed'—the fossil in which (*Cytheria incrassata*) strew the tumbled clays and commingle with recent shells on the shore." *Ostrea velata*, as at Headon Hill, is abundant above the part richest in Cytherea. This oyster occurs in vast abundance in the centre of the bay between Colwell and Bramble Chines, crowding out other fossils and forming a massive oyster bank about 20 feet thick. The Venus bed here is altered in character, and abundantly occurring with *Cytherea incrassata* are *Murex sexdentatus*, *Pisania labiata*, *Natica labellata*, *Nerita aperta*, *Cerithium variabile*, and *Ostrea velata*."

Upper Headon of Colwell Bay.—The horizon of *Cyrena Wightii* is a marked feature here, associated with *Corbicula obovata*; *Cerithium trizonatum* also occupies one horizon just below the buff-coloured Lymniæ limestone forming a narrow band with green clays; *Serpula tenuis* is equally characteristic, occurring at the same horizon both here and at Headon Hill, viz. in the *Upper Potamomya clay* just above the Lymnæa limestone.

PALÆONTOLOGICAL EVIDENCE

Having noticed the stratigraphical succession of the several divisions in the beds at Headon Hill and Colwell Bay, I now proceed to draw attention to the distribution of the fossils.

The authors of the paper have discussed the question as to whether the Colwell Bay has any more affinity with the Brockenhurst fauna than has the Headon Hill bed; and they compare the fauna both of the Colwell Bay and Headon Hill marine beds. This they do by separating in tabular form the fauna of all the localities which are to be compared together. The splendid collection of Tertiary fossils belonging to the late Mr. F. Edwards, and now in the British Museum, has formed the basis of their comparison, while their own researches have added occurences still more conclusive as to the correlation of species in the areas under examination and consideration. The authors obtained during their research in the Isle of Wight many species in the marine bed at Headon Hill which do not exist in the Edwards collection from that locality. "The test as to the contemporaneity of the beds in question is not to be obtained from the rarer forms only, but from a comparison of the commoner and more characteristic species." No less than fifty-eight species were obtained by the authors from the Middle Headon of two localities, Colwell Bay and Headon Hill, nineteen of which appeared in and came up from the Barton beds, and with seven exceptions all the fifty-eight forms came from both horizons.

It has been stated that the "*strata at Colwell Bay are of purely marine origin, while the so-called Middle Marine beds of Headon Hill and Hordwell Cliff are of totally different character.*" Messrs. Tawney and Keeping obtained from the marine series at Colwell Bay the brackish-water genera *Cerithium*, *Cyrena*, *Hydrobia*, *Lymnæa*, *Paludina*, *Planorbis*, *Melania*, and *Melanopsis*, although said to be found only at Headon Hill. It has also been stated that certain species of Cerithium are confined to Headon Hill, and do not occur in Colwell Bay, and that through this serious errors in our classification have been detected, as well as in the correlation of the strata under consideration.

The presence of *Cerithium concavum* in the Venus bed abundantly at Colwell Bay, and we may add from private information from Mr. Keeping that he has found it also at Whiteclift Bay in the same position, removes all doubt as to the non-occurrence of the zone in that locality. As has been stated, the species is not so common as at Headon Hill.

There is but one marine bed, and that is known only in the Middle Headon. The place of the Brockenhurst bed *is at the lowest horizon* in the Middle Headon, but it does not appear at Colwell Bay or anywhere in the west end of the island.

Middle Headon of Whitecliff Bay. It has been stated that the Colwell Bay bed is placed in the Brockenhurst, which is said to occupy a higher horizon than the Headon Hill and Hordwell marine bed. The true place of the Brockenhurst fauna in the Isle of Wight is confined *to one zone*, and that at the *base of* the the Middle Headon series, and *only at* Whitecliff Bay or in the New Forest.

The Geological Survey do not mention by name the Brockenhurst bed in their vertical section [Sheet 25] of Whitecliff Bay, as its peculiar fauna had not been recognised at that time. It is easily identified, however, in their section as the *basement bed* of their Middle Headon, the whole of which is given as 90 feet thick.

Brockenhurst Zone at Whitecliff Bay.—At the time the Geological Survey section was made, this bed at Brockenhurst was unknown, and its fauna undescribed. Subsequent observers have recognised the Brockenhurst fauna in the lowest bed (2 feet thick) of the Middle Headon at Whitecliff Bay. Sixty-nine species are known here, and 104 occur at Brockenhurst.

Affinities of the Brockenhurst Fauna.—If we take the whole Brockenhurst fauna, including the eighteen corals (special to the zone) we obtain a total of 151 species, of which from 74 to 81 pass up from Barton.

Messrs. Tawney and Keeping supply a list of 53 species from the Brockenhurst zone obtained from the Whitley Ridge Railway Cutting, New Forest. Fifty-one of these 53 forms have occurred in the 2-foot bed at Whitecliff Bay, 27 of which pass up from the Barton or Bracklesham beds.

The palæontological evidence therefore accords with the stratigraphical.

Relation of Colwell Marine to Brockenhurst Fauna.—Examination gives us 29 per cent. of Barton forms in the Colwell Bay bed. In the Brockenhurst bed the ratio was about 50 per cent., and in the Headon marine bed, 29 per cent. Examination also of the more characteristic Colwell and Headon marine fossils shows that these faunas are practically identical—and also shows that *only certain* Brockenhurst species occur at Colwell Bay, and not at Headon Hill. They are *Scalaria tessellata* and *Tellina affinis*, this latter a Barton form, while those occurring at Headon Hill, and *not at* Colwell Bay, are *Marginella æstuarina* and *Cardita paucicostata*, only "two in each case, which amounts to perfect equality." If we take into account those common to the Colwell and Headon marine beds, and not occurring at Brockenhurst, we find twenty-six species. It is therefore evident that the Brockenhurst fauna is not identical with that of the Colwell Bay bed, and not newer than that of Headon Hill.

Thus fossil as well as stratigraphical evidence shows that the Colwell Bay bed is identical with the Headon Middle Marine.

The same twofold proof demonstrates that the Brockenhurst bed, *where* present, lies at the base of the Middle *Marine* Headon beds, and immediately above the Lower Headon. This Brockenhurst bed is absent at Colwell Bay and Headon Hill, but occurs at Whitecliff Bay, Brockenhurst, and Lyndhurst.

The proposal by Prof. Judd to extend the name of the Headon series so as to include all the beds between the Barton and Brockenhurst series, and call them the "Headon Group," would cause great inconvenience. The term Middle Headon, based as it is on the classical work of Edward Forbes, is clear and definite. Again, it would entail the abandonment of the names Upper and Lower Headon also; and the non-occurrence of the Brockenhurst series, or its representative, in Colwell Bay admits of no recognition on the west side of the island, and therefore the classification would be based upon a defective appreciation of the beds.

Von Könen, in 1864, justly correlates the fauna, and since then, in 1866, the coral fauna has been described by Dr. Duncan.

Messrs. Tawney and Keeping, in their paper on the beds at Headon Hill and Colwell Bay in the Isle of Wight, uphold the work done by the Geologinal Survey, maintaining the correctness and integrity of the two Survey Memoirs, and the horizontal and vertical sections of the Tertiary beds of the Isle of Wight. Prof. Judd differs from the identifications and stated succession of the beds in Totland and Colwell Bays. He *introduces two new series at Headon Hill*, a marine and a freshwater (?) in addition to those which have been universally accepted for the last twenty-five years (*Quarterly Journal of the Geological Society*, vol. xxxvi.).

The sections prepared by Prof. Judd also differ very considerably from that of the Geological Survey, or those lately prepared by Messrs. Keeping and Tawney, during their late examination of the beds under notice. These are the marine series known as the *Middle Headon* or *Middle Marine.* Prof. Judd places them at the sea level near Widdick Chine. Consequently, between the *top of the marine bed* and that of *the Bembridge limestone*, there would be, on Prof. Judd's theory, 250 feet of beds, such being the altitude of the cottage on the Warren which marks the summit of the Bembridge limestone. This thickness must, however, be reduced by 100 or 105 feet, which is the altitude of the top of the Middle Headon at this point. This 105 feet of beds, or *another* freshwater and *another* marine have no existence; they can only be accounted for by counting the Lower and Middle Headon twice over. Now the only marine beds are those of the Middle Headon, inclosed between the altitudes of 70 feet above the sea *level;* the others are all fresh water.

The point wherein Prof. Judd's section differs from the Survey, and that of the authors, arises from the belief that a *second marine series*, termed the "Brockenhurst series," with another freshwater below, in all 105 feet, is intercalated above the *Upper Headon*—these two believed new formations having that portion of the section allotted to them which is occupied by the freshwater *Osborne marls* and part of the Upper Headon. It must be remembered that there is no positive evidence of the existence of this second marine (*Brockenhurst*) series *at the* spot where the Geological Survey place the *Osborne marls*. Careful examination fails to reveal these said to be additional beds. It is clear, therefore, that no bed having the peculiar fauna of the Brockenhurst bed occurs at the west end of the island; its place too, if found, would be at the *base of the* Middle Headon, and not *above the Upper*, where it has been wrongly assigned. Messrs. Keeping and Tawney, in their paper, object to the correlation of the *Brockenhurst* with the Colwell Bay bed—which is identical with the marine (Middle Headon) bed of Headon Hill. Thus the 105 feet of strata have no existence.

The Middle Headon, which is denuded away from the top of the cliffs in the centre of Totland Bay between Western and Widdick Chines, has been discovered in the Totland Bay brick-yard, which lies a little inland of this portion of the cliff, thus conclusively showing that this bed was continuous above the top of the cliff, consequently linking the Warden Cliff exposure to that of Headon Hill. They are visibly and absolutely continuous with those of Colwell Bay.

Palæontological Evidence.—The equivalency of the Colwell Bay and Brockenhurst beds is a point to be definitely settled. Most careful lists of fossils have been prepared from collections made both from the Middle Headon at Colwell Bay, and Headon. We find that out of fifty-seven species at Colwell Bay, fifty-three occur in the Middle Marine of Headon Hill, or 93 per cent. This clearly proves the identity of the horizon in the two localities.

The well-known shells *Cerithium concavum* and *C. ventricosum* occur both in Colwell Bay and Headon Hill, and on the same horizons. *C. concavum* appears to have a less restricted range at Headon Hill than *C. ventricosum*, occurring abundantly there through the greater part of the Middle Headon series. It has also been found in the "Venus bed" of Colwell Bay. Thus both stratigraphical and palæontological evidence are in harmony. All evidence tends clearly and conclusively to show that there is *only one marine series* in this section, viz. the Middle Headon of Edward Forbes, which is interstratified between the freshwater Lower and freshwater Upper Headon; while there is no evidence of the Brockenhurst bed occurring anywhere in the west of the island.

Whitecliff Bay and the New Forest.—The Brockenhurst bed was recognised at Whitecliff Bay by the Rev. O. Fisher in 1864, where it occurs in the lowest 2 feet of the Middle Headon series. No less than 70 species have been collected here out of 104 known at Brockenhurst. Many species are peculiar to it, but all are identical with those of the well-known section in the railway cutting near Brockenhurst. Many species are confined to this horizon *and do not pass up into* the "Venus bed." Thus the Brockenhurst fauna at Whitecliff Bay number 70 species, at Brockenhurst 104, and of these only 18 occur in the Middle Marine beds of Colwell Bay, or are common to Whitecliff Bay and type locality. Eighty-three Barton or Bracklesham species pass up, 25 to the Middle Marine of Colwell Bay, and 36 to the Brockenhurst bed of Whitecliff Bay, or these two localities yield the above number of Bartonian forms. To still further illustrate the value of the *Middle Headon* series of the Isle of Wight and elsewhere, I may mention certain characteristic fossils that occur in several zones. The "*Venus* bed" of the Geological Survey is about 30 feet thick at Colwell Bay, Headon Hill, and Whitecliff Bay, and contains the following well-marked shells, *Murex sexdentatus, Melania fasciata, Cerithium duplex, C. ventricosum, C. concavum,* and *Nerita aperta.* Shells characteristic of the Brockenhurst bed and confined to it are *Voluta suturalis, Leiostoma ovatum, Pecten bellicostatus, Modiola nysti, Cyprina nysti,* and *Cytherea solandri,* var. *attenuata.* In the Roydon zone occurs *Voluta geminata*, and nowhere else in England. *Pleurotoma transversaria, P. subdenticulata, Cardita deltoidea,* and *Protocardium hantoniense* are in both the Roydon and Brockenhurst zones, but not known in the Venus bed. Certain species range through the Middle Headon series and occur nowhere else. These are *Pisania labiata, Pleurotoma headonensis, Cancellaria muricata, C. elongata, Leda propinqua, Cytherea suborbicularis, Psammobia æstuarina,* and *Corbicula obovata.* The Brockenhurst zone is restricted to the lower 2 feet of the Middle Headon, and it lies immediately on the eroded surface of the Lower Headon. An error certainly has been committed in the New Forest Section, in assigning the place of the Brockenhurst series above the Middle Marine or Middle Headon. This is at variance with facts at Brockenhurst and Whitecliff Bay, and this misapprehension as to the stratigraphical position of the Brockenhurst bed refutes the theory as to the occurrence of this bed high up in the Headon Hill. It is not in existence there.

With reference to the affinities of the Brockenhurst fauna it has been stated that "nearly one-third of the Hordwell and Headwell Hill marine shells are Barton forms, and not more than one-fifth of those occurring at Brockenhurst, Colwell Bay, and Whitecliff Bay, are found at Barton." We should not expect the *Venus Bed* or *Middle Marine* would have more Barton species than the Brockenhurst Bed, seeing that the former occupies a higher zone in the Middle Headon series. The percentage of Barton forms, according to Mr. Tawney, in the Whitley Ridge bed, is 42 per cent.; a lower proportion than at Whitecliff Bay, arising from the number of corals being special to the Whitley locality. At Whitecliff Bay the Barton group has 52 per cent., and the proportion of Barton forms *from all the Brockenhurst* localities, including the Roydon zone, is 48 per cent., and the percentage of the Barton forms in the Middle Headon of Headon Hill is found to be 29 per cent.; the conclusion, therefore, from fossil evidence is that the Headon Hill marine bed is later in age, and higher stratigraphically than the Brockenhurst bed, the proportion of Barton forms in the latter being nearly 50 per cent., and not one-fifth, as stated. The result is in strict accordance with their stratigraphical positions. It is equally important to test by fossil evidence whether the Colwell Bay Venus bed (Middle Headon) is more nearly related to the Brockenhurst than is the Headon Hill bed. In Colwell Bay the observed Barton forms are 29 per cent. in common, and the same percentage in the Headon Hill bed, while in the Brockenhurst bed they were 48 per cent. To test still more the proof from palæontological evidence, it is stated, on the same authorities, that there are only *two species in each case* common to either Colwell Bay, or Headon Hill and Brockenhurst, and not occurring at Barton; while there are *twenty-six species common to Colwell Bay and Headon Hill*, and not occurring at Brockenhurst. It is clear, therefore, from all fossil and physical or stratigraphical evidence, that the position of the Brockenhurst bed has been misconceived, and it would be fatal to re-name the whole series of strata hitherto so well known and well determined as the Middle Marine or Middle Headon of the Isle of Wight, and call it the "Brockenhurst series." The classification and nomenclature of the Geological Survey must therefore be restored and maintained, all recent examination having strengthened the previous labours of Forbes and Bristow, and the later researches of Messrs. Tawney and Keeping, have still more firmly established the succession and correlation of the Middle Headon series of the island, and affording a basis for further research and analysis for the "Anglo-Parisian or Hampshire Tertiary Basin."

Mr. Tawney prepared an important paper upon the *Upper Bagshot Sands of Hordwell Cliff*, which was read before the Cambridge Philosophical Society, and published in their *Proceedings*. The object of the communication was to discuss the affinities of the *Bagshot* series with a view to their classification, and also to endeavour to show their correlation and equivalents in the Paris basin. "All observers are agreed as to the actual position of the sands being below the fresh-water Lower Headon. Edward Forbes and the Geological Survey distinctly ally it to the Marine Bagshot beds. They place it in the Middle Eocene Bagshot series, terming it Upper Bagshot (*instead of Headon Hill Sands*). Forbes noticed its containing Barton species at Whitecliff Bay. This leads to or shows its affinity to Barton beds. Dumont favoured a similar classification in his essay, and in his table the Headon Hill sands are grouped with the Barton clay as being respectively equivalent to the upper and lower divisions of the *Belgian Laekenian*, while the Headon Hill limestones and marls are placed *Tongrien*. Lately these views have been questioned by the author of the "Oligocene Strata of the Hampshire Basin," in the *Quarterly Journal of the Geological Society*, vol. xxxvi., who regards them as constituting the lowest member of the Headon group, stress being laid upon the occurrence of *Cerithium concavum* as a test. The author also places the whole of the Upper Bagshot sands and the Lower Middle Headon beds as the equivalents of the Mortefontaine sands, placing them *above* the St. Ouen limestone; these St. Ouen beds representing perhaps the Osborne, and all three Headon divisions, which come above the Mortefontaine beds. *Cerithium concavum* is said to occur both in the Bagshot and Headon series. Careful research and examination shows that the shell in question is Lamarck's *C. pleurotomoides* in the one case, and not *C. concavum*, which species has evidently been confounded with the Lamarckean shell. Examination of equivalent beds in France by Mr. Tawney, and the researches of Prof. Hebert and M. Munier-Chalmas clearly show that the Mortefontaine sands *do not contain Cerithium concavum*, the shell so common on that horizon being *C. pleurotomoides* Lamk." Comparison of the Headon shell with those brought from near Mortefontaine shows that the Long Mead End species agrees with the French form. It would appear that there is much greater parallelism between the French and English series than we have hitherto expected. The Mortefontaine sands are the upper part of the Sables de Beauchamp, representing our Barton beds; above this comes the Calcaire de St. Ouen, chiefly of freshwater origin. Connected with the St. Ouen limestone are sands and marls, containing at the top and bottom *Cerithium concavum* abundantly.

The St. Ouen period, therefore, without doubt represents our Headon series. "In our Hampshire basin the freshwater and marine condition in the Headon series are not in the same order as in the St. Ouen beds." "The marine facies in Hampshire, with *C. concavum*, comes between the freshwater Lower and Upper Headon deposits, near Montjavoult; the bulk of the freshwater limestone is in the centre or between two deposits with this *Cerithium concavum*." "In the Paris basin, therefore, the zone of *C. concavum* is not connected with the zone of *C. pleurotomoides*, but comes immediately above it." Thus *C. concavum* characterises the Middle Headon of Colwell Bay and Hordwell, while *C. pleurotomoides* is found only in the Upper Bagshot of Long Mead End. That the Long Mead End sands, and those of Mortefontaine are equivalents few can doubt. Both succeed or constitute the uppermost portion of the Barton beds, and 25 per cent. of the fossils are in common. These affinities show that the term Upper Bagshot sands is the most appropriate, and expresses the relationship of these sands, since the Barton and Bracklesham beds together are usually considered as the equivalents of the Middle Bagshots. The author believes, therefore, that it would be wrong to reject Edward Forbes's name of "Upper Bagshot" for the Long Mead End sands, and accept in place of it the older term of Headon Hill sands.

Mr. A. H. S. Lucas, M.A., in his concise but valuable paper "On the Headon Beds of the Western Extremity of the Isle of Wight" (*Geological Magazine*, n.s. decade ii. vol. ix.), correctly states, upon referring to the recent "answer to the present questioning of the hitherto accepted correlations of the beds of the Lower fluvio-marine Tertiaries of the Isle of Wight and South Hants, that it is obviously impossible for foreign geologists to institute useful comparisons between British and foreign subdivisions so long as we in England are quite at variance on the stratigraphical and palæontological *facts* of the beds in question.[1]

"The general relation of the whole group can only be satisfactorily determined after the primary question of the continuity or discontinuity of the Colwell Bay and Headon Hill beds is settled. At present there are two very definite, yet different views, having a perfectly distinct issue; first, that *the brackish-marine beds of Colwell Bay correspond to the brackieh-marine beds of Headon Hill which have been seen;* or, secondly, *that they correspond to some higher marine beds which have not been seen.*" Both these views and arguments are now fairly before those competent to judge. In 1880, however, Prof. Judd, in his paper "On the Oligocene Strata of the Hampshire Basin" (*Quarterly Journal of the Geological Society*, vol. xxxvi., p. 137, &c.), questioned and denied the succession as determined by Forbes and the Survey; this paper dealt with strata or higher marine beds, stated above by Mr. Lucas as "*not having been seen.*" On the other hand, in 1881, Messrs. Tawney and Keeping brought to bear upon the question a mass of evidence in support of the work of Edward Forbes and the Survey (*Quarterly Journal of the Geological Society*, vol. xxxvii. p. 85), showing conclusively the identity and continuity of the Colwell Bay and Headon Hill fluvio-marine beds. Still more recently, however, Prof. Blake (*Proceedings* of the Geological Association, vol. vii.) has "advanced an entirely new correlation, adducing stratigraphical evidence in its favour." His observations do not agree in certain cases either with those of Prof. Judd or Messrs. Tawney and Keeping. It is hoped, however, by or through evidence at the present meeting, that the question of the succession will be finally determined. Mr. Lucas does not attempt any solution as to the relation of these beds at Colwell Bay and Headon Hill to the deposits exposed at Hordwell, Brockenhurst, or Whitecliff Bay; they do not concern the succession. But the standard or synthetic sections at different localities, like those prepared by Messrs. Tawney and Keeping, have tended to clear up the succession, fully testing the continuity of these beds under dispute under their several aspects along the plane of deposition. This independent mode fully bears out the exact work of the Survey, showing differences in degree as regards accumulation, yet continuity as regards succession. Mr. Lucas gives measured sections of the freshwater beds, and the brackish marine series (p 99 *loc. cit.*), which confirm the work of the above authors.

The Headon beds were long ago "measured by Dr. Wright, lately by the authors just quoted, and the Osborne series by Edward Forbes, and the main divisions are so conspicuous that there can be no doubt about the succession." A third paper upon the fluvio-marine beds of the Isle of Wight was read before the Geologists' Association in June 1881, under the title, "On a Continuous Section of Oligocene Strata from Colwell Bay to Headon Hill" (*Proceedings* of the Geological Association, vol. vii.), by Prof. J. F. Blake, M.A., F.G.S. The author contends for a difference between the faunæ of the *Colwell Bay* beds and those of *Headon Hill*, and states that the "fauna of the so-called Oligocene group is chiefly to be found in the '*Venus bed*" of Colwell Bay; but the assumed *other* 'Venus bed' at Headon Hill contains rather the fauna of the uppermost Eocene, or zone of *Cerithium concavum*." The question, however, turns upon the identity of the two so-called Venus beds. In other words, the Colwell Bay "Venus bed"

[1] A concise and important paper on "The Classification of the Tertiary Deposits," by Prof, Judd, appeared in the *Popular Science Review*, or 1880, accompanied by a table showing the correlation of the Lower Tertiary strata of Western Europe. The Headon and Brockenhurst beds are placed under the Lower Oligocene, and the Bembridge and Hempstead series under the Middle Oligocene.

is said by the author to have one fauna, and the Headon Hill Venus bed another. This determination I hold to be untenable, all fossil and physical evidence being to the contrary, and show that they are one and the same bed. On both sides of Bramble Chine the "*Venus bed*" is fully developed. Mr. Blake calls it the "*oyster bed.*" Below these come thin bands of stratified marl, with abundance of *Cerithia* and *Cyrena* (not Cyclas, as stated). The Widdick Chine sands can be no other than the Headon Hill sands, and not the Upper Bagshots. The altitude of these sands above the sea Mr. Blake estimated at 100 feet; this is certainly too great an elevation, 70 feet being the received measurement by independent observers. Such difference, if it existed, would alter the reading and sequence of succeeding and higher beds in the section. The author seems to have omitted the *Triginocœlia* and *Neritina* bed immediately above the How Ledge limestone and below the thick oyster band. These correspond with the Warden Cliff section, and determine continuity of deposition, or are a confirmation of the identity of the beds. This is a crucial point in the continuity and equivalency of the marine series in Totland and Colwell Bays. The *Trigonocœlia* bed here is on the same horizon as in Warden Cliff and Colwell Bay, associated with *Cerithium pseudocinctum*, *Melanopsis fusiformis*, and *Natica labellata*, &c. The lower or Neritina concava bed, with *Melanopsis fusiformis* and *Corbicula ovata*, occurs also in the same position near the base of the series at Warden Cliff and Colwell Bay. "This can only be explained by admitting that the *Marine series in Totland Bay and Colwell Bay are identical.*" The occurrence of "*Cerithium ventricosum* at the top, and the *Neritina* [*N. concava*] and *Trigonocœlia* [*T. deltoidea*] at the base—identical in physical and fossil characters, are strong presumptive proof of this." It is extremely doubtful if *Ceritheum margarataceum*, mentioned on p. 6 of Mr. Blake's paper, occurs in the Colwell Bay section, or in the western area of the Isle of Wight—the *Ceritheum cinctum* is really *C. pseudocinctum*, and *Cyclas obovata* should be *Cyrena obovata*. The genus *Cyclas* does not occur. In correlation these are important items, especially with a continental fauna. It will also be found that the oyster beds do not rest immediately on the How Ledge limestone as asserted—the *Trigonocœlia* and *Neritina* beds intervene, and as at Colwell Bay, determine or prove the succession and identity of the series. At pp. 156-7 Mr. Blake remarks upon the similarity of the succession of the Colwell Bay beds with those of Headon Hill, and is "*tempted to come to the conclusion*" that the two "Venus beds are identical;" [they have always been so believed and recognised]; he at the same time states that "it would be absurd to argue that they are identical because they contain similar common fossils," when it has been "determined by Prof. Judd that the faunas are remarkably distinct." We have no other method whereby to determine the age and synchronism of deposits except through organic remains, and the faunæ of the "Venus beds" at both localities are to me identical, and Prof. Blake depends upon fossil evidence all through his paper, yet evidently he has not carefully examined the more complete fauna of the "Venus bed" at both localities. In another paragraph, on p. 157, the author states the proposition "that the Colwell Bay 'Venus bed' is not certainly identical with that at Headon Hill, but may occupy a higher horizon. Mr. Blake suggests that the Headon Hill bed corresponds to the series intervening between the Colwell Bay bed and the How Ledge limestone; and that the Colwell Bay bed corresponds to the slightly fossiliferous sands immediately *below the* Headon Hill limestone. This position or suggestion certainly cannot be received. In this case the so-called two "Venus beds" would be superposed on each other and nothing to separate them. The sands referred to are those at the base of the Upper Headon series, and are freshwater, for they contain Unio. Again, Prof. Blake's suggestion would thus place the Colwell Bay "Venus bed" below the Great Limestone, whereas Prof. Judd in his paper would place it above.

The author does not find any equivalents of the Colwell Bay opster beds *above the* Headon Hill limestone at Headon Hill, indeed that would be impossible, for they are indisputably the Osborne marls of Prof. Forbes, and capped by the Bembridge limestone.

As regards the terms Eocene and Oligocene, and their relation to each other, and the correlation of British strata and fossils with that of Germany, &c., it is far too intricate a question to be passed over, although without doubt the fluvio-marine strata of the Hampshire basin will ere long receive critical supervision with reference to similar deposits on the Continent. So far back as December, 1863, Herr Adolf von Könen prepared and read his paper on the correlation of Oligocene deposits of Belgium, North Germany, and the South of England, and endeavoured to show that in Britain we had an assemblage of fossils in our so-called Middle Eocene at Brockenhurst, Lyndhurst, and Roydon in the New Forest, that could be stratigraphically correlated with beds of the same age termed Oligocene in Northern Germany. The author believed that these Brockenhurst beds were of the same age as the Middle Headon beds of Colwell Bay and Whitecliff Bay. This view has led to much controversy, arising from the fact that no Brockenburst species occur in Colwell Bay. The rich cabinet of Mr. F. Edwards then afforded von Könen every facility for the comparison and determination of the species occurring common to Britain and Germany. Beyrich established the name Oligocene for the fossils of this age in Germany. The Lower Oligocene is well developed, with a true marine fauna, in Belgium, near Tongres (North of Liege), and in the North of Germany, between Magdeburg, Bernberg, Egeln, and Helmstädt (near Brunswick). This Lower Oligocene contains 700 species of mollusca besides other groups. The most characteristic of these, the author asserts, are found at Brockenhurst, and in Mr. Edwards's cabinet, fifty-six species occur, twenty-one of which are Barton clay forms, and forty-three of the fifty-six species occur in the Lower Oligocene of Germany.

SECTION D

BIOLOGY

Department of Anthropology

ADDRESS BY W. BOYD DAWKINS, M.A., F.R.S., F.G.S., F.S.A., PROFESSOR OF GEOLOGY AND PALÆONTOLOGY IN THE VICTORIA UNIVERSITY, VICE-PRESIDENT OF THE SECTION.

On the Present Phase of the Antiquity of Man—In taking the chair in this department of the biological section of the British Association, two courses lie open before me. I might give an address which should be a history of the progress of anthropology during the last year, or I might devote myself to some special branch. The swift development of our young and rapidly growing science, which embraces within its scope all that is known, not merely about man, but about his environment, in present and past times, renders the first and more ambitious course peculiarly difficult to one, like myself, labouring under the pressure of many avocations. I am therefore driven to adopt the second and the easier, by choosing a subject with which I am familiar, and which appears to me to be appropriate in this place of meeting. I propose to place before you the present phase of the inquiry into the antiquity of man, and to point out what we know of the conditions of life—though our knowledge of them is imperfect and fragmentary—under which man has appeared in the Old and in the New Worlds. The rudely chipped implements left by the primeval hunters in the beds of gravel of Hampshire and Wiltshire, and along the shores of Southampton Water and elsewhere, are eloquent of the presence of man in this district, at a time when there was no Southampton Water, and the elephant and the reindeer wandered over the site of this busy mart for ships; when the Isle of Wight was not an island, and the River-drift hunter could walk across from Portsmouth to Cowes, with no obstacle excepting that offered by the rivers and morasses. I propose to enter upon the labours of Prestwich, Evans, Stevens and Blackmore, Codrington, Read, Brown, and other investigators in this country, and to combine the results of their inquiries with those in other countries, and with some observations of my own which I was able to make in 1880, during my visit to the United States.

The Limitation of the Inquiry.—The most striking feature in the study of the Tertiary period is the gradual and orderly succession of higher types of Mammalia, so well defined and so orderly, that I have used it as a basis for the classification of the Tertiary period. We find the placental mammals becoming more and more specialised as we approach the frontier of history. The living orders appear in the Eocene, the living genera in the Meiocene, a few living species in the Pleiocene, and the rest in the Pleistocene. The characteristics of this evolution of living forms may be summed up in the following table :—

Definition of Tertiary Period by Placental Land Mammals.

VI. Historic; in which the events are recorded in history.	Events included in history.	Founded on discoveries, documents, refuse - heaps, caves, tombs.
V. Prehistoric; in which domestic animals and cultivated fruits appear.	Man abundant; domestic animals, cultivated fruits, spinning, weaving, pottery - making, mining, commerce; the neolithic, bronze, and iron stages of culture.	Camps, habitations, tombs, refuse-heaps, surface accumulation, caves, alluvia, peat-bogs, submarine forests, raised beaches.
IV. Pleistocene; in which living species of placental mammals are more abundant than the extinct.	Man appears; *Anthropidæ;* the palæolithic hunter; living species abundant.	Refuse-heaps, contents of caves, river deposits, submarine forests, boulder – clay, moraines, marine sands, and shingle.
III Pleiocene; in which living species of placental mammals appear.	Living species appear; apes, *Simiadæ*, in Southern Europe.	Fresh - water and marine strata; volcanic débris (Auvergne).
II. Meiocene; in which the alliance between living and placental mammals is more close than before.	Living genera appear; apes, *Simiadæ*, in Europe and North America.	Fresh - water and marine strata; volcanic débris (Auvergne); lignites.
I. Eocene; in which the placental mammals now on earth were represented by allied forms belonging to existing orders and families.	Living orders and families appear; lemurs (*Lemuridæ*) in Europe and North America.	Fresh - water and marine strata; lignites.

The orders, families, genera, and species in the above table, when traced forward in time, fall into the shape of a genealogical tree, with its trunk hidden in the Secondary period, and its branchlets (the living species) passing upwards from the Pleiocene, a tree of life, with living Mammalia for its fruit and foliage. Were the extinct species taken into account, it would be seen that they fill up the intervals separating one living form from another, and that they too grow more and more like the living forms as they approach nearer to the present day. It must be remembered that in the above definitions the fossil marsupials are purposely ignored, because they began their specialisation in the Secondary period, and had arrived in the Eocene at the stage which is marked by the presence of a living genus—the opossum (*Didelphys*).

It will be seen, from the examination of the above table, that our inquiry into the antiquity of man is limited to the last four of the divisions. The most specialised of all animals cannot be looked for until the higher Mammalia by which he is now surrounded were alive. We cannot imagine him in the Eocene age, at a time when animal life was not sufficiently differentiated to present us with any living genera of placental mammals. Nor is there any probability of his having appeared on the earth in the Meiocene, because of the absence of higher placental mammals belonging to living species. It is most unlikely that man should have belonged to a fauna in which no other living species of mammal was present. He belongs to a more advanced stage of evolution than the mid-Meiocene of Thenay, as may be seen by a reference to the preceding table. Up to this time the evolution of the animal kingdom had advanced no farther than the Simiadæ in the direction of man, and the apes then haunting the forests of Italy, France, and Germany, represent the highest type of those on earth.

We may also look at the question from another point of view. If man were upon the earth in the Meiocene age, it is incredible that he should not have become something else in the long lapse of ages, and during the changes in the conditions of life by which all the Meiocene land Mammalia have been so profoundly affected, that they have been either exterminated, or have assumed new forms. It is impossible to believe that man should have been an exception to the law of change, to which all the higher Mammalia have been subjected since the Meiocene age.

Nor in the succeeding Pleiocene age can we expect to find man upon the earth, because of the very few living species of placental mammals then alive. The evidence brought forward by Professor Capellini, in favour of Pleiocene man in Italy, seems both to me and to Dr. Evans unsatisfactory, and that advanced by Professor Whitney in support of the existence of Pleiocene man in North America, cannot in my opinion be maintained. It is not until we arrive at the succeeding stage, or the Pleistocene, when living species of Mammalia begin to abound, that we meet with undisputable traces of the presence of man on the earth.

The Pleistocene Period.—As a preliminary to our inquiry we must first of all define what is meant by the Pleistocene Period. It is the equivalent of the Quaternary of the French, and the Postpleiocene of the older works of Lyell, and it includes all the phenomena known in latitudes outside the Arctic Circle, where ice no longer is to be found, under the name of glacial and interglacial. It is characterised in Europe, as I have pointed out in my work on "Early Man in Britain," by the arrival of living species, which may be conveniently divided into five groups, according to their present habitats. The first consists of those now found in the temperate zones of Europe, Asia, and North America. It includes the following animals:—

Mole, musk shrew, common shrew, mouse, beaver, hare, pika, pouched marmot, water-vole, red field-vole, short-tailed field-vole, Continental field-vole, lynx, wild cat, wolf, fox, marten, ermine, stoat, otter, brown bear, grisly bear, badger, horse, bison, urus, saiga antelope, stag, roe, fallow-deer, wild boar.

The second consists of animals of arctic habit:—

Russian vole, Norwegian lemming, arctic lemming, varying hare, musk sheep, reindeer, arctic fox, glutton.

The third is composed of those which enjoy the cold climate of mountains:—

The snowy vole, Alpine marmot, chamois, and ibex.

These animals invaded Europe from Asia, and as the cold increased, the temperate group found their way into Southern Europe and Northern Africa, while the arctic division pushed as far south as the Alps and Pyrenees.

The fourth group of invading forms is represented by animals now only found in warm countries:—

Porcupine, lion, panther, African lynx, Caffre cat, spotted hyena, striped hyena, and African elephant.

This group of animals is found as far to the north as Yorkshire, and as far to the west as Ireland. Among the southern animals, too, must be reckoned the hippopotamus, which lived as far north as Britain in the Pleiocene age, and in the Pleistocene occurs in caves and river deposits, in intimate association with some arctic species, such as the reindeer.

The fifth group is composed of extinct species, hitherto unknown in Europe in the Pleistocene age, such as—

The straight-tusked elephant, mammoth, the pigmy elephants, woolly and small-nose rhinoceroses, the Irish elk, pigmy hippopotamus, and the cave bear.

The question as to which of these groups the River-drift man belongs must be deferred till we can take a survey of the evidence elsewhere.

The early Pleistocene division is characterised by the presence of the temperate and southern species in Britain; the middle stage by the presence of the arctic, but not in full force; and the late Pleistocene by the abundance of arctic animals, not only in Britain, but on the Continent as far as the Alps and Pyrenees, and the lower valley of the Danube.

The Early Pleistocene Forest and Mammals of East Anglia.—The first view which we get of the Pleistocene Mammalia in this country is offered by the accumulations associated with the buried forest of East Anglia. It extends for more than forty miles along the shores of Norfolk and Suffolk, from Cromer to Kessingland, passing into the cliff on the one hand and beneath the sea on the other. The forest was mainly composed of sombre Scotch firs and dark clustering yews, relieved in the summer by the lighter tinted foliage of the spruce and the oak, and in the winter by the silvery gleam of the birches, that clustered thickly with the alders in the marshes, and stood out from a dense undergrowth of sloes and hazels. Among the animals living in this forest of the North Sea were species which haunted the valleys of the upper Seine at the time, such as the southern elephant, the Etruscan rhinoceros, the deer of the Carnutes, extinct horses, and the large extinct beaver. There were in addition the shaggy-maned mammoth, the straight-tusked elephant, and the big-nosed rhinoceros. The stag, the roe, the Irish elk, were in the glades, Sedgwick's deer, with its many-pointed antlers, the verticorn deer, and the gigantic urus. The undergrowth formed a covert for the wild boar, and for beasts of prey, many in species and formidable in numbers. The cave bear, the hugest of its kind, the sabre-toothed lion, the wolf, the fox, and the wolverine. Among the smaller animals were to be noted the musk shrew, the common shrew, and a vole. In the trees were squirrels. Under foot the moles raised their hillocks of earth, and from between the lofty fronds of the Osmund royal beavers were to be seen building their lodges, and the hippopotamus as he emerged from the water and disappeared in the forest. Out of thirty species identified, no less than seventeen are living in some part of the world, and we have there obviously the stage in the evolution of mammalian life when the living species were becoming more abundant than the extinct. We may note, too, the absence of arctic animals in this fauna, more particularly of the reindeer.

The presence of these animals in Norfolk and Suffolk implies that at this time Britain was united to the Continent, and the presence of fossil species found in France indicate a southern extension of land in the direction of the Straits of Dover. The forest covered a large portion of the area of the North Sea, and in all probability the Atlantic seaboard was then at the 100-fathom line of the west coast of Ireland.

No traces of man have as yet been discovered in these deposits, although the large percentage of living species of higher Mammalia indicates that the geological clock had struck the hour when he may be looked for.

The Appearance of the River-drift Hunter at Crayford and Erith.—The living species in the forest bed are to be looked upon as an advanced guard of a great migration of Asiatic and African species, finding their way into North-western Europe, over the plains of Russia, and over barriers of land connecting Northern Africa with Spain by way of Gibraltar, and with Italy by way of Malta and Sicily (see "Cave Hunting and Early Man").

In the course of time the other living species followed, and extinct species became more rare. In the deposits, for instance, of the ancient Thames, at Ilford and Grays Thurrock in Essex, and at Erith and Crayford in Kent, out of twenty-six species, six only belong to extinct forms—the new-comers comprising the lion, wild cat, spotted hyena, and otter, the bison, and the musk sheep. A flint flake discovered by the Rev. Osmund Fisher, at Crayford, and a second discovered by Messrs. Cheadle and Woodward, at Erith, prove that man was present in the valley of the Thames at this time; while the more recent discoveries of Mr. Flaxman Spurrell indicate the very spots where the palæolithic hunter made his implements, and prove that he used implements of the River-drift type, so widely distributed over the surface of the earth. The arctic animals at this time were present, but not in full force, in Southern Britain, and the innumerable reindeer which characterise the later deposits of the Pleistocene age had not, so far as we know, taken possession of the valley of the Thames.

To what stage in the Pleistocene period are we to refer these traces of the River-drift hunter? The only answer which I am able to give is that the associated animals are intermediate between the Forest-bed group and that which characterises the late Pleistocene division in the region extending from the Alps and the Pyrenees as far north as Yorkshire. Nor am I able to form an opinion about their relation to the submergence of Middle or Northern Britain under the waves of the glacial sea. They are quite as likely to be pre- as post- glacial.

The Relation of the River-drift Hunter of the late Pleistocene to the Glacial Submergence.—The rudely chipped implements of the River-drift hunter lie scattered through the late Pleistocene river deposits in Southern and Eastern England in enormous abundance, and as a rule in association with the remains of animals of arctic and of warm habit, as well as some or other of the extinct species of reindeer and hippopotamus, along with mammoth and woolly rhinoceros. What is their relation to the submergence of the land and the lowness of the temperature, which combined together have resulted in the local phenomena known as glacial and interglacial?

The geographical change in Northern Europe at the close of the Forest-bed age was very great. The forest of the North Sea sank beneath the waves, and Britain was depressed to a depth of no less than 2,300 feet in the Welsh mountains, and was reduced to an archipelago of islands, composed of what are now the higher lands. The area of the English Channel also was depressed, and the "silver streak" was somewhat wider than it is now, as is proved by the raised beach at Brighton, at Bracklesham, and elsewhere, which marks the sea line of the largest island of the archipelago, the southern island, as it may be termed, the northern shores of which extended along a line passing from Bristol to London. The northern shore of the Continent at this time extended eastwards from Abbeville north of the Erzgebirge, through Saxony and Poland, into the middle of Russia, Scandinavia being an island from which the glaciers descended into the sea.

This geographical change was accompanied by a corresponding change in climate. Glaciers descended from the higher mountains to the sea level, and icebergs, melting as they passed southwards, deposited their burdens of clay, sand, and erratics, which occupy such a wide area in the portions then submerged of Britain and the Continent.

This depression was followed by a re-elevation, by which the British Isles, again formed a part of the Continent, and all the large tract of country within the 100-fathom line again became the feeding-grounds of the late Pleistocene Mammalia.

An appeal to the animals associated with the River-drift implements will not help us to fix the exact relation of man to these changes, because they were in Britain before as well as after the submergence, and were living throughout in those parts of Europe which were not submerged. It can only be done in areas where the submergence is clearly defined. At Salisbury, for instance, the River-drift hunter may have lived either before, during, or after the southern counties became an island. When, however, he hunted the woolly and leptorhine rhinoceros, the mammoth, and the horse in the neighbourhood of Brighton, he looked down upon a broad expanse of sea, in the spring flecked with small icebergs, such as those which dropped their burdens in Bracklesham Bay. At Abbeville, too, he hunted the mammoth, reindeer, and horse down to the mouth of the Somme on the shore of the glacial sea.

The evidence is equally clear that the River-drift hunter followed the chase in Britain after it had emerged from beneath the waters of the glacial sea, from the fact that the river deposits in which his implements occur either rest upon the glacial clays, or are composed of fragments derived from them, as in the oft-quoted cases of Hoxne and Bedford. Further, it is very probable that he may have wandered close up to the edges of the glaciers then covering the higher hills of Wales and the Pennine chain.

The severity of the climate in winter at this time in Britain is proved, not merely by the presence of the arctic animals, but by the numerous ice-borne blocks in the river gravels dropped in the spring after the break-up of the frosts.

The Range of the River-drift Man on the Continent and in the Mediterranean Area.—The River-drift man is proved, by the implements which he left behind, to have wandered over the whole of France, and to have hunted the same animals in the valleys of the Loire and the Garonne as in the valley of the Thames. In the Iberian peninsula he was a contemporary of the African elephant, the mammoth, and the straight-tusked elephant, and he occupied the neighbourhood both of Madrid and Lisbon. He also ranged over Italy, leaving traces of his presence in the Abruzzo, and in Greece he was a contemporary of the extinct pigmy hippopotamus (*H. Pentlandi*). South of the Mediterranean his implements have been met with in Oran, and near Kolea in Algeria, and in Egypt in several localities. At Luxor they have been discovered by General Pitt-Rivers in the breccia, out of which are hewn the tombs of the kings. In Palestine they have been obtained by the Abbé Richard between Mount Tabor and the sea of Tiberias, and by Mr. Stopes between Jerusalem and Bethlehem. Throughout this wide area the implements, for the most part of flint or of quartzite, are of the same rude types, and there is no difference to be noted between the *haches* found in the caves of Cresswell in Derbyshire, and those of Thebes, or between those of the valley of the Somme and those of Palestine. Nor is our survey yet ended.

The River-drift Man in India.—The researches of Foote, King, Medlicott, Hacket, and Ball, establish the fact that the River-drift hunter ranged over the Indian peninsula from Madras as far north as the valley of the Nerbudda. Here we find him forming part of a fauna in which there are species now living in India, such as the Indian rhinoceros and the arnee, and extinct types of oxen and elephants. There were two extinct hippopotami in the rivers, and living gavials, turtles, and tortoises. It is plain, therefore, that at this time the fauna of India stood in the same relation to the present fauna as the European fauna of the late Pleistocene does to that now living in Europe. In both there was a similar association of extinct and living forms, from both the genus *Hippopotamus* has disappeared in the lapse of time, and in both man forms the central figure.

The River-drift Hunter in North America.—We are led from the region of tropical India to the banks of the Delaware in New Jersey by the recent discoveries of Dr. C. C. Abbott in the neighbourhood of Trenton. After a study of his collections in the Peabody Museum in Cambridge, Mass., I have had the opportunity of examining all the specimens found up to that time, and of visiting the locality in company with Dr. Abbott and Professors Haynes and Lewis. The implements are of the same type as those of the river gravels of Europe, and occur under exactly the same conditions as those of France and Britain. They are found in a plateau of river gravel forming a terrace overlooking the river, and composed of materials washed down from the old terminal moraine which strikes across the State of New Jersey to the westward. The large blocks of stone and the general character of the gravel point out that during the time of its accumulation there were ice-rafts floating down the Delaware in the spring, as in the Thames, the Seine, and the Somme. According to Professor Lewis it was formed during the time when the glacier of the Deleware was retreating ('late glacial'), or at a later period ('post-glacial'). The physical evidence is clear that it belongs to the same age as deposits with similar remains in Britain. The animal remains also point to the same conclusion. A tusk of mastodon is in Dr. Cooke's collection at Brunswick, New Jersey, obtained from the gravel, and Dr. Abbott records the tooth of a reindeer and the bones of a bison from Trenton. Here, too, living and extinct species are found side by side.

Thus in our survey of the group of animals surrounding man when he first appeared in Europe, India, and North America, we see that in all three regions, so widely removed from each other, the animal life was in the same stage of evolution, and 'the old order' was yielding 'place unto the new.' The River-drift man is proved by his surroundings to belong to the Pleistocene age in all three.

The evidence of Palæolithic man in South Africa seems to me unsatisfactory, because as yet the age of the deposits in which the implements are found has not been decided.

General Conclusions.—It remains now for us to sum up the results of this inquiry, in which we have been led very far afield. The identity of the implements of the River-drift hunter proves that he was in the same rude state of civilisation, if it can be called civilisation, in the Old and New Worlds, when the hands of the geological clock pointed to the same hour. It is not a little strange that his mode of life should have been the same in the forests to the north and south of the Mediterranean, in Palestine, in the tropical forests of India, and on the western shores of the Atlantic. The hunter of the reindeer in the valley of the Delaware was to all intents and purposes the same sort of savage as the hunter of the reindeer on the banks of the Wiley or of the Solent. It does not, however, follow that this identity of implements implies that the same race of men were spread over this vast tract. It points rather to a primeval condition of savagery from which mankind has emerged in the long ages which separate it from our own time.

It may further be inferred, from his wide-spread range, that the River-drift man (assuming that mankind sprang from one centre) must have inhabited the earth for a long time, and that his dispersal took place before the glacial submergence and the lowering of the temperature in Northern Europe, Asia, and America. It is not reasonable to suppose that the Straits of Behring would have offered a free passage, either to the River-drift man from Asia to America, or to American animals from America to Europe, or *vice versâ*, while there was a vast barrier of ice or of sea, or of both, in the high northern latitudes.

I therefore feel inclined to view the River-drift hunter as having invaded Europe in pre-glacial times along with the other living species which then appeared. The evidence, as I have already pointed out, is conclusive that he was also glacial and post-glacial.

In all probability the birthplace of man was in a warm if not a tropical region of Asia, in 'a garden of Eden,' and from this the River-drift man found his way into those regions where his implements occur. In India he was a member of a tropical fauna, and his distribution in Europe and along the shores of the Mediterranean prove him to have belonged either to the temperate or the southern fauna in those regions.

It will naturally be asked, to what race can the River-drift man be referred? The question, in my opinion, cannot be answered in the present stage of the inquiry, because the few fragments of human bones discovered along with the implements are too imperfect to afford any clue. Nor can we measure the interval in terms of years which separates the River-drift man from the present day, either by assuming that the glacial period was due to astronomical causes, and then proceeding to calculate the time necessary for them to produce their result, or by an appeal to the erosion of valleys or the retrocession of waterfalls. The interval must, however, have been very great to allow of the changes in geography and climate, and the distribution of animals which has taken place—the succession of races, and the development of civilisation before history began. Standing before the rock-hewn tombs of the kings at Luxor, we may realise the impossibility of fixing the time when the River-drift hunter lived on the site of ancient Thebes, or of measuring the lapse of time between his days and the splendour of the civilisation of Egypt.

In this inquiry, which is all too long, I fear, for my audience and all too short, I know, for my subject, I have purposely omitted all reference to the successor of the River-drift man in Europe—the Cave man, who was in a higher stage of the hunter civilisation. In the course of my remarks you will have seen that the story told by the rudely chipped implements found at our very doors in this place, forms a part of the wider story of the first appearance of man, and of his distribution on the earth—a story which is to my mind not unfitting as an introduction to the work of the Anthropological Section at this meeting of the British Association.

SECTION E

GEOGRAPHY

OPENING ADDRESS BY SIR RICHARD TEMPLE, BART., G.C.S.I., D.C.L., F.R.G.S., PRESIDENT OF THE SECTION

The Central Plateau of Asia

THE subject chosen for this address is the Plateau of mid-Asia. This area, which is one of the most wonderful on the surface of the earth, contains nearly 3,000,000 of English square miles, and is equal to three-fourths of Europe. Its limits, its exterior configuration, its central and commanding situation in the Asiatic continent, will be clearly perceived from the large diagram of Asia which is exhibited here. As compared with some of the more favoured regions, it is singularly destitute of natural advantages. Though it has several deep depressions of surface, yet its general elevation is very considerable, and some of its large districts are the most elevated in the globe. It is walled in from the outer world and excluded from the benign influences of the sea by mountain chains. Its climate then is very severe on the whole, more distinguished for cold than for heat, but often displaying extremes of temperature high as well as low. It offers, from the character of its contour, extraordinary obstacles to communication by land or water. Though seldom inaccessible to courageous explorers, it is generally hard of access, and in several respects very inhospitable. In the progress of civilisation it is, with reference to its historic past, excessively backward. Its capacities for the production of wealth have been but little developed. Its population is scanty, scattered, and uncultured. Its agriculture comprises only a few areas widely segregated from each other, and many of its largest districts are amazingly desolate.

Nevertheless this plateau has eminent claims on the attention of geographers, for several reasons which may be summarised thus:—

1. A mountain system which dominates the greater part of Asia, and includes stupendous ranges with the loftiest peaks yet discovered in the world.

2. A series of heights and depressions almost like the steps

of a staircase within the mountainous circumvallation of the plateau.

3. The sources and the permanent supply of rivers which, passing from the plateau, flow through densely populated regions, and help to sustain the most numerous families of the human race.

4. A lacustrine system, comprising lakes of which some are saline while others have fresh water, and of which many are situated at great altitudes.

5. The home of conquering races, whence warrior hordes poured during several centuries over nearly all Asia and a large part of Europe.

6. Natural products of value, variety, or interest, and pastoral resources susceptible of indefinite development.

7. An enormous field for scientific research, with many regions which, though not wholly undiscovered, yet need much further discovery.

8. An imperial jurisdiction offering many problems for the consideration of social inquirers.

I shall now offer a brief explanation regarding each of the eight points stated above.

In the first place it will be seen from the diagram that the plateau, in shape somewhat of an irregular rhomboid, is completely enclosed by six grand ranges of mountains, namely, the Himalayas looking south towards India, the Pamir looking west towards Central Asia, the Altai looking north towards Siberia, the Yablonoi looking north-east towards Eastern Siberia, the Yun-ling and the Inshan (inclusive of the Khingan), looking towards China. These several ranges preserve generally a considerable altitude varying from 6000 to 25,000 feet above sea-level, and reaching in the Himalayas to more than 29,000 feet. The tallest of these summits have been accurately measured by the Great Trigonometrical Survey of India. Their altitude is about double that of the highest mountains in Europe, and surpasses any altitude yet observed in any quarter of the globe. But as a great part of these several ranges is as yet unsurveyed by trigonometry, it is possible that still greater heights may be discovered, and that "excelsior" may be the proud answer rendered by the everlasting hills to human investigation.

Regarding these and the other chains yet to be mentioned, it must be borne in mind that there are many cross ranges and transverse lines of mountains. Even the chains, too, often consist of detached groups separated by deep valleys. It is by observing the position of the groups relatively to one another that the tendency of the chain can be discerned.

Such being the outer barriers of our plateau, there are within it two great ranges mainly parallel and running from west to east, namely, the Kuen-lun and the Thian Shan.

While the Himalayas form the southern flank of the great Tibetan upland, the Kuen-lun constitutes the northern. The modicum of knowledge possessed by us regarding the Kuen lun, a most important factor in the geography of our plateau, is largely due to the praiseworthy travels of the Russian Prejevalsky. This range may be said in a certain sense to overlook the Tarim basin ending in Lake Lob, though the mountains are actually distant more than a hundred miles from that lake. It forms the southern boundary of the Tarim basin, which contains some of the few beautiful tracts in our plateau. If there be such a thing as a backbone to these regions, or anything like a dorsal ridge, it consists of the Kuen-lun.

The Thian Shan starts from the Pamir, and runs westward for full 1500 miles, till it joins with some of its spurs the uplands of Mongolia proper, or touches with others the dreary desert of Gobi. As the Kuen-lun forms the southern boundary of the Tarim basin, so the Thian Shan constitutes the northern.

Connected with the north-western part of the Himalayas is another range which some regard as an offshoot, but which others treat separately under the name of Karakuram. Together with the Himalayas it joins the Pamir.

Thus three of the greatest mountain ranges in Asia converge upon the Pamir, or according to some are there interlaced; namely, the Himalayas, the Kuen-lun, and the Thian Shan; to which perhaps two others might be added, namely, the Karakuram just mentioned and the Altai. But it may be more accurately said that the outer border of our plateau north of the Pamir is formed by the terminal spurs of the Thian Shan. It is to be remembered also that the Indian Caucasus—which does not concern our plateau directly enough to fall within this address—probably joins the Pamir. In general terms, the convergence of mountain ranges on the Pamir renders it geographically the most important position in Asia. The uninstructed Asiatics have evinced a hazy admiration of its grandeur by calling it "the roof of the world." The comparatively instructed Europeans have revered it as the source of the classic Oxus, and as fraught with political considerations. Unless further discoveries shall alter existing information, we may expect that completely informed geographers will consider that this Pamir is the mother of mountains, that other ranges are to it as the branches are to the root, and that here if anywhere is the true boss of the Asiatic shield.

In the second place the vast surface of our plateau, though almost uninterruptedly environed by its rocky walls, presents an extraordinary series of elevations and depressions. In the heart of the plateau there is the depression known to geographers as the Western Gobi, sometimes called the Tarim basin. Within this there is the Lob Lake or Lob Nor, truly an inland sea into which the waters of several rivers ultimately flow, finding no vent towards the ocean. The total length of the Tarim River with its affluents debouching into Lob Nor, cannot be less than 800 miles. This curious and interesting lake is not more than 2000 feet above sea-level and forms almost the lowest dip in our plateau. It is like the bottom of a vast platter, or the centre in the hollow of a mighty hand. Around this depression there are on all sides uplands of various heights like gradations in the Asiatic terrace terminating in the intermediate ranges, or in the outer circumvallation of mountains already described. On the east side of it there is the tract called Eastern Gobi, partly desert, and Mongolia, averaging 4000 feet above sea-level; on the north the Altai uplands, exceeding 5000 feet. On the west the Pamir rises abruptly, exceeding 13,000 feet; on the south Tibet, with equal abruptness, having an average altitude of 15,000 feet above sea-level, thus being the loftiest expanse in the world; and on the south-east the tract around the Kuku Nor Lake, 10,000 feet.

Further, there is a detached depression known as the Zungarian Strait, extending to the northern confine of our plateau between the Thian Shan and the Altai ranges. This strait, hardly exceeding 2000 feet above sea-level, is as low as, perhaps even lower than, any part of our plateau, and is very near breaking its continuity, which may be considered as being just saved by the comparatively humble altitude above mentioned. The depression is geographically important as forming the only broad pass between our plateau and the world without. It runs from Mongolia, the most important tract within our plateau, to Siberia outside. Great value was, in early times, attached by the Chinese to it, as being the only natural highway on a large scale between Northern and Central Asia.

The existence of this and the other depressions above described has led to interesting speculations among geologists as to their having been in primeval times within our plateau at least one inland sea as large as the Mediterranean of Europe.

Be that as it may, there is no doubt that a process of desiccation has been going on within our plateau during historic ages, whereby the climate is considerably affected, and many signs or evidences show that this process is still in operation.

On most of its sides our plateau is extraordinarily inaccessible, the passes being steep in the extreme, and culminating in ridges 18,000 to 20,000 feet above sea-level. Towards Siberia the Altai passes are easier, and on the north-east between Mongolia and China there are several passes that have witnessed the historic outpourings of the Mongol hordes, and which are ominously remembered by the Chinese as the openings through which their invaders rushed like the great river in flood, or the land-slip from the mountain side, or the avalanche sweeping along the boulders and *débris* to the destruction of the valleys beneath.

The great desert of Eastern Gobi occupies the eastern portion of our plateau. With its accumulating forces of sand and powdered earth it has a tendency to encroach, and is regarded by man with a vague awe. Its present extent is enormous, being not less than half a million of square miles. Nor does it exist alone within our plateau, for between the Tarim basin and the Kuen-lun spurs there is a lesser desert called Takla-makan, with 100,000 sqare miles of area. It may probably be found that these two deserts join or are otherwise connected.

In the third place we have noted that while the prevailing characteristics of our plateau are wildness, ruggedness, or desolation, yet within it are the sources of several great rivers which sustain the most teeming peoples on the face of the earth. The monarch as it were of all these noble waters is the Yang-tse-Kiang. Though its head streams have been but imperfectly explored, yet its true source is known to be in the Kuen-lun Mountains already mentioned. After quitting our plateau and passing out of its prison-house in the mountains through natural gates of the utmost magnificence, it permeates the most thickly-peopled provinces of China—provinces inhabited by about 120 millions of souls. It sustains the life of this enormous population by supplying the necessary moisture and by affording the means of irrigation and of water-traffic. No river has ever in ancient or modern times played so important a part in the increase of the human race as the Yang-tse-Kiang. Its supply of water is immense and unfailing, and this most essential characteristic is caused by its connection with the snow-clad and ice-bound regions of our plateau, within which it has a course of 700 miles before entering China proper. Amidst the same Kuen-lun range, the Hoang-ho rises, from unexplored springs, which the Chinese figure to themselves as "the starry sea." After bursting through several water-sheds, making wondrous bends from its main direction near the base of our plateau, and changing its course more than once to the confusion of comparative geography, it traverses Northern China and confers agricultural prosperity on some 70,000,000 of souls. It also has a course of some 400 miles within our plateau, in consequence of which its water-supply is perennially snow-fed. Again, the Irawady and the Mekhong, the former watering Burma, and the latter watering Cambodia, rise in the offshoots of the Kuen-lun. That region, then, in respect of the parentage of important rivers stands in the first rank. This beneficent circumstance arises from the direction of subsidiary ranges which admit to this part of our plateau some of the moisture-laden breezes from the Pacific Ocean.

Similarly the two Indian rivers, the Brahmaputra, and the Indus with its affluent, the Satlej, have their origin at a great distance within our plateau, and their water-supply is indefinitely augmented in consequence. Notwithstanding the vast volume of their waters, these rivers play an economic part which, though great, is much less than that of the main Chinese rivers. The Brahmaputra above its junction with the Megna cannot be said to sustain more than 15,000,000 of people; and the Indus, together with the Satlej, may support 12,000,000. The Ganges and Jamna, issuing from masses of snow on the southern scarp of our plateau, sustain before their junction at Allahabad a population of 30,000,000—quite irrespective of the deltaic population of the lower Ganges for whom moisture is supplied from other sources. Of these Indian rivers the waters, perpetually snow-fed, are largely drawn away for canals of irrigation on a grand scale. Taken all in all, despite defects, the Ganges Canal is the most imposing example of hydraulic engineering that has yet been seen. From the glaciers of the Pamir and the western terminus of the Thian Shan there spring the head-streams of the Oxus, the Jaxartes, and other rivers, ending in the inland sea of Aral. To these, in Persian phrase, the epithet of "gold-scatterer" or "wealth dispenser" is felicitously applied by the natives.

Of the rivers rising in the northern section of our plateau, the Amur has possibilities of which the future may see the development. But the great rivers of Siberia, such as the Obe, the Yenisei, and the Lena, though flowing through rich soils and affording marvellous facilities for several systems of inland navigation to be connected with each other, yet have their long estuaries in the permanently frost-bound lands of the Tundra, and their mouths in the Arctic waters frozen during most months of the year. Therefore they can never, in economic importance, vie with the rivers above mentioned, which flow into the Pacific and Indian Oceans.

In the fourth place, the lacustrine system, though not comparable to that of North America or of Central Africa, and not approaching in beauty or interest that of Southern Europe, is yet very considerable. It is not, however, the only one in Asia, and from it must be excluded the three great Siberian lakes of Issykkul, of Baikal, and of Balkash, which, though connected with our plateau, are beyond its actual limits. Exclusive of these, however, the lakes, great and small, within our plateau, are extraordinarily numerous. Not less than a hundred of them may be counted on the maps of this region. Of these lakes, however, some are insignificant, being little more than saline swamps. Others, again, as the Pangong, though romantically beautiful—reposing at an altitude equal to that of the highest European mountains, and reflecting the perennial snow of surrounding peaks—do not illustrate specially any geographical problem, nor produce any economic result. But some may be selected as having a scientific interest irrespective of beauty or of strangeness.

The Lake Victoria, discovered by Wood in 1838, rests in the heart of the Pamir, already mentioned, at an elevation of 14,000 feet above sea-level. It is frozen over during the greater part of the year, and lies with a glistening and polished surface in the midst of a snow-whitened waste. In that state it powerfully affects the imagination of the spectator who reaches it as the final goal, after a protracted and toilsome ascent from the barren or deserted plains of Ariana. It is the source of the Oxus, and is near the point of contact between the British and the Russian political systems in Asia.

In the sharpest contrast to a highly-placed Pamir lake is the Lake Lob, already mentioned. Shallow water, sedgy morass, dreary sands, parched forests, the monotony of desolation, are reported to be its characteristics. It apparently consists of the dregs of an inland sea that is mostly dried up, and is, as it were, kept alive only by the Tarim river, which has its sources in the everlasting snows of the Pamir. Despite the proximity of saline tracts, the lake has fresh water. Near it is a great desert, of which the soil, though now arid and friable, owing to the gradual desiccation, was once more or less productive, and where a population has probably become extinct or has disappeared by migration.

The Pamir then is a water-parting for two inland seas, one the Aral, beyond our plateau, the other Lob Nor within it—both saved from speedy desiccation only by the influx of rivers from the snow line.

Again in contrast is the Kuku Nor, a sheet of water 10,000 feet above sea-level, in the eastern section of the Kuen-lun mountains, near the source of the Hoang-ho. Its waters, profound and saline, have a dark azure hue, which is compared by the natives to that of the exquisite silks in China. It is in the Tangut region, mentioned by Marco Polo in his Itinerary. In respect to the lakes in this region, and especially the morasses of Tsaidam, there are geological speculations as to another Asiatic Mediterranean (besides that already mentioned), long since dried up, whereof there are a few widely-scattered remnants, among which the Kuku Nor is one.

Lastly, a word of passing notice may be devoted to two among the Tibetan lakes, that of Tengri, near Lhassa, on the shore of which stands a venerated Buddhist convent, and the Bul-tso, from which have been obtained quantities of the best borax.

In the fifth place, the north-eastern part of our plateau was during remote ages, beyond the ken of history, the home of hardy and aggressive Tartars. These Tartar races, dwelling among the uplands in the lee of the mountains, used for many centuries to emerge and harry the fertile Chinese plains lying between the mountains and the Pacific Ocean. It was to ward off these incursions that the Great Wall was constructed, winding like a vast serpent of stone along the ridges of mountains for 2,000 miles from the Pacific coast to the Siberian confines. The cost and labour expended on this amazing work attest the dread with which the Tartar highlanders had inspired the Chinese lowlanders. Some centuries after the building of the Wall, the most warlike among the Tartar tribes, in the council of their national assembly, acclaimed Temujin as their king, in the year 1206 A.D. He took a title which is translated by Europeans as Chinghiz Khan, a title which for two centuries or more was the best known name in the whole world. At the head of his Tartar adherents, he first subdued the other kindred tribes of our plateau. Then he organised and disciplined the whole Tartar manhood into an army of horsemen. This is the most wonderful instance of military mobilisation known to history ancient or modern. Its results too were equally appalling. In medieval times the marches of the Arabs and the Saracens, in modern times the expeditions of Napoleon, have dazzled Asia or Europe. These were hardly, however, equal to the distant conquests of Alexander the Great in ancient times. But even the wars of Alexander were perhaps surpassed by the ravages of Chinghiz Khan and the Tartars of our plateau. The countries of China, India, Afghanistan, Bactria, Persia, the Aral-Caspian basin, Siberia, Asia Minor, Russia, were overrun within a hundred years by Chinghiz Khan, his lieutenants, and his immediate descendants. Thus, through the hordes of our plateau there was established a dominion stretching from Cape Comorin near, the equator, to the Arctic Ocean, and from the Pacific shores to the banks of the Vistula in Poland. The latest historian of the Mongols considers that nothing but the unexpected death of the Tartar sovereign, and the political combinations arising in consequence within this very plateau of ours, prevented the Tartar invasion from spreading even to Western Europe. Though it is often held that these terrific events have been overruled by Providence for the progress of mankind, still at the time they caused what Gibbon truly calls a shipwreck of nations. Notwithstanding this, the Tartars won, in a certain sense, an unparalleled success, which is attributed to the geographical circumstances of our plateau.

The influence of the precipices, the forests, the prairies, the wild sports, in forming the national character is so obvious that it need not be specified. We readily understand how the sturdy mountaineer, the daring hunter, the practised archer becomes the able soldier. In Mongolia, however, the local speciality was this, that the practically boundless extent of the pasturage and the nutritious richness of its quality, induced the people to maintain countless horses, cows, buffaloes, sheep, goats, and camels, neglecting the tillage of the soil, never building houses, but living in tents made of warm felt, accumulating a certain sort of rude wealth, still roving and roaming about at some seasons incessantly from one encampment or one grazing-ground to another, dragging with them their families and their effects by means of the pack animals and the roomy waggons drawn by many oxen yoked abreast. Thus was a truly nomadic existence practised on the largest scale ever known. Mongol armies, better drilled, armed, accoutred, and equipped than any forces then known in the civilised world, would emerge from our plateau into the inhabited plains around, and would observe houses and towns for the first time. It is even alleged that some of them had never seen cultivated crops before.

In this state of existence the temptations to depredation of all sorts were excessive, and the danger from the climate, the savagery of nature, and the wild beasts as always imminent. Consequently the Mongals were obliged to hold themselves together by the cohesion of families, clans and tribes. Thus by the force of circumstances a social organisation was established which proved the foundation of a military discipline suitable to the genius of the people, almost self-acting, and unfailing even in the remotest expeditions. The horses, too, upon which the Mongol warriors mainly depended, naturally fell into the training; being always turned out to graze in herds, they habitually kept together, and the field manœuvre fixed habits which had been already acquired. It used to be remarked that a line of Mongol cavalry was like a rope or a chain perfectly flexible but never parted.

The Mongodian food included little of cereals or vegetables, but consisted mainly of cheese and meat. For stimulating drink there was the fermented mare's milk. The name 'koumis' or 'prepared milk,' apparently much esteemed medically now-a-days, is a Mongolian word. Manifestly, men thus nurtured could live in the saddle day and night, carrying with them their sustenance in the smallest compass, and scarcely halting to eat or drink. Thus the bardihood evinced on protracted marches, which would otherwise be incredible, can be accounted for.

It is probable that this diet while sustaining vivacity produced also a violence of disposition. Certainly, ruthlessness, cruelty, indifference to suffering characterised the Mongols and marred the effect of their grand qualities. Massacres, holocausts, conflagrations marked their warlike operations. Even famines and epidemics have hardly done more for depopulation than the Mongol conquests. A Mongolian chief would say that the keenest enjoymet in life was to stamp upon a beaten enemy, to seize his family, and despoil his encampment.

It is not the purpose of this address to describe the policy of the Mongols or the institutions which they founded in conquered countries. A few salient points only have been indicated in reference to the geography of our plateau. It is here, near what is now known as the upper regions of the Amur, that the Onon, the Orkhon, and the Kerulen, classic streams in Mongol story, take their source. Here is the site of Kara Koron, the emperor's head-quarter encampment. Here the Kurultai assemblies were held to decide the fate of nationalities. Here were the camps, the Urts, and Urdus, rude names at first unpronounceable in the civilised world, but soon to become terribly familiar. Here were the hordes mustered under their banners, each standard having its distinctive colour, the supreme ensign being, however, the yak's tail raised aloft. Hither, also, the corpse of Chinghiz Khan was borne in a cumbrous catafalque, dragged through the deep loam by oxen yoked twenty abreast, while his henchmen chanted a dirge which was a pathetic effusion from the heart of a valiant nation, and was full of poetic images drawn from the Mongolian surroundings.

In the sixth place, though our plateau has possessed, and still possesses, some patches of fine cultivation, such as those in the Upper Tarim basin, near Yarkand and Kashgar, and some near Lhassa in Tibet, still it has comparatively but little of agriculture, of trade, or of industry. Nevertheless it has many natural resources of value and interest, while its pastoral resources have proved astonishing. Its breed of horses, though by no means the finest, has yet been quite the largest ever known. These horses have never displayed the beauty of the Arabian or the size of the Turkoman breed. They are middle-sized, and do not attain the speed of thoroughbreds. But in nimbleness amidst rugged ground, in endurance over lengthened distances, and in preserving their condition with scanty nourishment, they are unrivalled. Their numbers too may well exercise the imagination of modern breeders. For many years the Tartar emperors maintained in the field at least 500,000 cavalry, for which the horses were drawn chiefly from our plateau. This enormous cavalry force was engaged in fighting over an area of many thousand miles in length and breadth, during which operations much desperate resistance was encountered. It was occupied in steep ascents and descents, in traversing deserts, in crossing frozen lakes, in swimming rapid rivers. How vastly numerous then must have been the casualties among these horses, and how immense the breeding studs. The pasturage too was so potent in nutritive qualities that ordinarily there was risk of animals suffering from repletion, and emaciated creatures rapidly gained flesh and strength.

In other respects too the fauna are noteworthy—the sheep and goats, with wool or down of the softest texture—the buffalo herds and the yaks inured to the sharpest cold—the gazelles careering in thousands—the untameable camel of the desert having a speed and agility unknown in other species—the wild asses and the white wolves—the waterfowl at times like clouds darkening the air.

The flora too, though less abundant, has its specialities—the pointed grasses sharp enough to pierce leather, the gigantic rhubarb, the magnificent holly, the branching juniper.

The mineral resources of the Kuen-lun are certainly enormous; nobody yet knows how great they may prove. Indeed our plateau is remarkable for the antimony, the sulphur, the saltpetre, the borax, the gold-washings, the turquoise, and the classic jadestone.

In the seventh place, the field offered by our plateau for scientific research will be apparent from even a cursory consideration of the stage to which our knowledge has reached. From the second of the two diagrams, which shows in deep pink those portions of Asia that have been professionally surveyed, in light pink those that have been roughly surveyed, in lighter pink those that have been explored only, and in white those that are unexplored—it will be seen that almost the whole of our plateau is unsurveyed, and that while much of it has been explored more or less, some portions yet await exploration. For some time, however, it has been the sphere chosen by many among the most skilful, enduring, and intrepid travellers of Europe. The journeys of the Russian Prejevalsky in the Tarim basin and Mongolia, of Potanin and Rafailoff in the same region, of Malussovski near Kobdo, of the French missiouaries Gabet and Huc in Mongolia, of the Bishop Desgodius in Tibet, of the German Schlagintweit in Turkestan, of the Englishmen Forsyth, Trotter, Johnson, Shaw, Hayward in the Tarim basin, of Wood in the Paymir, of Ney Elias in Mongolia, of Delmar Morgan in Kulja, of Bogle and Manning in Tibet, while teaching us very much, have yet left our minds dazzled with a sense of what remains to be learnt. Even the trigonometrical determination of the Himalayan summits by the English Surveyors General, namely, Everest, Waugh, and Walker, the researches of Basevi, Stolicksa, Godwin-Austen, Thomson, Biddulph, in the same quarter, and the Siberian surveys by the Russians among the Altai and Tian Shan mountains, have brought us only to the verge of half-discovered or undiscovered countries. The greatest unexplored region in all Asia, namely the Kuen-lun range, lies in the very heart of our plateau. It is remarkable too that if the principal geographical problems awaiting solution in Asia be specified, such as the true and ultimate sources of the Hoang-ho, the Irawady, the Salwin, the Mekhong, the relation of the San-po with the Brahmaputra, the connecting links between the Kuen-lun and the Chinese mountain chains, they will be found to concern our plateau.

At a few points only has our plateau been penetrated by geological surveys, namely, in some parts of the Altai and at the western end of the Thian Shan; and these surveys are Russian. But the formations, the strata, the upheavals, the denudations, the fluvial action, awaiting scientific examination, are indescribably great. A notion of some of the questions inviting inquiry from the geologist and palæontologist may be gathered from what has been already said under previous headings in respect to the general desiccation and the subsidence or evaporation of the primeval waters.

To the naturalist few regions present more surprising opportunities for the observation of the coming, the resting, the departing of migratory birds.

To meteorologists many of the natural phenomena must prove highly interesting—the causation of the wondrous dryness, the effects produced on animal comfort by the rarefaction of the air, the mummified bodies dried up without undergoing putrefaction, the clouds of salt particles driven along by furious gusts and filling the atmosphere, the fires in the parched vegetation of the desert, the spontaneous ignition of coal-beds, the caves emitting sulphurous gases, the rocky girdle of syenite bounding the Gobi desert, the gradual contraction of the glaciers, the ordinarily rainless zones sometimes invaded by rain-storms with a downpour like that of the tropics.

In the eighth place, our plateau is now under one imperial jurisdiction, and offers many problems for social inquirers. It belongs entirely to the Chinese empire with the exception of one small tract where the Russian authorities have crossed the mountain border. The geographical features for the most part favour national defence and territorial consolidation. The old Chinese Wall is still suitable to the political geography of to-day. In the Zungarian strait, however, in the Ili valley near Kulja, perhaps, also, in the line of the Black Irtish, near Zaisan, the Chinese empire, in its contact with Russia, has weak points strategically, or chinks in its armour. Though the plateau was originally under the Chinese suzerainty, it became, under the Mongolian emperor Chinghiz Khan and his successors, the mistress of China, as indeed of all Asia and of Eastern Europe. As the Mongol power, however, shrunk and withered, the Chinese reasserted themselves. At length under a dynasty, from Manchuria, outside the mountain border, the Chinese became lords over our plateau. The Zungarian tribe of Eleuths rose, and after severe military operations were suppressed. The Muhammadan inhabitants of the Tarim basin rebelled against the Chinese government, and for a while maintained an independent principality for Islam. It was during this time that the British sovereign sent an envoy to Yarkand to conclude a commercial treaty, in 1873 Subsequently the Chinese broke down this rising independence, and the whole region of the Tarim receives its orders from the emperor at Pekin.

The decline and fall of the Mongol empire, the disruption of that wide-spread dominion, like the breaking up of the ice on its own frozen rivers, are historical themes beyond the scope of this address. But the changes which have gradually come over the national character of the Mongolians are cognate to the studies of geographers. As already seen, the annals of the Mongols reveal one of the many examples of the theory of causation, explaining how geographical surroundings mould or affect the human character. There remain the mountains, the sea of undulating uplands, which are still among the few important regions not essentially modified by human action. The pine forests, though hardly intact, have not been extensively cleared. There is the dread desert—where to the ears of superstitious Mongols the rolls of the mustering drums and the shouts of victorious battle are audible—and which has engulfed in sandy waves additional tracts once productive. The pastoral resources, the nomadic diet and exercises, the tribal organisation, are in kind the same as of yore, though perhaps modified in extent or degree. The short-lived heat may perhaps be gaining strength as the ages advance; but the winters must be nearly as long and hard as ever. Thus the same physical and climatic conditions which once caused the Mongolian nation to become one of the mightiest engines ever directed by man are still surrounding the politically degenerate Mongols of to-day, who are best represented by the tribe of Khalkas. Once audaciously ambitious, the Mongols are now sluggish and narrow-minded; once passionately fond of an independence as free as their mountain air, they are now submissive to the domination of races formerly despised by them as inferior; once proud of a tribal organization and a voluntary discipline that wrought world-renowned wonders, they are now split up into factions like a faggot of sticks that has been unbound. A man who, though the feeblest of pedestrians, grips with his bowed legs the saddle of the most restive horse as with a vice, is all that remains of the historic Mongol. It is for the social inquirer to determine what have been the circumstances counteracting the climate and local causes which made this nation potential in moulding medieval history.

Here too may be observed the tendencies of Paganism, Buddhism, and Muhammadism respectively. Of all regions our plateau offers the best means of studying Buddhism, which still counts more adherents than any other faith. Though the mid-Ganges Valley was the birthplace of this widespread religion, and was for ages regarded by pious Buddhists as their holy land—yet during recent centuries the active centre of the faith has been in Tibet. Of the four incarnations of Buddha now held to exist, three are within our plateau, namely, two in Tibet near Lhassa and at Teshu Lumbo, and one in Mongolia at Urga, near the spot where mounds attest the burial of heaps of slain after one of Chinghiz Khan's earliest battles. In Tibet may be seen to the best advantage those religious ceremonies, the sight of which has always attracted the observation of Roman Catholic missionaries.

In conclusion, this brief summary of our geographical knowledge regarding the plateau of mid-Asia is provisional only. For it avowedly deals with regions mostly unsurveyed and seldom even explored completely. Further exploration or discovery therefore may reverse some of our specific conclusions, or may modify the current of our topographical ideas. It is probable indeed that there will be such changes, inasmuch as almost every investigation within this vast area has revealed something unimagined before, or has caused disbelief of something previously believed. This address, then, is limited to a *résumé* of things imperfectly known, with a view of bringing into strong relief two matters which are unquestionable, namely, the importance of our plateau and the grand field it offers for research. If the public consideration of these matters shall induce inquirers to direct their enterprise towards this grand region, we may hope that by degrees the errors in our facts may be removed, the misdirection of our conclusions remedied, the vagueness of our notions made definite. At present the physical obstacles in the path of such enquiries are so grave as to be almost deterring. But they do not finally deter those who after forethought decide to brave peril, distress, sickness, suffering, in order to enlarge the bounds of knowledge. Each inquirer, however, has the consolation of reflecting that he makes the rough ways smoother for those who shall come after him. Every journey that is accomplished must facilitate successive discovery in the same line of country. Probably as fast as one line is made good geographically fresh lines may present themselves, and new vistas will be opened to the astonished gaze of geographers. At length, with all the constancy and courage which arduous travel never fails to inspire, the inquirers of the future will doubtless explore this plateau till it becomes as well known as the Alpine regions of Europe.

SECTION G

MECHANICAL SCIENCE

Opening Address by John Fowler, C.E., F.G.S
President of the Section

Of all the important sections of the British Association the one over which I have now the honour of presiding is, you will all, I think, admit, at once the most practical and the most characteristic of the age. In future times the present age will be remembered chiefly for the vast strides which have been made in the advancement of Mechanical Science. Other days have produced as great mathematicians, chemists, physicists, warriors, and poets, but no other age has made such demands upon the professors of mechanical science, or has given birth to so many men of eminence in that department of knowledge. Though a member of the profession myself, I may venture before my present audience to claim that the civil engineer is essentially a product and a type of the latest development of the present century. Telford has admirably defined the profession of a civil engineer as "being the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters, and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns." This definition, written more than half a century ago, is wide enough to include all branches of engineering of the present day, although amongst those specifically mentioned the departments presided over by the railway engineer, the locomotive superintendent. and the electrician will be looked for in vain. As Telford was beyond all question the most widely experienced and far-seeing engineer of his time, this little omission well illustrates and justifies my statement that the typical civil engineer of the day is a late product of the present century; for even Telford never foresaw the vast changes which railways, steam, and electricity would evolve in the course of a few years.

My predecessors in this chair have on several occasions stated their conviction that it was better for the author of an address to confine his attention to the particular department of engineering in which he had special knowledge, than to wander over the whole field of mechanical science. A well-informed man has been defined to be a man who knows a little about *everything* and all about *something*. If you give me credit of being a well-informed engineer, I will endeavour to justify your good opinion by showing, whilst presiding at these meetings, that I know a little about steam-navigation, and machinery generally; a little about iron and steel, and other manufactures, and I trust a good deal about the construction of railways, canals, docks, harbours, and other works of that class.

There have undoubtedly been published during the last fifty years many works of mark and merit, but the work which above all others would, I think, have astonished and perplexed our ancestors, is the little one known to all the civilised world as "Bradshaw." This indispensable handbook of the nineteenth century testifies that the face of the country is dotted over literally with thousands of railway stations; that between many of these stations trains run at two-minute intervals, whilst the distance between others is traversed at a mean speed of nearly 60 miles an hour. The public are often justly indignant at the want of punctuality on some railways, but they should blame the management, and not the engineers, for the daily conduct of the heavy traffic between England and Scotland shows, that notwithstanding the constantly varying condition of wind and weather in this climate, a run of four hundred miles can, on a properly laid out railway, and with suitably designed rolling-stock, be accomplished with certainty to the minute, if the management is not at fault. On the Great Northern Railway, for instance, of which I am consulting engineer, the 400 miles between London and Edinburgh is traversed in nine hours, or deducting the half-hour allowed at York for dining, at the mean rate of no less than 47 miles per hour including stoppages. A few months ago the Duke of Edinburgh was taken on the same line of railway from Leeds to London, a distance of 186¾ miles, in exactly three hours, or at a mean rate, including a stop at Grantham, of over 62 miles an hour. I know of no railway in the world where this performance has been eclipsed, and it will be perhaps both instructive and amusing to contrast with it the performance of the engines at the opening ceremony of the Liverpool and Manchester Railway, on September 15, 1830. A newspaper correspondent of the time, after describing many eventful incidents of his journey, proceeds as follows: "The twenty-four vehicles left behind were now formed into one continuous line, with the three remaining engines at their head, and at twenty minutes past five o'clock we set out on our return to Liverpool. The engines not having the power, however, to drag along the double load that had devolved upon them at a faster rate than from five to ten miles an hour (once or twice only, and that but for a few minutes, did it reach the rate of twelve miles an hour), it was past eight o'clock before we reached Parkside. Proceeding onwards, we were met on the Kenyon Embankment by two of the missing engines, which were immediately attached to the three which had drawn us from Manchester. We went still slower than before, stopping continually to take in water (query to take breath), and creeping along at a snail's pace till we reached Sutton inclined plane, to get up which the greater part of the company were under the necessity of alighting and making use of their own legs. On reaching the top of the plane we once more took our seats, and at ten o'clock we found ourselves again at the company's station in Crown Street, having accomplished the distance of 33 miles in four hours and forty minutes."

The incident of the passengers descending from a train headed by five engines to walk up an insignificant incline is, I think worthy of being recalled to the remembrance of the travelling public who are accustomed to see without astonishment a single engine rushing along with a train of a dozen heavy carriages at as high a speed as if it were running alone. We must do our immediate forefathers, however, the justice to remember that even they effected some considerable improvements in the speed of locomotion. For example, in 1763 the only public conveyance for passengers between London and Edinburgh was a single coach, which completed its journey in fourteen days, or at the average rate of 1¼ mile per hour. Strange as it may appear, there are at the present time many large fertile districts in Hungary where, owing to the absence of both road and water communications, a higher rate of speed cannot be attained in a journey of seven day's duration.

An essential condition of the attainment of high speed on the railway, is that the stopping places be few and far between. The Great Northern express previously referred to makes its first halt at Grantham, a distance of 105 miles from London, and consequently but little power and time are lost in accelerating and retarding the speed of the train. In the instance of the Metropolitan Railway, on the other hand, the stations average but half a mile apart, and although the engines are as powerful as those on the Great Northern Railway, whilst the trains are far lighter, the average speed attainable is only some twelve miles an hour. No sooner has a train acquired a reasonable speed than the brakes have to be sharply applied to pull it up again. As a result of experiment and calculation, I have found that 60 per cent. of the whole power exerted by the engine is absorbed by the brakes. In other words, with the consumption of 30 lbs. of coal per train mile, no less than 18 lbs. are expended in grinding away the brake blocks, and only the remaining 12 lbs. in doing the useful work of overcoming frictional and atmospheric resistances.

Comparatively high speed and economy of working might be attained on a railway with stations at half-mile intervals if it were possible to arrange the gradients so that each station should be on the summit of a hill. An ideal railway would have gradients of about 1 in 20 falling each way from the stations with a piece of horizontal connecting them. With such gradients gravity alone would give an accelerating velocity to the departing train at the rate of one mile per hour for every second; that is to say, in half a minute the train would have acquired a velocity of 30 miles an hour, whilst the speed of the approaching train would be correspondingly retarded without the grinding away of brake blocks. Could such an undulating railway be carried out, the consumption of fuel would probably not exceed one-half of that on a dead level railway, whilst the mean speed would be one-half greater. Although the required conditions are seldom attainable in practice, the broad principles should be kept in view by every engineer when laying out a railway with numerous stopping places.

Nearly thirty years ago, when projecting the present system of underground railways in the metropolis, I foresaw the inconveniences which would necessarily result from the use of an ordinary locomotive, emitting gases in an imperfectly ventilated tunnel, and proposed to guard against them by using a special form of locomotive. When before the Parliamentary Committee in 1854, I stated that I should dispense with firing altogether, and obtain the supply of steam necessary for the performance of the single trip between Paddington and the City from a plain cylindrical egg-ended boiler, which was to be charged at each end of the line with water and steam at a high pressure. In an experimental boiler constructed for me, the loss of pressure from radiation proved to be only 30 lbs. per square inch in five hours, so that practically all the power stored up would be available for useful work. I also found by experiment that an ordinary locomotive with the fire "dropped" would run the whole length of my railway with a train of the required weight. Owing to a variety of circumstances, however, this hot-water locomotive was not introduced on the Metropolitan railway, though it has since been successfully used on tramways at New Orleans, Paris, and elsewhere. I am sorry to have to admit that the progress of mechanical science, so far as it affects locomotives for underground railways, has been absolutely *nil* during the past thirty years. The locomotive at present employed is an ordinary locomotive, worked in the ordinary way, except that in the tunnel the steam is condensed, and combustion is aided by the natural draught of the chimney alone, instead of being urged by a forced blast as on open portions of the line. Whether a hot-water, a compressed air, or a compressed gas locomotive could be contrived to meet the exigencies of metropolitan traffic is a question which, I think, might be usefully discussed at the present or some future meeting of the Association.

A reference to the underground railway naturally suggests the wider question of tunnels in general. The construction of tunnels was not one of the novelties presenting itself to railway engineers, for many miles of tunnel had been driven by canal engineers before a single mile of passenger railway had been built in this or any other country. To foreign engineers belongs the honour of having boldly conceived and ably accomplished tunnel works of a magnitude which would have appalled a canal engineer. I need only refer to the Mont Cenis Tunnel, over $7\frac{1}{2}$ miles in length, commenced in 1857 and finished in 1870; the St. Gothard Tunnel, $9\frac{1}{4}$ miles in length, commenced in 1872 and finished in 1882; and the Hoosac Tunnel, $4\frac{3}{4}$ miles in length, commenced in 1854 and finished in 1875. In all cases rock of the hardest character had to be pierced, and it is needless to remark that without the aid of the machinist in devising and manufacturing compressed air machinery and rock-boring plant the railway engineer could not have accomplished his task. Intermediate shafts are not attainable in tunnels driven through great mountain ranges, so all the work has to be done at two faces. In the case of the Mont Cenis Tunnel the mean rate of progress was 257 feet and the maximum 400 feet per month. In the St. Gothard Tunnel the mean rate was 429 feet and the maximum 810 feet. In the Hoosac Tunnel the average rate was 150 feet per month.

Tunnels under broad navigable rivers and estuaries have been a subject of discussion by engineers for at least a century, but the only one at present completed is the unfortunate and costly Thames Tunnel. Two important works of the class are, however, now well in hand, the Severn Tunnel at Portskewet, and the Mersey Tunnel at Liverpool. Having reference to this fact, it will be interesting to quote the following passage from a letter addressed to the press by a Mr. Thomas Deakin on March 6, 1835, that is to say, more than forty-seven years ago. Mr. Deakin writes: 'The Great Western Railroad from London to Bristol will be accomplished no doubt, and why not continue it under the Severn mouth, near Chepstow, Monmouthshire, through Glamorganshire, and to Milford Haven in Pembrokeshire? It would then traverse the coal-field of South Wales throughout its whole extent—a tract of country possessing also inexhaustible stores of iron-stone. A tunnel was once so proposed to be formed under the Mersey at Liverpool, and had it not been for the failure of the Thames Tunnel would most probably have been carried into effect." It is not a little singular that the two tunnels thus foreshadowed by Mr. Dakin should both be in hand at the present moment.

Undoubtedly the numerous accidents which occurred during the construction of the Thames Tunnel, together with its enormous cost of about 1,500*l*. per lineal yard, and the eighteen years occupied in its construction, destroyed the chance of any other projected subaqueous tunnel for many subsequent years. One lesson enforced by the Thames Tunnel was the necessity of leaving a reasonable thickness of ground between the water and the tunnel. In the Severn Tunnel the minimum thickness is 40 feet and in the Mersey Tunnel 22 feet. The width of river at the point of crossing of the former tunnel is $2\frac{1}{4}$ miles, and the maximum depth of rails below high water, 163 feet. In the case of the Mersey Tunnel the width is nearly three-quarters of a mile, and the depth 144 feet. The Thames Tunnel, as almost everyone knows, was carried on by means of a special contrivance termed by Brunel a "shield." No special appliances have been adopted in either of the Severn or the Mersey Tunnels. Both are driven in the ordinary way, but of course enormous pumping power is required and has been provided.

When no special appliances are used in the construction of a subaqueous tunnel, it will be clear to all that an unknown risk is encountered. All may go well, and the engineer will then justly receive congratulations from everyone for his boldness and success. But, on the other hand, something may go wrong, even at the last moment, and I fear the engineer then would be abused no less roundly by the unthinking public for his temerity and consequent failure. It would be a "Majuba Hill" incident over again, and if the accident caused much loss of life the engineer probably would envy the fate of the brave but ill-starred General Colley, who at least fell with the victims of his rashness.

In many cases of tunnels under estuaries, special appliances could be used which would obviate all risk and make the successful completion of the work a mathematical certainty. A tunnel under the Humber, about $1\frac{1}{2}$ mile in length, projected by myself in 1873, the Bill for which was subsequently passed by the Commons and thrown out by the Lords, was a case in point. The bed of the Humber is of very fine silt, and I proposed to build the tunnel in lengths of 160 feet, under the protection of rectangular iron caissons 160 feet long by 42 wide, sunk by the pneumatic process. As the pressure of the air in the caissons would always be slightly in excess of that due to the head of water in the river, no interruption from influx of water could ever occur, and the operation of building the tunnel in lengths inside this huge diving-bell would be as certain and free from risk as the every-day work of sinking a bridge-pier by the pneumatic process.

A tunnel over a mile in length, now in progress under the Hudson River at New York, is being driven through a silty stratum by the aid of compressed air, and with a certain amount of success, as only some twenty men have been drowned up to the present time. The principle upon which the compressed air is used is, however, a false one, since it is merely forced into the tunnel with a view to uphold the ground by its pressure, like so much timbering, and not to keep out the water on the principle of a diving-bell. It is clear, therefore, that the completion of the Hudson River Tunnel, if the present system be persevered in, is purely a matter of conjecture, and all we can do is to hope for the best. The same remark applies, of course, to the Severn Tunnel and the Mersey Tunnel, although in those cases the character of the ground is such that the contingencies are small in comparison with those encountered in the construction of the Thames Tunnel and the Hudson River Tunnel. Nevertheless, as I have already observed, unless special appliances of the nature of the pneumatic process be used, a subaqueous tunnel, whether it be the Channel Tunnel itself or one but a few yards in length, must necessarily present an unknown risk. The prototype of all these tunnels is the one commenced at Rotherhithe in 1809, which was successfully driven a distance of 900 feet under the Thames, and failed when within a little more than 100 feet of the opposite shore. A tunnel about $1\frac{1}{2}$ mile in length was commenced about ten years ago under the Detroit River in America, but was abandoned in a similar manner. So far good fortune has attended both the Severn and Mersey Tunnels, and there is, I am glad to say, every chance of its continuing.

That the series of mishaps with the Thames Tunnel, and the consequent postponement of all other projects for subaqueous tunnels, were due to errors in design and want of foresight on the part of the engineer, is patent to everyone now, and was foreseen by at least one acute contemporary of Brunel himself. Only a few months ago, when turning over the leaves of an old periodical, I became aware of a fact that a scheme, identical in all its main features with my Humber Tunnel project, had been suggested for adoption in the case of the Thames Tunnel, in lieu of the plan proposed by Brunel. Writing in December, 1823, or fifty-nine years ago, the author of the project, a working smith of the name of Johnson, says: "I propose to construct the Thames Tunnel without coffer-dams by making it in parts 28 feet in length, each part having the ends temporarily stopped up, and being constructed on the same principle as the diving-bell. The men dig from the inside round the edge as if sinking a well, and throw the earth towards a dredger, the buckets of which work some feet below the bottom of the excavation. Each length will be suspended between two vessels, and be conveyed to the place where it is let down." A description of the mode of connecting the several lengths is given, and I may add that the tunnel blocks had a sloping face to tend to bring the faces of the joints together, a plan since adopted with the huge concrete blocks at Kurrachee and other harbours. There is not a flaw in the design from beginning to end, as modern experience in the sinking of numerous bridge-piers on precisely the same plan has amply demonstrated. It is beyond all doubt that if the design of this working smith had been adopted in lieu of that tendered by Brunel, the Thames Tunnel would have been completed in a couple of years, instead of eighteen years, and at a cost of about 300*l*. per yard instead of 1,500*l*.

If another tunnel be constructed under the Thames, which is far from improbable, as the requirements of below-bridge traffic necessitate some such means of communication, I venture to predict it will be built in accordance with the plan suggested fifty-nine years ago by the working smith, and not on that of Brunel's Thames Tunnel, or of any other tunnel yet carried out.

At the beginning of the present century a committee was appointed to consider the "practicability of making a land communication by tunnel under the River Forth, at or near Queensferry." In a report dated November 14, 1805, it was recommended that a double tunnel should be constructed at an estimated cost of 164,000*l*., or at the rate of 30*l*. per yard, exclusive of shafts and pumping. The surveyors reporting, grounded their belief in its practicability upon the fact that at Barrowstowness, coal-workings had been carried under the same Firth for a mile, and at Whitehaven coal was worked for the same distance under the Irish Sea, in both places less water being met with under the sea than under the land. The report concludes in the following words: "That a more easy and uninterrupted communication betwixt every part of a country increases the intercourse of commerce, arts, and agriculture, all must know. Ferries are still and often a formidable bar in the road. Of these in this country, the one under review at Queensferry is perhaps the most conspicuous. It is, in fact, the connecting point betwixt the north and south of Scotland, and indeed of the realm, and in this point of view the improvement of it must be considered a national object." These words are as true and as applicable to the case in 1882 as they were in 1805. A ferry still is the only means of communication across the Forth of Queensferry, though the traffic has increased a hundredfold. Parliment, by the passing of the Forth Bridge Act during the present session, has given a practical recognition of the truth of the statement in the above-quoted report, that the improvement of the Forth passage is a "national object."

As you will receive a paper on the Forth Bridge from my partner, Mr. Baker, I will not trouble you with details of the proposed structure at the present moment. I may state, however, that after a careful consideration of the difficult problem, in concert with my able colleagues, Mr. T. E. Harrison, the chief engineer of the North-Eastern Railway, and Mr. W.H. Barlow, chief engineer of the Midland Railway, we unanimously advised the directors of the Forth Bridge Company to abandon the project for a suspension bridge, and to construct a steel girder bridge of the unprecedented span of 1,700 feet. The total length of the structure is 1½ mile, and it includes two spans, as aforesaid, of 1,700 feet, and two of 675 feet, over the navigable channels on each side of Inchgarvie. The execution of the work has been intrusted to me, and my intention is that the Forth Bridge shall be not only the biggest, but the strongest and stiffest bridge yet constructed.

Although great navigable rivers offer the most serious impediments to lines of communication lying at right angles to the direction of the stream, and necessitate such formidable undertakings as the Forth Bridge, with a clear headway of 150 feet above high water, and the Severn Tunnel at a depth of 163 feet below the same datum, still it must be remembered that such rivers were the earliest, and are yet the cheapest, highways for inland communication. Antwerp, the third port in the world, ranking only after London and Liverpool, owes its commercial importance undoubtedly to the Scheldt, which affords admirable water-carriage for a distance of 60 miles from the sea coast inland. London, similarly, is an inland port situated about 50 miles up the Thames; hence one-half of the distance between Antwerp and London is made up of fine rivers capable of being navigated by the largest ocean-going steamers. The practical result of the existedce of this splendid line of natural communication is, that iron girders and rails can be conveyed from the heart of Belgium to the metropolis at a far lower price per ton than from any ironworks in this country. Unfortunately, the southern coast of England and the opposite coast of France are indented by no such rivers as the Thames and the Scheldt, or we should never have heard of the horrors of the "middle passage" in "cockleshell" boats, or of the Channel Tunnel.

To realise, however, the important part which rivers play in facilitating inland communication, it is necessary to glance at the other side of the Atlantic. In Canada, for instance, we have the great inland port of Montreal, where transatlantic steamers anchor some 500 miles from the coast. The very term "stream of traffic" suggests a river, and the St. Lawrence well illustrate, it. Into some small forest tributary of the Ottawa the lumbermen slide a log of timber, and many months after will that log with thousands of others, forming together a huge raft, with huts upon it for the accommodation of the care-takers. be found pursuing its slow but ever continuing progress down the St. Lawrence to Quebec, where it will be shipped to this country.

In Egypt for countless ages the "ship of the desert" and the boats of the Nile constituted the only means of communication. Wheeled carriages were practically unknown, although as long ago as 1832, Mehemet Ali bewildered the pilgrims by starting off for Mecca across the desert in a Long-Acre barouche. But the Nile holds an exceptional position amongst the rivers of the world, for not only was it until quite recently practically the sole means of inland communication for the country through which it flows, but it was, and still is, literally the life of Egypt, since without Nile water there would not be a green spot in the whole of that now fertile land. Having filled the office of consulting engineer to the Egyptian Government for seven years, I have had occasion to give particular attention to the Nile, and I may state that in an average year that river conveys no less than 100,000 million tons of water, and 65 million tons of silica, alumina, lime, and other fertilising soils down to the Mediterranean. The Nile begins to rise about the middle of June, at which time the discharge averages about 350 tons of water per second, and attains in September a height of from 19 feet to 28 feet, and a discharge of from 7,000 to 10,000 tons per second.

Napoleon the Great said that every drop of Nile water should be thrown on the land, and he was right so far as Low Nile discharge is concerned. The cultivated land in the provinces of Lower Egypt have an area of 3 million acres, and to irrigate this effectually at least 30 millions of tons of water per day would be required, an amount somewhat exceeding the whole of the Low Nile discharge. At present the irrigation canals are totally inadequate to convey this quantity, and imperfect irrigation and consequent loss of crops is the result. In many instances a couple of men labour for a hundred days in watering by shadoof a single acre of ground, all which amount of labour might be dispensed with if the barrage of the Nile were completed, and a few other works carried out, the whole of which would be paid for handsomely by a water rate of two shillings an acre. You will gather, therefore, that I do not think the resources of Egypt have been fully developed, magnificent as they even now are, having reference to the size of the country.

It is hardly necessary to say that a net-work of canals laid out with a view to irrigating the lands of lower Egypt can also be used at any time in the event of war for the offensive or defensive flooding of the whole or any part of the said lands. Except for the work of man, Lower Egypt for four months in the year would be simply the bed of a river, and for the remaining months a mud bank. Long before the historic period, however, the Nile had been embanked, and canals, such as the Bahr-Jusef, had been formed; the first, to keep the floods off the land, except in desired quantities; and the second, to run off the inundation waters as soon as the fertilising matters in suspension had been deposited on the lands. Should the inhabitants of Egyyt neglect at any time to maintain the works of their ancestors, successive floods would quickly destroy the embankments and wash the light material into the canals. Thus the whole surface of the country would again be levelled, and the land of Egypt would revert to its primitive condition of being a river's bed for one-third of the year, and probably a malarious swamp for the remainder.

It is hardly possible to refer to Egypt without saying a few words about the Suez Canal. Far-seeing people, including the late Khedive, have long been of opinion that another ship canal will be required in Egypt. In 1876 I submitted to His Highness, in accordance with my instructions, detailed plans and estimates for such a canal from Alexandria through Cairo to Suez. The total length of the canal was 240 miles, and with the same width as the existing Suez Canal the estimated quantity of excavation was 160 million cube yards.

An interesting and significant incident in the history of the Suez Canal occurred in May, 1878, when a fleet consisting of ten steamers and sixteen sailing vessels passed through with 8,412 native troops bound from India to Cyprus. During the same year no less than 58,274 soldiers traversed the Canal. Since 1878 events have marched rapidly, for no one then foresaw that the next important movement of British troops canal-ways would be of a nature hostile in appearance, if not in fact, to the inhabitants of Egypt. The announcement that French and not British troops were to hold the canal was received by the public with an expression of surprise and perhaps of slight resentment, because no one can dispute the vital importance of the work to this country. Periodically the question of the Euphrates Valley Railway is revived, and indeed quite recently I have had to reconsider the question professionally, but this route can never rival the existing one by the Isthmus of Suez.

The inauguration of steam navigation to India was much delayed by the vacillation of the authorities respecting the Suez and the Euphrates Valley routes. Happily, however, the Arabs stole the first bag of mails that went by the Euphrates, and so in 1834 a Committee of the House of Commons finally resolved that "steam navigation between Bombay and Suez having in five successive seasons been brought to the test of experiment, and the practicability of that line being established, it be recommended to His Majesty's Government to extend the line of Malta packets to Egypt to complete the communication between England and India." Nothing appears to have been done during the next two years, but in 1837 a new paddle-wheel steamer, the *Atlanta*, of 650 tons, steamed out to Calcutta, round the Cape in ninety-one days, and was put on the Red Sea station. She left Bombay with the mails on October 2nd, 1837, and arrived at Suez on October 16th. The mails were carried across the desert by camels, and down the Nile to Alexandria in four days, where they remained until H.M.S. *Volcano* took them on board on November 7th. At Malta, on November 16th, they were transferred to H.M.S. *Firefly*, and finally were landed in this country on December 4th, having been in all sixty-three days in coming from Bombay to England. At the present time about eighteen days are occupied in carrying the mails from Bombay *viâ* Brindisi to London.

The town of Southampton, where we are now assembled, has always held a distinguished position in connection with the development of improved communication with our Eastern empire. The opening of the first section of the railway from London to Southampton was coincident with the establishment of steam navigation *viâ* Egypt to India, and in the same year the French engineers at Cairo completed their studies for the proposed railway across the desert to the Suez.

A few months later the London public were startled by an advertisement headed "Steam to New York," and 94 passengers were plucky enough to embark at London, on April 4th, 1838, in the *Sirius*, of 700 tons and 320 horse-power, for New York, where they arrived on the 23rd, having performed the voyage in seventeen days from London, and fifteen days from Queenstown. The *Great Western* sailed from Bristol on April 7th, and arrived at New York a few hours after the *Sirius*, and thus was the great problem of steam navigation to America successfully solved by vessels of small size, and capable of maintaining a speed of but eight to nine miles an hour. I need hardly remind you that since the year 1838 the ships conducting the enormous traffic between Europe and America have been of ever-increasing size and speed. Thus the *Britannic*, built in 1874, has an extreme length of 468 feet, a beam of 45 feet 3 inches, a displacement of 8,500 tons, and a speed of 16 knots per hour; whilst the *Servia*, built in 1881, has an extreme length of 530 feet, a beam of 52 feet, a displacement of 13,000 tons, and a speed of 18 knots, and the *City of Rome*, built in the same year, has a length of 600 feet, a beam of 52 feet 3 inches, and a displacement of 13,500 tons. Another Atlantic liner, the *Alaska*, having a length of 500 feet, a beam of 50 feet, and a displacement of 12,000 tons, attained a speed of $18\frac{1}{2}$ knots on the measured mile, and has done the distance between Queenstown and New York in seven days four hours and thirty-two minutes, and the return voyage in six days and twenty-two hours, a mean ocean speed of, say, 17 knots per hour, or more than double that of the first steam vessels trading in America.

The present generation has grown so accustomed to the embodied results of the progress of mechanical science, that it has long ceased to wonder at big ships, or at any other novelty. To realise what has been attained it is necessary to place ourselves as far as possible in the position of our immediate ancestors, and to look at things through their spectacles. With this view, and to give you some scale of comparison to measure the size of the present Atlantic liners by, I quote a short passage from a newspaper of September 19, 1829, where reference is made to a vessel then under construction, of about the size of one of the much abused "cockle-shells" performing the Channel service between Dover and Calais: "The Dutch have been engaged for the last five years in constructing and equipping a steamboat of extraordinary magnitude, in order to facilitate the communication between Holland and Batavia. It has four masts, is about 250 feet long, and has been appropriately christened the *Monster*. In consequence of her great length, she hung when going off the slips, and it was some days before she was fairly launched; a circumstance which gave the wits of Paris occasion to remark that their Dutch neighbours were so determined to excel all other nations in the magnitude of their steamboats, that they had built one so long that it was several days running off the stocks. One of the most remarkable features of this enormous vessel is her extreme narrowness as compared with her length; her greatest breadth of beam being only about 32 feet. The great size of this vessel will bring to the recollection of our readers the *Columbus*, which was built in the river St. Lawrence in 1824, and made the passage to England in safety, but was afterwards broken up on account of her unmanageable bulk. We shall not be surprised to find that a similar fate awaits the *Monster*, and for a similar reason."

The Channel boat, *Albert Victor*, now on the Folkestone station, is of the same length as the *Monster*, namely 250 feet, whilst the beam of the former is but 29 feet, instead of what the critic of 1829 termed the "extreme narrowness" of 32 feet.

The successive attempts at mitigating the discomforts of the Channel passage by the swinging saloon and twin-steamers of Sir Henry Bessemer and Captain Dicey have gradually prepared the way for what I believe will be the next important step of establishing Channel communication by means of large floating stations, or ferry steamers, capable of traversing the narrow sea between England and France in little more than an hour. Ten years ago I applied to Parliament for powers to carry out this project, and obtained the unanimous sanction of a Committee of the House of Commons. The Bill was, however, thrown out in the House of Lords by the casting vote of the chairman.

What was practicable at that time has now become comparatively easy, owing to the introduction of steel into shipbuilding, and the improvements which have been effected in marine engines and mechanical appliances generally.

Whether the over-sea or under-sea mode of crossing the Channel—the ferry or the tunnel—is to be the adopted scheme will soon be determined. It may be that both will be carried out, and then at least all tastes will be met, and all anticipations respecting the resulting increase in traffic, both in goods and passengers, between the two countries will be brought to the test of experience. However this may be, I am very pleased to be able to announce that my friends Mr. Abernethy and Mr. Clarke Hawkshaw will read papers on the subject, the former on the over-sea, and the latter on the under-sea plan, and I shall be disappointed if the papers do not lead to an interesting and valuable discussion.

In few departments of the engineer's work has such progress been made as in that of steam navigation. When in 1820 steamships were first used for conveying merchandise as well as passengers, the tonnage of the whole of the steam traders of this country, it is stated, amounted to but 505 tons. At the present time the corresponding figure is $2\frac{1}{2}$ million tons. Did time permit I would say more on the subject, but I fear that in speaking at all upon steamships I have departed somewhat from my avowed intention of keeping within the sphere of engineering, in which I have chiefly worked. My apology must be that a discussion of railways led me to a consideration of tunnels and bridges, and this naturally suggested a reference to the rivers necessitating the construction of the said tunnels and bridges. From river traffic to ocean traffic is but a step, and so I have been insensibly led to touch upon the wonderful results achieved in recent times by naval architects and mechanical engineers.

I will not similarly err in troubling you with any remarks of mine upon the no less wonderful results achieved by electricians. A description of the work done by my friend Dr. Siemens during the past quarter of a century would in itself constitute a concise history of electrical science. Remembering, however, the warning of King Solomon, that "He who praiseth his friend with a loud voice, it shall be counted a curse to him," I will refrain from referring to Dr. Siemens, or to my immediate predecessor in this chair, Sir W. G. Armstrong, and conclude my address at once with a sincere wish that the present session of the British Association may prove not less interesting and productive of benefit to science than any of those which have preceded it.