

NOTES ON THE NATURE OF THE GEOLOGICAL RECORD.

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It appears to me that in these days of ever-increasing specialism a Presidential Address is never more useful than when it deals with those broad elementary questions of which the specialist is too apt to lose sight. I therefore propose to discuss on this occasion various points which have interested me in connection with the nature of the geological record; to consider both the character of the evidence it affords and the gaps in it, whether resulting from unconformities between different beds or from the narrow range of the fossil remains the sedimentary rocks may contain.

Fifteen or sixteen years ago it was generally supposed that the Globigerina Ooze of the Atlantic was so nearly identical with Chalk that the latter might be considered as a deep-sea formation, the deposition of which had been going on continuously since Cretaceous times in the deeper parts of the ocean. But further examination showed that the fauna of the deposits of Globigerina Ooze from comparatively shallow water much more resembled that of the Chalk than did the organic remains obtained from the deep sea; and it was established by Dr. Gwyn Jeffreys* and others that the fossils of the Chalk pointed to its deposition in a comparatively shallow sea, though at a considerable distance from any land, and consequently beyond the area in which sands, clays, and other shore deposits were being formed. It was further shown that the sands and clays now found directly below the Chalk, but which may have been forming near the shore while the Chalk itself was being deposited further out at sea, show an assemblage of fossils with much general resemblance to those of the Chalk. In short, that formation, which used to be considered one of the best examples of a deep-sea deposit, and as testifying to the former extension of the Atlantic Ocean, with a depth of 1,000 to 2,000 fathoms, over what is now central Europe, is now known to imply only the existence in Cretaceous times of a comparatively shallow

* 'Rep. Brit. Assoc.' 1877.

sea, somewhat larger than the Mediterranean,* and with a depth not necessarily exceeding 250 or 300 fathoms.

With this view as to the origin of the Chalk there has grown up a fuller recognition of the fact that the great masses of sedimentary rock of Palæozoic age show in their ripple-markings, annelid-burrowings, and desiccation cracks, evident signs of deposition in shallow water. In fact, there is nothing but the great thickness of some of these formations to suggest that they are not simply shore deposits; and, on consideration, this great thickness is seen to offer no real difficulty; for all it really necessitates is the gradual sinking of the area in which deposition is taking place at a rate nearly equal to that of the growth of the deposit. Thus it may be said that one of the most recent developments of geological thought has been the recognition of the various marine formations as deposits formed in more or less shallow water, whether near to or far from the shore. This view implies the acceptance of the opinion, which for long gained little ground among geologists, of the general permanence of continental areas as mainly land and of deep oceanic basins as ocean. Whatever may have been the case in the very earliest periods of the earth's history, this would seem to be true of the ages that have passed away since the beginning of the geological record. It may, however, occur to many persons to remark that though what are now deep-sea basins of 1,000 fathoms or more, may always have been deep seas, yet that every part of every existing continent must have been more than once under water; and this has evidently been the case. But all that is meant by the permanence of continental areas as mainly land is that at no time has land now part of a continent been deep sea of 1,000 fathoms or more, though considerable portions of its surface may have been covered again and again by seas of from 50 to 500 fathoms or thereabouts. Thus, what is now a compact and solid continent must have consisted at many different periods of two or more parts too large to be called islands, with many smaller islands of various sizes grouped around the larger masses. In the Eocene period, Mr. A. R. Wallace informs us,† tropical Africa was cut off from Europe and Asia by a sea stretching from the Atlantic to the Bay of Bengal, Northern Africa being then included in the Eurasian

* See Wallace's 'Island Life.'

† 'Island Life,' p. 390.

continent ; and in Cretaceous times, as we have seen, Europe, cut in two by the sea in which the Chalk was deposited, was rather a cluster of islands than a continent. Indeed, we may recall the remark of Darwin* that he agrees with Mr. Godwin-Austen that " the present condition of the Malay Archipelago, with its numerous large islands separated by wide and shallow seas, probably represents the former state of Europe, whilst most of our formations were accumulating."

And if, from oceans and continents we turn to an area of mid-land seas, like that now occupied by the Mediterranean, Black, and Caspian, we find evidence of a similar combination of permanence with variations. At one time Europe (Sir A. C. Ramsay tells us)† was in all probability completely separated from Asia, the Black, Caspian, and Aral seas being united, and the whole having an outlet connecting them with the Arctic Ocean east of the Ural Mountains, along what are now the valleys of the Tobol and the Obi. At another period the Mediterranean had no outlet into the Atlantic at Gibraltar, the isthmus of land then connecting Europe and Africa allowing an interchange of mammalia at that point. This took place, we learn from Sir A. C. Ramsay, probably during an interglacial episode of the Glacial Period. Subsequently this isthmus was again submerged, and with it the Rock of Gibraltar, to a depth of at least 700 feet. After this a re-elevation occurred, which again appears to have been sufficient to permit the passage of mammals ; and it is highly probable that, either at the periods of elevation just mentioned or at others, there was a passage across what is now shallow sea between Sicily and Tunis, which was doubtless found of service by migratory animals. On the other hand a physical map of the Mediterranean and Black Seas shows that it is very unlikely that the areas now occupied by them have been wholly or mainly land for an immense period. For the central part of the Black Sea is more than 1,000 fathoms in depth, while most of it varies between 100 and 1,000 fathoms. In the Mediterranean the proportion of deep water is much greater. An elevation of the whole area to the height of 6,000 feet, which would make dry land of the Adriatic and Ægean Seas, join Cyprus to Syria, and connect both Sicily and Sardinia with Italy and Africa,

* 'Origin of Species,' Chap. IX.

† 'Europe,' by F. W. Rudler and G. G. Chisholm. Edited by Sir A. C. Ramsay, Lond., 1885.

as well as close the Straits of Gibraltar, would yet leave a great lake occupying most of the surface between Sicily and Egypt, another between Italy and Sardinia, and a third between Sardinia and Spain.

Thus a full recognition of the truth of the view that continental land areas have always been mainly land and that deep oceans have remained sea since the beginning of the geological record, does not exclude variations in sea and land amply sufficient to allow of the deposition of the Chalk and other comparatively pure limestones, in addition to the beds generally recognized as shallow-water or shore deposits. Similarly, though broad areas of depression within a continental area, like that occupied by the Mediterranean, Black, and Caspian Seas, may have been mainly areas of depression through many geological ages, they have varied so much in character from time to time as to allow of the most important changes in physical geography, and consequently in the fauna and flora of the adjacent land-areas. Centres of elevation, also, though equally persistent, and dating their origin from Palæozoic times, may, as in the case of the Alps, have had many upliftings and depressions since, and have even been largely under water as late as the Eocene Period.

Perhaps the most important confirmation of this view of the general permanence of continental and oceanic areas is afforded by the present distribution of animal and vegetable life in the islands, large and small, which are found at various distances from the continents. Mr. A. R. Wallace, in his admirable 'Island Life,' has shown how decidedly the resemblance of the animals and plants of an island to those of the nearest continent varies not merely with distance but also with the depth of the sea between them. For of course, on the theory of the permanence of continental and oceanic areas, the separation of an island by a deep sea of 1,000 fathoms or more makes it very unlikely that it was ever united to a continent; a sea varying between 250 and 500 fathoms makes it probable that connection must have been only at some remote period; while a sea of 100 fathoms or less suggests union at a comparatively recent date.* It will be best to illustrate the matter by considering briefly the cases of three islands or island

* Of course any figures are but approximate; upheavals and depressions during any given period having been much greater and more frequent in some areas than in others.

groups, one Britain, which may be classed as recently continental, a second, Madagascar, as remotely continental, and a third, St. Helena, as oceanic.

In the case of the British Isles we find, in the first place, that an elevation of the whole area to the amount of 100 fathoms or 600ft. would not merely join them to the Continent and connect Ireland with Britain, but that the new land would extend outside Western Ireland and the Hebrides so as to include the Orkney and Shetland Isles. All that is now sea between Denmark and Brittany would then be land. Secondly, the rocks composing the British Isles are simply westerly extensions of those of the continent, and the indigenous fauna and flora are almost identical. In short, all the facts testify to a former connection and a very recent separation. But if we turn to Madagascar we notice that though the sea between Madagascar and Africa is decidedly shallower than that east of the great island, yet that it is much deeper than that between Britain and the Continent, being mainly over 100 fathoms in depth. Indeed, an elevation of the sea bottom between Africa and Madagascar to the extent of 600ft. would only serve to enlarge the areas and increase the number of the Comoro Islands, making it easier for birds to cross, while land mammals would find the task almost as impracticable as ever. As regards the rocks, the Rev. R. Baron, in his recent paper on the geology of Madagascar,* says that there are some which, when referred to the European standard of geological chronology, would be classed as Jurassic, Cretaceous, Eocene, and Recent. Mr. Wallace tells us that there are 66 species of mammals in this island, a fact pointing to its former connection with the Continent. But 33 out of these 66 species consist of lemurs, which are nowhere so abundant as in Madagascar; there are a dozen species of Insectivora; the Carnivora are represented by a peculiar cat-like animal, and by eight species of Civet-cats. There are also a river-hog, a small hippopotamus, and some rats and mice. Thus all the lions, hyænas, elephants, rhinoceroses, giraffes, zebras, baboons, and other animals characteristic of Africa are entirely absent, a fact which, apart from others telling in the same direction, tends to show that there has been no land-connection between Africa and

* 'Quart. Journ. Geol. Soc.,' Vol. xlv, p. 305 (1889).

Madagascar since a very remote period, and confirms the inference drawn from the depth of the sea between them.

St. Helena is a good example of what is termed an oceanic island. It is situated more than 1,100 miles from the coast of Africa and 1,800 from that of South America. We learn from Mr. Wallace that it is about ten miles long and eight broad, and that it is composed wholly of volcanic rocks. It is mountainous, and is bounded by stupendous precipices. Its highest point is 2,700ft. above the level of the sea. Everything indicates that it is simply a volcanic mass that has been built up from the depths of the ocean, and that it has never been much larger than it now is. The depth of the ocean for hundreds of miles around it varies between 2,000 and 3,000 fathoms. It was discovered by the Portuguese in the year 1502. There are no indigenous mammals, reptiles, fresh-water fishes, or true land birds. When discovered, it was densely covered by luxuriant vegetation; but the introduction of goats shortly afterwards caused its almost entire destruction, so that the island is now barren and bare. The native flora is of very ancient type. There are many species of insects. Of the Coleoptera there are 203 species, but of these 74 are common and widely diffused, and were probably introduced by man. Of the remaining 129, which are believed to be aboriginal, all but one are found nowhere else. These facts point to their great antiquity, which has allowed time sufficient for their modification and adaptation to this remote island. They probably date back from Miocene or still earlier times. As a large proportion of the St. Helena beetles live, even in the perfect state, within the stems of plants and trunks of trees, they probably came over chiefly in drift-wood.

It would be easy to take other examples, with similar results. Of course, in many instances there is something special—something which seems at first sight difficult to explain; but it seems to me that it would be almost impossible to mention a case seriously antagonistic to the view held by Mr. Wallace and others, that continental areas have been permanently land or shallow-water, and oceanic areas deep-water, since the beginning of the geological record.

I think the general opinion would be much more decidedly in favour of the Darwinian theory if the number and importance of the gaps

in the geological record of past life were more fully realized. It is not that there is any fault to be found with the doctrines on this subject as they are laid down in our text books; but that our practical belief in the importance of the missing information is apt to be absurdly small. It is acknowledged, with the lips only in too many cases, just as some of us recognize that "there are more things in heaven and earth than are dreamt of in our philosophy," and straightway proceed to talk and write as though future workers would have little but detail to occupy them.

The imperfection of the geological record is many-sided. Besides the absence of evidence here and there, as shown by the unconformities between different formations, the evidence afforded by a fossiliferous bed itself is necessarily of an extremely partial description. A marine formation, as a general rule, contains simply the remains of marine creatures whose hard parts allow of their preservation, the bones of land-animals (if any) being there as the result of what may be called accident. If, on the other hand, we turn to terrestrial, lacustrine, or river formations, we are equally far from an assemblage of fossils fairly representing the life of the period. Hence, as experience has so often shown, the extremely small weight due to merely negative evidence.

In Darwin's well-known chapter on the "Imperfection of the Geological Record" the illustrious author notes the enormous destruction of rock through denudation, the great periods of time that have often elapsed between the deposition of the uppermost beds of one formation and those of the lowest beds of its successor, and also the evidence that each separate formation has been intermittent in its accumulation. His observations had convinced him that nearly all thick fossiliferous formations must have been formed during the subsidence of a shallow sea-bottom—not as deposits beginning in profound depths of the sea; and he remarks that he had been much struck by the fact that an examination of many hundred miles of the South American coast (which has been elevated several hundred feet during the Recent Period) showed the absence of any Tertiary or Recent deposits sufficiently extensive to last for even a short geological epoch. These formations were gradually worn away by the action of the waves as soon as they attained a certain level, and either destroyed or only slight fragments preserved. Having been formed on a sea-bottom that was gradually rising, they necessarily could not attain

the thickness necessary to enable them to endure, without almost entire destruction, the fury of the waves during their upheaval.

But it is evident that even in the case of a very thick deposit, situated as were those mentioned by Darwin, destruction of the upper beds would go on at the same rate as in a thin formation of the same material. The lower beds, having the advantage of being more consolidated, would offer more resistance to erosion, and might be to some extent preserved. Thus it seems inevitable that a considerable destruction of the upper beds must occur where any area is being elevated, and is during elevation exposed to the waves of an open sea. The strata thus removed may be re-deposited in other places, but they will be found in the newer deposits they have helped to form, mixed with other coast material of various ages but similar lithological character, and having usually lost their fossils. If, as Darwin remarks, "it has been observed by more than one palæontologist that very thick deposits are usually barren of organic remains except near their upper or lower limits," it is evident that this denudation of the upper beds of thick formations during their emergence must be a most important influence in increasing the imperfection of the geological record.

Of course, denudation of the upper beds of an emerging formation is not more likely to occur than the planing down of the uppermost beds of a subsiding one. In many cases the fact that the older of two formations has become land, and has consequently been exposed to subaerial denudation previous to the submergence that has allowed the deposition of its successor, is at once obvious from the unconformity between them. But occasionally a very decided unconformity has only been shown to exist after much detailed work in the field, and there can be little doubt that many unconformities remain yet undiscovered. A good example of an unconformity revealed only after much field-work is that of the Plumpton Rocks near Knaresborough, which were visited by this Association during the excursion to the West Riding of Yorkshire in 1882. A paper on these beds by the late James Clifton Ward * gives the opinions of various geologists of eminence as to their affinities; from which we learn that Prof. Sedgwick, Prof. Phillips and Sir Roderick Murchison thought (at the date of the

* 'Quart. Journ. Geol. Soc.', Aug., 1869.

paper's appearance) that they were Permian, while Mr. Binney and the Rev. Stanley Tuke inclined to the belief that they were of Millstone Grit age. Ward (who had been working at the Millstone Grit beds in detail for the Geological Survey), after much work in the field, and many visits to places at which colleagues thought he might find evidence bearing on the matter, came at last to the conclusion that the Plumpton Rocks belonged to the Millstone Grit; and there seems to be no doubt as to the correctness of his view; but when we reflect that the three eminent geologists who had entertained the opposite opinion were all men skilled and experienced in field-work, who had formed their opinion after more or less inspection of the locality, and when we also remember that the Permian rocks, which lie unconformably on the Coal-Measures, are necessarily still more unconformable to the underlying Millstone Grit, we see now easily a less decided yet still important unconformity might escape notice, even in Western Europe.

Of course where beds have not been simply raised into land and again submerged, but have also been decidedly tilted during the process, the unconformity of the formation deposited thereon to the strata on which it rests is usually at once manifest. But in many cases formations appear to have been elevated and depressed with much evenness over a large area, and then the detection of an unconformity may be by no means an easy matter. Thin and variable passage-beds might be found here and there, and there might be occasional signs of erosion between the two formations; but on the other hand there would probably be a decided appearance of general conformity between them, the escarpments marking their respective outcrops keeping nearly parallel with each other over considerable breadths of country. In the case of our own Coal-Measures it would seem that the numerous changes of level which took place during their deposition must often have involved more or less denudation of the upper surfaces of the beds, though the evenness with which they have been depressed has usually prevented any recognition of the resulting unconformities. No great amount of rock may have been removed, and yet its removal may have been of the highest importance from a palæontological point of view.

In the 'Geological Survey Memoir on the Yorkshire Coalfield' (Chapter II, Section 1) Prof. A. H. Green gives a general

sketch of the Carboniferous rocks, which contains a much fuller account of the mode of formation of the various deposits than is usual in text-books, and which has the additional advantage of being the result of unequalled practical knowledge of the beds described. As regards the Carboniferous Limestone and Yoredale Beds, I need only say that the Limestone was evidently formed, like the Chalk, in a sea beyond the area occupied by shore deposits, while the Yoredale sandstones and shales, together with the more or less earthy limestones of that age, indicate a shallower sea, and greater nearness to land. The overlying Carboniferous beds, the Millstone Grit and the Coal-Measures, consist almost entirely of shales, sandstones, coals, and underclays, limestone being scarcely ever found. They consequently point to shallow water or terrestrial conditions. Prof. Green remarks on the great irregularity of the sandstones in these upper groups of strata, some having a fairly regular thickness of 100ft. or more for miles, wedging out to nothing in a space of a mile or less. But there is one very coarse sandstone which forms the topmost bed of the Millstone Grit and is called the Rough Rock, which is exceptional in character, as it spreads over hundreds of square miles with a tolerably even thickness. Prof. Green thinks this Rough Rock may have arrived at its present condition in the following way. The water near the shore becoming full of banks of coarse sand, the action of the waves during elevations in which the banks became land, and depressions during which they were beneath the level of the sea, tended to rearrange the material and form a broad deposit of much the same character throughout. Of course changes of this kind would tend to the utter destruction not only of any shallow-water fossils the sandbanks might contain, but of any remains of land animals which might have existed on them during their periods of elevation.

As regards the sandstones generally, Prof. Green remarks that "the junction of a sandstone with the overlying shale is often very uneven, as if part of the original sandbank had been cut away before the shale began to be deposited." In many cases, he adds, "there can be little doubt that the surface of the sandstone bed was for a time a land-surface traversed by streams of running water."

Sandstones being usually deposited in shallower water than shales, it is evident that a slight upheaval would make their tops

into land surfaces. Coals are often found on the top of sandstones, though there is almost always a band of underclay or "spavin" beneath each coal seam. This spavin is sometimes very siliceous, and is then called spavin stone. It is the soil on which the coal-plants grew, and is more or less full of rootlets. Fossilized trunks of trees, still standing erect and attached to their roots, are sometimes seen to rise from an underclay. Thus, a thick bed of coal indicates a considerable period during which the area it occupies was low-lying swampy ground, neither elevated nor depressed to any perceptible degree.

In the Millstone Grit and Coal-Measures the prevalent fossils are land plants, with certain freshwater shells; but occasionally marine shells are found, though rarely, and in thin bands, usually of black shale. In many instances, Prof. Green remarks, "these marine bands form the roof of a coal, and this rather looks as if in these cases the land went down with a small jump, when subsidence recommenced, after the stationary period during which the growth of the coal went on."

As each band of coal with its spavin or underclay marks the existence of a land-surface which lasted for a considerable period, while the overlying shales and sandstones indicate one of depression, it is possible, with the aid of a sheet of the vertical sections of the shafts of various collieries (published by the Geological Survey), to ascertain what oscillations of level took place between any two given horizons. In the Yorkshire Coalfield the two most important coals are the Silkstone and the Barnsley, and they are certainly the best-known in the London market. These coals are on the average about 1,000ft. apart, the Silkstone being the lower of the two. We learn from a sheet of vertical sections arranged so as to illustrate the strata between these two coals in the southern part of the Yorkshire coalfield, that, starting from the Silkstone, we have evidence of at least twelve old stationary land-periods alternating with others of depression, before we reach the Barnsley; and if we consult another sheet of sections showing the beds between the Barnsley and the Wathwood or Melton Field Coal, which lies on the average rather more than 500ft. above the Barnsley Coal, we find that there must have been between them certainly ten stationary periods alternating with others during which there was subsidence. But the 1,500ft. of beds between the Silkstone and Wathwood Coals form only about

two-fifths of the whole of the Coal-Measures—taking the average for the southern part of the district.

Enough has been said to illustrate the numerous changes of level during Coal-Measure times; and we must not forget that by fixing our attention on the coals and underclays alone we under-rate the number of these ancient land-surfaces; for, as I have already remarked, the tops of some of the sandstones show signs of having been for a time land-surfaces traversed by streams of running water. This indicates a slight upheaval in each case, while the growth of a coal does not necessarily imply anything more than the silting up of an area to such an extent as to allow plants to grow on its surface. Then the mere growth of vegetation during a stationary interval would allow the formation of a coal-seam. In such a case there would be no planing-down action on the part of the sea on the emergence of the tract as land. But the sandstone land-surfaces must have been more or less denuded both during upheaval and subsequent subsidence; for, as Prof. Green remarks, in a passage already quoted, "the junction of a sandstone with the overlying shale is often very uneven, as if part of the original sandbank had been cut away before the shale began to be deposited."

Now the importance of these facts in their bearing on the Fossil Record seems to me to lie in the following considerations. While coal-swamps might abound in Labyrinthodonts and other reptiles, land mammalia (supposing them to have existed) would mostly have preferred the drier land resulting from elevation of the area, of which we have evidence in these sandstones. Thus in the case of this most terrestrial of formations, the Coal-Measures, land-surfaces on which mammalia might have lived have been eroded away, while those on which reptiles flourished have remained to a great extent, if not wholly, uninjured.

The Permian and Triassic, or, in other words, the New Red Sandstone Series of rocks, are now generally believed to have been deposited in great lakes or inland seas, which varied from time to time in size, in saltness, and in the degree, if any, of their communication with the open sea. Above the highest beds of New Red Sandstone age are the Rhætic Beds, which in Britain vary in thickness from about 20 to 150ft., and form passage beds between the New Red Sandstone series and the Lower Lias. The most persistent portion of these Rhætic (or Penarth) Beds are black

shales, whose most characteristic fossil is the *Avicula contorta*. The late Prof. Edward Forbes considered that the Rhætic fossils much resembled those of the Black and Caspian seas, where there are misshapen forms due to the freshening of the water from the influx of rivers. The Lower Lias strata are entirely estuarine or marine. Sir A. C. Ramsay notes ('Q. J. G. S.,' 1871) that in England "the Lower Lias follow the Rhætic Beds wherever they go," and adds that, "though there are symptoms of erosion between them at Penarth and at Curry Rivell in Somerset, yet the conformity is, on the whole, so complete, that wherever we meet with the base of the Lower Lias we look for the Rhætic Beds below, and as yet we have not been disappointed." But he admits that the transition between Rhætic and Lias forms in these areas is very sudden and difficult to explain.

Besides land-plants, among the very few fossil remains found in the upper beds of the New Red Sandstone Series are those of many species of reptiles, while in the highest beds have been discovered the bones of the earliest British mammal yet known, a small creature of marsupial affinities, the well-known *Microlestes*. The presence of the footprints of the reptiles in the sandy Keuper mud shows that the places at which they were found were not far from land, probably, Sir A. Ramsay thinks, where a moist surface had been left uncovered by water owing to the summer evaporation of a lake; for if left at low tide they would probably have been obliterated in a few hours by the next high tide, whereas exposure to a hot sun for many weeks before they were covered by water would bake and harden them, and immensely increase their chances of preservation. These footprints are found at many places in England, a circumstance which seems to point to the conclusion that in England, towards the close of this period, these lakes were of no great size.

We have seen that Sir Andrew Ramsay notes the strong general conformity of the Lower Lias to the Rhætic Beds, though there are occasional signs of erosion between them. But it seems evident that considering the thinness and variable nature of these beds in England, and their character as passage beds, they might easily be present at two places 100 miles apart, and absent at certain spots between them.

Though in the passage between the uppermost beds of the lacustrine New Red Series and the lowest of the marine Lias we

have probably as near an approach to conformity between two formations of dissimilar kinds as any furnished by our geological record, it is evident that the conformity, if it may be so called, can only be of a broad and general character. For the sinking of the lacustrine area beneath the sea so as to allow of the deposition of the Lias, necessarily involved the planing down of the interlacustrine land on which the Triassic land-plants, reptiles, and mammals lived, and the destruction of any remains of them that may once have been deposited on its surface. Thus the relics of Upper Triassic land-life seem to be those of plants and animals whose remains were borne down into the salt lakes by rivers, especially during floods, together with the footprints of the reptiles which crossed the borders of the lakes when they were at their lowest. If the interlacustrine land-surfaces had not been planed down to the level of the lakes the unconformity between Trias and Lias would have been at once manifest. But the destruction of the Triassic land-surfaces, which has practically increased this unconformity, has at the same time tended very much to impart a delusive appearance of conformity to these two formations.

Though there can hardly be any doubt that mammalia were the last class of creatures to appear on the earth, it is by no means improbable that they may some day be discovered to date from a much earlier period than that of the uppermost beds of the New Red Sandstone Series. Had the earliest mammals been creatures of marine habits, (the land-mammals showing signs of being their modified descendants), we should probably have found their fossil remains in almost as many formations as now show those of fish. But, as we all know, the Cetacea, on the contrary, exhibit every mark of being the much modified descendants of land-mammalia, and consequently are creatures which we could expect to see only at a late period. It seems likely that the lowest division of the Mammalia known to us, the Monotremata, was never very numerous or widely diffused, if we may judge from its extremely restricted range at the present day, its two living representatives, the *Ornithorhynchus* and *Echidna*, being confined to Australia, Tasmania, and New Guinea, and their fossil remains to New South Wales. They, in common with the Australian marsupials, probably owe their continued existence to abundance of food, together with the absence, till quite recent times, of any competition with the higher mammalia.

But the marsupials, unlike the monotremes, show by their

existence nowadays in countries so remote from each other as Australia and America, and their presence in a fossil state in the Secondary and Lower Tertiary strata of Europe, that they were once very numerous and very widely distributed, having originated in the great Eurasian continent and thence spread to Australia and America, though now supplanted in the land of their birth by the competition of higher forms. All the mammals of the Mesozoic or Secondary period in Western Europe whose remains have yet been discovered have been marsupials, the earliest known at present being the already mentioned *Microlestes*, found in the uppermost beds of the Trias. At the base of the Great Oolite in Oxfordshire and Gloucestershire is the so-called Stonesfield Slate, which consists of calcareous sandstones, having a total thickness of about six feet. These beds, according to the late Prof. Phillips, were probably deposited in a lagoon, with bordering marshes and drier land. The remains found in them are those of small insectivorous marsupials, of insects and of land-plants, together with those of marine mollusca, of fishes, and of reptiles. The Stonesfield Slate is a purely local development, and by no means always found at the base of the Great Oolite; it is chiefly known, says Sir A. C. Ramsay,* east of Cheltenham on the Oolitic plateau, and perhaps attains its greatest thickness near the town of Stonesfield. Of course, being, as its fossils tend so strongly to show, a lagoon deposit, it cannot be expected to spread over a very large area, a circumstance much to be regretted considering its great palæontological interest. Yet what but a lagoon deposit would be likely to contain so rich and varied a fauna, and to retain it unharmed by erosion during subsequent depression. For firstly, in a lagoon we get the occasional free admission of sea-water and marine creatures of all kinds, combined with the proximity of land suited to the habitation of terrestrial reptiles and mammals. Secondly, the remains of land-plants and animals, borne into a lagoon by streams, especially during floods, would largely remain within it, subside tranquilly, be covered quickly in an unusual thickness of sediment, and thus be permanently preserved. If the same remains were brought down to an open shore, they would be much more widely dispersed, be less likely to escape being devoured while floating about, and have much less chance of sinking at a spot where a quick deposit of

* 'Physical Geology and Geography of Great Britain.

sediment was taking place. In treating of the Collyweston Slate, found near Stamford in Lincolnshire, which is sometimes 18 feet thick, or three times as thick as the Stonesfield Slate, Mr. H. B. Woodward remarks* that the general resemblance between the Collyweston Slate and the Stonesfield Slate, caused them at one time to be confounded. But though the Collyweston Slate contains marine fossils and numerous plant-remains, and shows in ripple-markings, worm-tracks and burrows that it was deposited close to the shore, neither reptiles nor mammals have been found in it; and considering the lithological resemblance between the two formations and their common nature as shore deposits, together with the presence of plant-remains in each, this absence of reptilia and mammalia in the Collyweston Slate seems more likely to be traceable to the absence of lagoon conditions than to any other probable source of difference.

It is well-known that the Yorkshire Oolites differ in many respects from those of the South-west of England. Among the rocks of that age in N.E. Yorkshire is one called the Millepore Bed, the fossils in which much resemble those common in the Inferior Oolite of the South-western district. Above this are some 80 to 100 feet of shales and sandstones, interstratified with at least eight distinct bands of coal. Mr. W. H. Hudleston† remarks that one of these bands is said never to exceed a thickness of 18 inches, though in general it is about 10 inches. Sir A. C. Ramsay states that the coal beds have not been formed of drifted vegetation, but that under each coal seam there is an underclay containing roots precisely like that underlying the coals of the Coal-Measures. We have thus in the Yorkshire Oolite eight beds of terrestrial origin in a total thickness of 80 to 100 feet of measures. Now, though this thickness is a mere trifle compared with that of the Coal-Measures, it is immensely greater than that of the Stonesfield Slate in which so many mammalian remains have been found, and which is on nearly the same geological horizon. But no mammalia have been discovered in these Yorkshire beds, in spite of their terrestrial origin and the abundance of Oolitic mammals elsewhere. Probably mammalia did not inhabit the coal-bearing swamps, and those living in drier parts and borne down the flooded streams to the sea were not retained in a lagoon. This case seems to me to

* 'Geology of England and Wales.'

† 'Proc. Geol. Assoc.' Vol. iii, p 310.

supply an excellent illustration of the danger of relying on negative evidence in the case of fossil remains, and of the immense influence of the conditions of their deposition on their preservation. How slight becomes the presumption against the existence of mammalia in Coal-Measure times derived from the non-appearance of their fossil remains, when we find that in Oolitic Coal-Measures—in a time and country in which they abounded—they have not been discovered.

In the beds of the Purbeck Series, which are sometimes classed as the topmost Oolites, sometimes united with the Wealden strata as the lowermost Cretaceous rocks, we again meet with mammalia. As in the Stonesfield Slate, they consist of small marsupials. The Purbeck Series are well known for their Dirt Beds, which are evidently old soils, in which the roots and the stems of trees are found in the positions in which they grew. Sir A. C. Ramsay says that the thickness of the whole of the Purbeck Beds is, in the Isle of that name, about 360 feet, and that according to the Geological Survey there are indications in them of four terrestrial surfaces, eleven sets of fresh-water beds, four brackish-water, and three marine. The mammalian remains, which are almost all simply lower jaws, have been found in a carbonaceous bed only a few inches thick, seen at Durlstone Bay. Mammalian lower jaws, as everybody knows, are the parts most speedily detached from floating carcasses of animals of that class. Mr. H. W. Bristow's table of Purbeck Beds shows that above the mammalian bed is a fresh-water bed, and below it "marly fresh-water beds;" while beneath these last are "soft cockle beds; chiefly marl, with gypsum and pseudomorphous crystals of rock-salt in places." This gypsum would seem to have been deposited in a salt lagoon which afterwards became freshened.

Both the small size and marsupial affinities of the fossil Oolitic mammalia of Britain have been much noted by geologists of eminence, who have also called attention to the fact that both the fauna and flora of the British Oolites are extremely like the recent animals and plants of Australia. After the spread of the marsupials, perhaps in Oolitic times, from the Eurasian continent to America by way of what are now Behring's Straits, and to Australia by way of the East India Islands, subsidences, with the consequent formation of sea-barriers, either prevented the admission, or largely reduced the number of the higher mammalia in Australia and

America. Hence the existence of what may be called from our point of view an Oolitic fauna and flora in Australia at the present day. Mr. A. R. Wallace ('Island Life') shows that the existence in central Australia of a broad belt of country from the Gulf of Carpentaria to the mouth of the Murray river, covered with rocks (according to our standard) of Cretaceous and Tertiary age, demonstrates that during those periods south-westerly Australia was separated from northern and eastern Australia by a broad sea, and that to this long isolation of south-western Australia is due the peculiar Australian flora of that region. Of course the same evidence which explains the special character of the land-plants of south-western Australia is equally good to show in what way the marsupial fauna of that country has been preserved. At an earlier period than that of the deposition of the Australian Cretaceous and Tertiary rocks, at a time when Australia had been more or less united to Asia by upheaval of the area occupied by the East India Islands, it became possessed of its peculiar fauna and flora, while subsequent subsidence, which has lasted almost to recent times, has preserved their peculiarities almost unmodified by the influence of organisms more recently developed, which flourish in the Eurasian continent.

It seems to me likely that the Oolitic marsupials of Britain were by no means so invariably small as the fossil remains yet found would incline us to believe. Marsupials, as we have seen, existed in Triassic times, and even if we suppose them to date from that period, a vast amount of time for modification elapsed between the deposition of the Trias and that of the Purbeck Beds; and when we learn from Dr. A. Geikie that the Stonesfield Slate has yielded the remains of four genera of marsupials, and that from the Purbeck Beds have been procured twenty species belonging to eleven genera, the smallness of the various forms seems to me more likely to have been due to local circumstances, such as the nature of the food obtainable and the habits of the creatures found, than to the non-existence of larger forms. In Australia at the present day the larger kangaroos are certainly not small animals, and in old river deposits of that country, which may correspond in Australia to the Miocene, Pliocene, and Pleistocene strata of Europe, are the bones of many extinct marsupials, some of very large size. Thus, one of the most abundant of these creatures is the *Diprotodon*, which was as large as a hippopotamus or rhinoceros, while the

skull of a certain extinct kangaroo is twice as long as that of the largest living animal of that kind. It seems to me, therefore, that, as important changes in the physical geography of Australasia have isolated in Australia a mammalian fauna of the same entirely marsupial type as that of the Oolitic period in Europe, the presumption is that in both districts there were large as well as small forms. The smaller mammals are necessarily both much more numerous and much more evenly diffused than the larger; for there are few spots in which small animals cannot obtain food and shelter, while large ones, though they may abound in places specially adapted to their habits and wants, are largely restricted to those places. Then, if any given number of the carcasses of mammalia, large and small, are floating down a river, they will tend to be deposited in different places according to their respective sizes. Some of the smaller forms may become entangled with the larger and sink with them, but as a general rule the small animals will float down the stream much farther than the larger ones. It may be remembered that Sir Samuel Baker enabled the parents of a drowned girl to discover her body by recognizing the fact that two bodies of about the same size and bulk, thrown in at the same place will tend to settle at the same spot.* He suggested that a log of heavy wood as near the girl's size as possible should be thrown into the rapids at the spot where she had disappeared. This was done, the log was found stationary about two miles lower down, in a back-water, and there also the girl's body was found. However, whether we suppose that the land adjacent to the spot at which our British Oolitic marsupials have been found was suited only to the habitation of small creatures, or that our deposits simply indicate that the smaller animals naturally drifted to the spots where they are now found, or are not quite satisfied with either explanation, enough has been said to show the little weight to be attached to merely negative evidence in this matter.

If we turn our attention for a moment to the nature and habits of existing marsupials we find that many of them are very small, are arboreal in their habits, live on insects, small birds, and fruits, and thus find excellent habitations in woods, on the banks of rivers, or even in mangrove swamps on the borders of the sea. For example, in America at the present day the Texas opossum is particularly fond of the black persimmon, which abounds on the

* 'Nile Tributaries of Abyssinia,' Chap. XI.

borders of the Rio Grande, while the crab-eating opossum is so called from the crab being apparently its favourite food. The Yapock, of Brazil, is a small creature, little more than a foot long, which lives on the banks of the rivers of Brazil and Guiana, and feeds upon fish, crustacea, and other aquatic animals. In Australia and Tasmania the phalangers are all small animals of arboreal habits, living on fruit, leaves, and small birds, while the bandicoot rats are small creatures, more insectivorous in their diet. Among the kangaroos there is a small tree kangaroo of arboreal habits, and a kangaroo of very large size, which lives in the woods which border most of the Australian streams. The other large kangaroos prefer open ground or hilly districts. The family to which the extinct genus *Diprotodon* belongs is now represented only by the wombat, a grass-eating animal, which burrows and lives among the hills.

If we are disposed to wonder why the largest of Australian marsupials have become extinct, I think we shall find the true explanation in the extraordinary droughts to which the country is liable. Even now, though great care has for some time been exercised in the storage of water, drought has been known to kill horses, cattle, and sheep by hundreds of thousands in a single year. The Australian explorer, Sturt, being brought to a standstill by the frightful heat and the want of water, dug out an underground chamber in which he and his men passed some terrible months. The wombat and many of the smaller marsupials are, as we have seen, of burrowing habits; but the gigantic *Diprotodon*, together with the huge extinct kangaroo and other large marsupials, more restricted to certain localities than smaller creatures, and without burrowing habits and capabilities, would naturally be among the first to fall victims to drought. This view receives confirmation from the fact that their remains are found in deposits of late Tertiary age, so that they must have become extinct during that comparatively recent period in which Australia became one great island, and droughts were rendered possible and inevitable. But a calamity of this kind can hardly have afflicted Western Europe in Oolitic and Cretaceous times.

The only indigenous mammal of Australia not marsupial is the carnivorous dingo, representing the ubiquitous dog family, the widely-distributed cats not being represented in that country. If we turn from Australia to Western Europe we find that the

mammals found in deposits of Lower Eocene age are almost entirely marsupial. And this is, at least, conclusive as to the abundance of marsupials in Europe at that time, however little it may decide as to the paucity of higher forms. Prof. W. Boyd Dawkins* tells us that among the carnivora of Western Europe in Upper Eocene times were creatures resembling wolves, foxes, wolverines, hyænas, and civets, "all with characters like the hyænodon, now only found among the marsupials." Among the mammals of Miocene age in Europe the opossum still lingered, though the remains of the higher mammalia have been discovered in much greater abundance. In Upper Miocene strata the cat family is represented by the great sabre-toothed lion (*Machairodus*), and in deposits of the same age have been discovered the rhinoceros, giraffe, deer, and antelope. No marsupials have been found in European beds of Pliocene age; and in the so-called "Forest Bed" of Norfolk, which dates from the time immediately preceding the Glacial Epoch, we have the sabre-toothed lion and the cave-bear, together with three distinct species of elephants, two of rhinoceroses, and many still existing mammals.

The "Forest Bed," though but a very few feet thick, is of the highest interest from the abundance of its mammalian and other remains. It may be seen at the base of the Norfolk cliffs between Happisburgh and Weybourn, as displayed on the admirable sheet of sections showing the coast between those places, drawn by Mr. Clement Reid and published by the Geological Survey. From Cromer westward it is seen to rest on the Chalk, and between Happisburgh and Cromer, Chalk is probably not far below the surface, though it becomes visible only for a short distance about Trimingham. At Happisburgh, Mr. Reid records that the Forest Bed is exposed at the base of the cliff after storms, and "generally consists of clay and loam with much lignite and occasional large mammalian bones. All the lignite and stools of trees appear to have been drifted." Near Bracton we learn that the Forest Bed is composed of blue clay with beds of lignite and gravel, the fossils being chiefly the bones and teeth of the elephant. At Paston the Forest Bed is very fossiliferous, large bones being particularly abundant. At Sidestrand its most abundant fossils are bones and teeth of two species of elephant, and the antlers and limb-bones of several species of deer; while between Overstrand and Cromer,

* 'Early Man in Britain.'

where the deposit is most fossiliferous, there have been found three species of elephant, and the remains of *Hippopotamus major*, *Rhinoceros etruscus*, *Equus caballus*, *Ursus spelæus*, and various kinds of deer, &c. It is also very full of fossil remains at East Runton, the bones of elephants, of *Trogontherium* (a kind of extinct beaver), and of deer having been discovered; while at Lower Sherringham the bones of elephants and deer are again recorded.

It is at once evident that the name "Forest Bed" is an unfortunate one to apply to strata in which the stools of the trees have all been drifted to the positions in which they now stand. But the remarkable thing among the mammalia, when contrasted with those from analogous formations of Oolitic age, is their great size. It is true that smaller forms are not entirely absent, but it is clear that in the Forest Bed the remains of large mammals are decidedly the most numerous. No doubt the mammalia of the Forest Bed period in Britain were, on the average, decidedly larger than those of our Oolitic age, even if we suppose marsupials as large as the *Diprotodon*, and the gigantic kangaroo, to have existed here in Oolitic times.* Still, whatever epoch we take, it seems unquestionable that the smaller mammalia must always have been vastly more numerous than the larger—in any considerable area there must always have been hundreds of creatures no bigger than a rabbit for one of the size of a buffalo or an elk, not to mention a rhinoceros or an elephant. The explanation seems to me to be that the drifted tree trunks and the carcasses of the large mammalia would tend to float away and to be stranded together in certain spots, while smaller creatures, similarly brought down the rivers to the shore, would, as a general rule, be carried farther on, though occasionally checked by obstacles in the shape of the larger animals and the drifted trees. Thus, in the Forest Bed, it appears to me that the geological record tends to give us an exaggerated notion of the average size of the mammalia of Britain, just as in the Oolites it probably gives an unfounded impression of their invariable smallness.

In 'Early Man in Britain,' Prof. W. Boyd Dawkins decides against the probability of the existence of man in the Miocene period on the ground that no living species of land mammal has

* Just as the mammalia of South Africa are on the average decidedly larger than those of South America, though the latter country is not destitute of large animals.

been met with in the Miocene fauna. He adds that "Man, the most highly specialized of all creatures, had no place in a fauna which is conspicuous by the absence of all the mammalia now associated with him." In treating of Pliocene times also he states that a certain argument against the probability of the existence of man in Italy during that epoch seems to him unanswerable. It is this. Of 21 species of fossil mammalia which inhabited Tuscany in the Pliocene age there is only one species now alive, and that it is highly improbable that man should be present in a fauna composed of so many extinct species, as "they belong to one stage of evolution, and man to another and a later stage."

While there can be no doubt that the circumstances on which Prof. Boyd Dawkins relies are by no means without a certain significance, a little consideration will show that they are by no means decisive; for the strong resemblance of the existing Australian mammals to those of the European Oolites, and the almost entire absence of the higher mammalia in that country, have shown how deeply the distribution of land-mammalia is affected by the existence or non-existence of land-passages between adjacent land-areas at certain periods. The nature of the mammals of Madagascar, as compared with those of South Africa, also testifies very strongly to the power of this influence. Yet in both these countries man was found as an indigenous mammal on their discovery, though in Australia the only other representative of the higher mammalia was the dingo, and in Madagascar the only other examples of the *Primates* were certain lemurs. In Africa, as everyone knows, man co-exists with monkeys, baboons, the chimpanzee, and the gorilla. Thus it is obvious that in Australia and Madagascar we should find the fossil remains of man in cave, river, or other deposits, in much lower mammalian society than that in which they might appear in Africa.

Now, as regards Tuscany, Sir A. C. Ramsay has pointed out* that the Alps must have been at the beginning of post-Miocene (or Pliocene) times, "prodigiously higher than they now are; and the amount of depression that the Mediterranean area underwent must have been commensurate, so to speak, with the great height to which the Alps, the Pyrenees, and other mountain ranges were upheaved in post-Miocene times." Thus the Pliocene period in Italy seems to have been one during which that country was

* 'Europe,' Chap. I.

peculiarly isolated, the Alps being more impassable than they now are, while the sea flowed over the plain of Lombardy and between Sicily and Africa ; and, as we have seen, the mammals of an isolated area may differ in the most fundamental manner from those of neighbouring districts.

But primitive man, from a very early period, must have possessed considerably greater powers of crossing sea-barriers than the rest of the mammalia. If influenced by migratory instincts he might, by the aid of a rudely-constructed raft, take advantage of calm weather to cross straits which would be far beyond the natural swimming powers of the strongest and most active of other land-animals ; and even where the watery channel might not prevent an animal from being now and then accidentally carried by favourable currents to the opposite shore, no permanent settlement there would be possible to stray individuals thus reaching it at considerable intervals of time. But men could construct a raft only by combining together to make one, and they would make one only for the purpose of settling in a new home across the water ; and as the native Australian, who is now among the lowest of mankind, could hardly have travelled to his present home from the Eurasian continent without having crossed more than one strait, we may infer that European man, at a very early period of his existence, had a power of changing his environment far beyond that of the other land-mammals.

We are too much accustomed to look upon savages as men inferior to ourselves in everything of the slightest importance, and to forget that primitive man could not possibly have been gradually increasing his lead among animals during so many ages, except through the development of his powers of observation and reasoning. The main difference between the intellectual education of savages and that of more civilized men is due to the fact that savages have largely to struggle for their existence with other animals, while civilized men compete mainly with each other. But if savages are compared fairly with their more advanced brothers, the result will demonstrate that they possess special intellectual advantages as well as defects, their advantages being such as must be obvious to all members of this Association. Thus Mr. A. R. Wallace remarks —

“Savages make long journeys in many directions, and their whole faculties being directed to the subject, they gain a wide and

accurate knowledge of the topography, not only of their own district, but of all the regions round about. . . . His acute observation enables him (the savage) to detect the slightest undulations of the surface, the various changes of subsoil and alterations in the character of the vegetation that would be quite imperceptible to a stranger. His eye is always open to the direction in which he is going; the mossy side of trees, the presence of certain plants under the shade of rocks, the morning and evening flight of birds, are to him indications of direction almost as sure as the sun in the heavens."*

It is thus evident that the educated savage is decidedly proficient in that power of observing the phenomena of external nature in which the educated man of civilization is usually lamentably deficient, a deficiency the latter is now endeavouring to remedy by the study of natural science, and the formation of naturalists' field clubs.

It would seem that primitive man must have had, from a very early period, two great advantages over the other mammalia; a greater power of communicating his thoughts to his fellows, and the sole power of lighting a fire. Even if we suppose the language of the men whose implements we find in our river drifts to have been not more advanced than that of English children about two years old, the advantage may have been one of almost incalculable importance to them. And it seems to me that to the superiority of the intelligence of primitive man we indirectly owe the absence of his personal remains in the river drifts of the Thames and elsewhere, in which his implements are so abundant.

No doubt we may often find flint implements in gravel in which the bones of either man or of other animals must speedily have disappeared from the percolation of rain-water through the deposit. Yet there is nothing in the nature of man's bones to account for their non-appearance in river drifts, where those of deer, oxen, and other animals have been preserved, in periods during which man's implements show him to have existed. The true explanation seems to me to lie in the fact that man is not an animal whose habits and intelligence make it likely that his bones would appear in river drifts.

* 'The Limits of Natural Selection as applied to Man.' Livingstone makes similar remarks about the South African natives, 'Mission Trav.', Chap. I.

Even the largest creatures, such as elephants and rhinoceroses, are liable to be carried away on attempting to cross flooded rivers. Thus Sir Samuel Baker remarks in his journal ('Nile Trib.,' Ch. VIII): "A dead elephant floated down the river to-day; this is the second that has passed within the last few days." Other herbivorous creatures, such as oxen and deer, very frequently become the prey of the larger carnivora at drinking places by the waterside, the attack occasionally resulting in the drowning of both assailant and assailed. Hence the fact pointed out by the late Prof. John Morris, more than fifty years ago, that the remains of mammals in the river drifts of the Thames belong chiefly to the Ruminantia and the Carnivora, the former being abundant, and the latter sparingly distributed. Since the existence of the Carnivora (and especially of the Felidæ), these are the two orders we should expect to find especially well represented in a deposit containing Mammalia; and as only a percentage of the remains floating down a river would be preserved, those of genera forming one per cent. or less of the drifting carcasses would in all probability not be preserved at all.

But primitive men would have usually no difficulty in selecting sites for their dwelling-places, which would enable them to obtain water without danger from lurking Carnivora, while their keen powers of observation would enable them to avoid floods better than their fellow mammals. When man of the river-drift period fell a victim to some carnivorous animal, he would not generally perish by the waterside, but be pounced upon from some inland bush or crag, and devoured near the place of his capture, his remains being thus wholly lost to the geological record. Nowadays, except in certain islands, we obtain information about savages mainly when their more civilized competitors have deprived them of the best land and driven them to the worst. But in Palæolithic days, when men were few and far between, there was no pressure of population, and the best sites for temporary or permanent villages were all open to them. In every clime the Carnivora have been immensely more formidable to man as destroyers of his domestic animals than as slayers of himself. This is eminently the case in India at the present day, where, though they kill a very considerable number of cattle and other domestic creatures every year, the bites of snakes cause a loss of human life eight or nine times as great. Palæolithic man had

probably no domestic animals to attract Carnivora to his settlements.

My object in the foregoing remarks has been to remind you not merely of the fragmentary nature of the geological record as shown by the very large number of unconformities between different formations, but also to illustrate its extreme uncertainty as a guide to the nature of the terrestrial life of any given place and period. Mammalia, the most interesting and important of all animals, are of all the most certain to be represented by a selection, showing merely the forms whose habits made them especially liable to be buried in deposits of somewhat exceptional character, and which abounded near the place at which the deposit was formed. The uncertainty of mammalian evidence is well shown in Mr. Whitaker's recently published memoir on 'The Geology of London.' Readers of the very interesting chapter which consists of a 'Review of the Literature of the Thames Valley Drift,' will learn that while the two greatest stratigraphical authorities agree as to the formation of the valley and the respective ages of the beds, an eminent palæontologist had contested their views on the ground that they were diametrically opposed by the mammalian evidence, and would, "if proved to be true, overthrow the Palæontological value of the labours of all the Tertiary mammalogists." It is hardly necessary to point out that the stratigraphical position of beds is the only testimony furnishing absolute evidence of their age. Where stratigraphical evidence is wanting, that of fossils may give a presumption of more or less strength as to the affinities of a formation; but opposed to stratigraphical evidence its weight is nothing as regards the settlement of age, though it may be in the highest degree valuable and interesting in other respects. Speaking of these Thames Valley Drifts, Prof. Boyd Dawkins remarked in 1867,* that "the presence of *Elephas priscus* and *Rhinoceros megarhinus* indicates the affinity of the group to the Preglacial deposits of Norfolk, and to the foreign Pliocene strata. The tichorhine and leptorhine Rhinoceroses, on the other hand, point towards deposits of clearly-defined Postglacial age. . . . The beds under consideration are also as remarkable for the absence of some as for the presence of others of the Pleistocene mammals." In this case stratigraphical authority decidedly inclines to a belief in the (locally) postglacial origin of

* 'Q. J. G. S.,' Vol. xxiii.

the beds, while the palæontological evidence, as we have seen, is almost equally in favour of their preglacial, and of their post-glacial age.

In conclusion, I would remark that evidence of ice-action in our later formations is not in itself necessarily sufficient to warrant us in dating them from the Glacial epoch. In the case of these Thames Valley Drifts, for example, some geologists see in the presence of large and but slightly worn blocks of stone in the terrace gravels but evidence of the action of river-ice; others look upon these blocks, and on slight surface contortions in these old river deposits, as establishing the rocks in which they appear to be of the Glacial Period. It seems to me that as river-ice is not only quite competent to produce these effects in Thames Valley Beds, but must often have produced them during the ages in which the river valley has been slowly assuming its present shape, glacial indications of this kind may possibly be of any postglacial period, and should not be referred to the Great Ice Age simply because they point to ice-action of some kind. We are now in the year of Jubilee as regards the recognition in England of ice action as a great geological agency, the famous papers of Agassiz and Buckland having been read before our Geological Society in the autumn of 1840. The geologist of to-day who reads an account of the discussion which took place after the reading of Buckland's paper* will find that at that time moraines, erratic blocks, boulder clay, etc., had been all lumped together as "diluvial detritus." He will note that Buckland, Agassiz, and Lyell were opposed by Murchison, Whewell, and Greenough, and that while the supporters of the glacial view had no conception of the former existence of a Great Ice Age in the northern hemisphere, their opponents relied on the wide extent of the sheets of "diluvial detritus" in low countries as showing how little the mere agency of glaciers could account for their existence.

I had thought of touching on certain matters connected with the Glacial Period, which, however, the time at my disposal will not allow me to discuss. I will therefore refrain from saying anything calculated to elicit that warmth of feeling which Glacial in common with Archæan questions invariably excite, and bring to an end these desultory remarks on the geological record.

* See 'Midland Naturalist,' Oct., 1883, where notes of the discussion taken by the late Dr. S. P. Woodward are given by Mr. H. B. Woodward.