

so that it is traversed by simple curved veins converging at the apex. But in *Sciadopitys* it appears from one of Zuccarini's figures (t. 3, f. 7) that the dichotomy is not confined to such narrow limits as in *Pinus*, and that consequently forked veins occur higher up in the scale. This was to some extent apparently also the case in the Solenhofen scales.

Mr. Carruthers has named his species after the persons from whose collections he has described them. I shall follow his example in attaching the name of Häberlein to the species from Solenhofen.

*Araucarites (Eutacta) Häberleinii*, Dyer, n. sp.—Strobili squamis late obovatis vel subrhomboidalibus abrupte acuminatis, lepidio brevissimo, nervis leniter curvis demum furcatis.

### III.—ON THE CLIMATE OF THE POST-GLACIAL PERIOD.

By S. V. Wood, Jun., F.G.S.

IT has been generally assumed by geologists that the climate of the period which followed the elevation of the Glacial beds was one of gradual amelioration from a rigorous to a mild one. The Rev. O. Fisher some time since, however, in describing certain appearances presented by some superficial sections which he denominated "Trail,"<sup>1</sup> suggested that they were due to a second period of cold, which he regarded as having occurred between 100,000 and 200,000 years back. Without adopting, in all respects, the views of Mr. Fisher, I yet think that the facts, as far as yet known, point to the conditions of climate during the Post-glacial period having been the reverse of what has been generally assumed with respect to them; and I propose here to give some reasons for that idea.

1. *The Geological evidence.*—Speaking for the Eastern side of England, as that which has more particularly come under my notice, there seems to be an absence of any evidences of ice-action during the emergence of the land from the Glacial sea. If masses of shore-ice, such as now gather in winter round the coasts of Labrador and Hudson's Bay, and even in the Gulf of St. Lawrence, had, during this submergence, accumulated in the numerous inlets and channels formed by the partially emerged rocky districts of the North of England, and of Scotland, such ice travelling southward in summer would, we might expect, have passed over the lower and therefore not yet emerged country of East Anglia, and have plentifully bestrewn it with some of those blocks that in millions cover the surface of the Glacial drift of these rocky districts; but I have never met with a boulder in East Anglia whose presence may not be traced to weathering from the Glacial clay beneath it, or to the denudation from the place of its occurrence of Glacial clay in which it was once embedded.

This negative evidence is not, however, altogether satisfactory, because, by a parity of reasoning, we should expect the surface of East Anglia to have been strewn with similar blocks by ice that

<sup>1</sup> Quart. Journ. Geol. Soc., vol. xxii., p. 553; Geol. Mag., Vol. IV., p. 198.

drifted from the same mountainous districts during the late part of the Glacial period itself, when, the continental ice to which the Glacial clays are due having passed away, these districts had become an archipelago in which the boulder-sands, boulder-beds, and boulder-earth, which constitute the Glacial drift of these mountain districts, were, according to my view, accumulated; but we do not find evidences of such a distribution of surface-blocks in East Anglia. It is, however, quite conceivable that these last results of the ice-action of the Glacial period were altogether removed by the considerable denudation to which the sea-bottom must have been exposed during its emergence. As a rule, all large areas from which the Glacial beds have been removed by Post-glacial denudation are thus destitute of boulders. Such, for instance, is the case with the Great Valley of the Thames, the eastern part of which, having its northern heights crowned by Glacial clay, is proved to have been once covered by the Glacial sea;<sup>1</sup> but in which, as also in the wide sheet of Post-glacial gravel that occupies the lower part of the valley, no boulders, save those in the Grays brickearth alluded to in the sequel, occur. It can hardly be denied that into such valley, so far as it had then come into existence, some of the winter-formed ice issuing in summer from the half-emerged valleys and glens of the mountain districts, and drifting southwards, would be carried by the tide, and distribute blocks, if at that time the climate of these districts was such as to generate marine ice.

It is very important, in this question, that the distinction between Glacial-clay and Boulder-clay should be kept in view. Glacial-clay may be Boulder-clay, or be nearly destitute of boulders, according to the nature of the country over which the Glacial-ice travelled before shedding at its seaward termination the *moraine profonde*, to be distributed over the contiguous sea-bottom as Glacial-clay. If that country be a rocky one like the North of England, or like Scotland, boulders abound in the clay; but if an extensive area of soft strata intervene between the sources of the ice-stream and its seaward termination, such as was the case in East Anglia, the bulk of the resulting Glacial-clay consists of the degraded material of these softer strata, and the boulders in it form but a subordinate feature. Where this kind of clay lies against the Chalk Wold of Lincolnshire, it is nothing but reconstructed chalk, so pure as to be burnt for lime; and generally all over the counties south of the Humber and east of the Trent, the Glacial-clay is principally formed of rolled chalk, with boulders only sparsely scattered through it. On the other hand, Boulder-clay produced by the dropping of boulders over a sea-bottom from coast-ice, without the presence of any sea-terminated glacier, with its submarine terminal moraine, is a different thing, presenting none of that glacially degraded material which constitutes the mass of Glacial-clay. In the East of England we

<sup>1</sup> Until the objections submitted by me at p. 92 of Vol. VIII. of this MAGAZINE to any other than a submarine origin for this clay are removed, I assume the existence of such clay on the heights above the Thames Valley as proof of the Glacial sea having covered them.

find such a non-Glacial clay in that of Hessele, in Yorkshire, and also, as it appears to me, in the South of England along the coast of Sussex, about Selsey and Bracklesham.<sup>1</sup> Both the Hessele and the Sussex clays occur in the neighbourhood of the chalk country, and ought, if accumulated under similar Glacial conditions to the Glacial-clays of East Anglia, to be similarly constituted, so far as its general character is concerned, which is not the case. I shall refer in the sequel to both these clays, which seem to me to have been accumulated long after the emergence of the principal part of the land from the Glacial sea, and long after the Glacial period proper had passed away; and to furnish evidence of a return to cold conditions after a period of warmth, during which Northern Europe became stocked by the great Mammalia.

2. *The Palæontological evidence.*—It is well known that Northern Europe and Asia were inhabited, after the emergence from the Glacial sea, by various species of large mammalia, and notably by several species of the genera *Elephas*, *Rhinoceros*, and *Hippopotamus*, whose living congeners inhabit exclusively hot countries. The occurrence, in a frozen state, in Siberia, of individuals belonging to two out of these genera, clad in a coat of hair, seems to have led geologists to the conclusion that these pachydermata, as well as the Cave Lion, were specially adapted for a cold climate; and that their extinction before the historical period, all over Europe, and Central and Northern Asia, must have been due to some other cause than that of inclemency of climate; and the favourite hypothesis seems to have been that they owed their extinction to the attacks of Post-glacial man, whose implements are not unfrequently associated with their remains in Post-glacial deposits. A little reflection will, however, I think, show that much improbability attaches to this idea.

Africa has been from the remotest historical times peopled by numerous inhabitants, and to these the use of iron seems long to have been known; but until the ivory hunters with fire-arms, and more recently with rifles and explosive bullets, began to persecute them, the African pachydermata seem to have maintained their numbers. Similarly the civilization of Southern Asia is very ancient, and the use of metals probably dates back there several thousand years; but what have the civilized Asiatics with the accessories of metal weapons and of the domesticated horse done towards exterminating the Asiatic pachydermata and great felines? Modern sportsmen with their destructive weapons have done more towards this in half a century than has been done during thousands of years of antecedent civilization. Are we then to suppose that thousands of years before this civilization even commenced (and when no doubt similar uncivilized races existed in Southern Asia and in Africa to exterminate, if they could, the great mammalia of those regions also) the scattered tribes of men who managed to exist along the shores and rivers of Europe, and of Northern and Central Asia, exterminated with their

<sup>1</sup> Brought to notice by Mr. Godwin-Austen. See Quart. Journ. Geol. Soc., vol. xiii., p. 55. Like the Hessele, the Sussex Clay contains numerous chalk fragments, but is quite different from chalky *Glacial* clay.

feeble weapons of bone and flint the gigantic pachydermata and felines of the Post-glacial period? Fancy attacking a rhinoceros, whose hide will turn a rifle bullet, with a flint hatchet or a bone skewer! Contrivances of various kinds have probably been employed by the Asiatics and by Africans, from time immemorial, for ensnaring these animals; but no appreciable effect in diminishing their numbers seems to have resulted. Von Wrangel describes the soil of Siberia as having teemed with the bones and tusks of the elephant, before it had been so much ransacked by the ivory hunters; and he mentions that in some islands of the Arctic Sea, which lie off the Siberian coast, forest beds occur full of elephantine remains which are now beyond the limit of arboreal vegetation, and where now a moss-covered soil only exists, forming a favourite haunt of the reindeer. No one who reads his account of the few wandering tribes that now inhabit the Siberian wastes, and which seem to be in a condition scarcely superior to that of the Post-glacial bone and flint implement races, can suppose that they exterminated the great herds of elephants that once roamed over Northern Asia, for they cause no diminution in the numbers of the easily-vanquished herds of reindeer, which they attack and slaughter while crossing the rivers, since these return again in equal numbers another year.

Mr. Dawkins has pointed out that the remains of the reindeer occur in certain Post-glacial deposits only, and more particularly in those of the caves, and that with them are associated the remains of the more recent species of extinct pachydermata; and reasoning from the habits of their living analogues, we may without qualification assert that conditions which would be essential for the subsistence of the pachydermata would be unfavourable for the reindeer, and *vice versa*. The reindeer subsists principally on a moss, which grows rapidly over the frozen soil of the regions skirting the Arctic Sea, upon which arboreal vegetation will not exist, retiring from these mossy wastes to the woody regions for a season only; and no large herbivorous animal, except the musk ox, is able to sustain life in the regions that are peculiarly the haunts of the reindeer. The rhinoceros and elephant, on the other hand, require an arboreal vegetation for their support, and are never away from it; and however the hippopotamus may have struggled against them during its decline, we can scarcely suppose that it could ever have been tempted to *migrate into* a region of frozen rivers, or to abandon the abundant feeding ground afforded by the banks and swamps of warm southern rivers for the frozen and barren wildernesses frequented by the reindeer.

The question then arises, how do we come to find the remains of such incongruous animals in association in Post-glacial deposits? The answer appears to me to be, that when the pachydermata spread themselves over Northern Europe, after the Glacial period, the climate was mild and equable; and that it was owing to a subsequent and late Post-glacial refrigeration that the reindeer coming from the North overran the country thus already occupied by the great mamalia; and that these latter, as the cold gradually progressed, adapted

themselves as best they could to its adverse influence, until this eventually brought about their extinction; the assumption of a hairy coat being merely one of those efforts to protect itself which nature helps animals to make. Doubtless the pachyderms for a long time resisted these influences by a southward migration during winter, when their places were taken by the reindeer, which, in its turn retiring northward in the summer, gave place during that season to the pachyderms; and in this way, probably, their bones have become intermingled in Post-glacial deposits. But this southerly migration of the pachyderms being limited in Europe by the Mediterranean and Black Seas, and in Asia by the great mountain chains that stretch across the centre of that continent, would only afford relief so long as the cold did not necessitate their more southerly retreat. The same kind of problem seems presented to us by North America, where the Tapir,<sup>1</sup> found fossil in Carolina, but now confined to the south of the Panama Isthmus, once ranged; and where the larger felinae, which abound in the southern part of North America, decline to follow their prey into the inclement region of the north.

Mr. Dawkins has dwelt upon the absence of reindeer remains from those older Post-glacial formations, such as the Brick-earths of the eastern valley of the Thames, and of Clacton, which yield a mammalian fauna with a somewhat older facies than the generality of the Post-glacial deposits,<sup>2</sup> and with which fauna the river shell *Cyrena fluminalis* occurs in association. He has indeed insisted that the mammalia of these formations indicate an even warmer climate than now prevails in Britain;<sup>3</sup> and so much was he impressed with this, and with the older facies presented by the remains, that he at first assigned a Pre-glacial age to the formations in question. This view of their age he has since relinquished,<sup>4</sup> but, with the exception of the occurrence of some remains of the Musk-ox, the inference he drew as to the warmer climate and older palæontological aspect presented by the group of mammalia yielded by these formations remains, so far as I know, untouched. These formations, I have endeavoured elsewhere to show,<sup>5</sup> seem to me to have been accumulated about that middle stage of the Post-glacial period when conditions of climate adequate to produce ice, capable of the transport of blocks, were again coming upon a region that had long enjoyed a temperate climate. If we look at the distribution of the existing species of Elephant, Rhinoceros, and Hippopotamus, we see that their northerly migration into the regions once occupied by their fossil congeners is prevented by the Mediterranean and Black Seas, and by the lofty and snow-capped mountain-ranges which stretch from the Black Sea to the southern frontier of China; the bridge which Capt.

<sup>1</sup> I omit the Mastodon, as we have no living analogue of that animal wherewith to judge of its climatal peculiarities.

<sup>2</sup> Quart. Journ. Geol. Soc., vol. xxiii., p. 108; vol. xxiv., p. 515; vol. xxv., p. 213. The presence of the Megarhine Rhinoceros seems to be the special older feature in the fauna of the Eastern Thames Brickearths.

<sup>3</sup> Ibid.

<sup>4</sup> Ibid. vol. xxv., p. 217.

<sup>5</sup> Ibid. vol. xxiii., p. 394. GEOL. MAG., Vol. III., pp. 57, 99, 348, and 398.

Spratt has shown to have once probably existed about Malta,<sup>1</sup> and by which intercourse between the two continents was formerly possible, having probably disappeared at the period before alluded to, when the southerly winter migration of the pachydermata was arrested. Now the molluscan associate of the great mammalia in the older Post-glacial deposits of Britain, *Cyrena fluminalis*, seems to be cut off from Europe and from Northern Asia by nearly the same barriers as those which confine the great pachydermata, since it ranges at the present day from the Nile, through Syria, to the Himalayas and China; while, so far as is yet known, this shell has not occurred in this country in association with Reindeer remains.

It should not be forgotten, in this question, that the remains of some *Coleopterous* insects, obtained by Mr. Fisher from an undoubted Post-glacial deposit at Lexden (and from which as yet we have no occurrence of Reindeer remains), were examined by Mr. T. V. Wollaston, F.L.S., who, guarding himself from a decided opinion as to the specific identification of the specimens, states that from two of them (especially a *Cossiphus*, which he says does not occur north of the Pyrenees) he did not think there could be much doubt that a warmer temperature than at present obtains was indicated by the forms thus procured by Mr. Fisher.<sup>2</sup> If Mr. Wollaston's view be correct, it would be only necessary to suppose that this Post-glacial deposit of Lexden preceded others in which the remains of insect groups resembling those of Northern Europe occur.

3. *The Geological evidence resumed.*—At Paul Cliff and Kelsea Hill, in Yorkshire, there occurs a gravel, containing, in association with marine shells, this freshwater molluscan associate of the Megarhine Rhinoceros in the Thames Brick-earths, *Cyrena fluminalis*, which, like its Mammalian associate, inhabited this country in pre-glacial times. This gravel, at one of these localities, is seen to rest on the Glacial-clay, and at the other to be overlain by the non-glacial Boulder-clay of Hessle previously alluded to. The marine mollusca occurring with it, moreover, are clearly Post-glacial, being all of living species, which, with two or three exceptions found in seas immediately to the North, inhabit British seas; contrasting in this respect with the Glacial-clay on which the gravel reposes, which yields (not far off, at Bridlington) a more arctic fauna, and one containing the two well-known Crag species *Nucula Cobboldiæ* and *Tellina obliqua*, whose nearest living analogues occur in the Pacific. The presence of this fluviatile shell in swarms in this gravel shows that the land had emerged from the glacial sea so as to support a river not far distant; and the position of the gravel thus overlain by the Hessle-clay, is shown by the coast section to occupy troughs cut out of the deeply-denuded glacial beds. We cannot doubt, therefore, that we have here one of the deposits of the earlier part of the Post-glacial period, similar to the Brick-earths of the Eastern Thames valley, that are full of the same shell; and that in its overlay by the non-glacial Boulder-clay of Hessle we get evidence of the incoming,

<sup>1</sup> Quart. Journ. Geol. Soc., vol. xxiii., p. 292.

<sup>2</sup> Quart. Journ. Geol. Soc., vol. xix., p. 399.

about this time, of ice conditions adequate to the transport of small boulders, such as is evinced by the remarkable nest of boulders which occurs in the Brick-earth at Grays, in the Eastern Thames valley.

I have in various papers endeavoured to show that the South and South-east of England was, during the earlier part of the Post-glacial period, covered principally by sea, the bottom of which was undergoing disturbance and great denudation from subterranean action, the country to the North of the Thames being land, and penetrated by small rivers in which these *Cyrena*-bearing Brick-earths accumulated; and I have given restoration maps in which I have endeavoured to trace the emergence of the South of England from this stage.<sup>1</sup> Now it is remarkable that in all the great sheet of the Thames gravel which preceded this Brick-earth we should get no traces of boulders, while so many should occur in the Brick-earth itself; and the circumstance seems to me to indicate the absence of ice-action during the deposit of the former, and its commencement during the accumulation of the Brick-earths. Further, in those gravels of Hampshire which, in the paper last referred to, I have on totally different evidence endeavoured to correlate with these *Cyrena* Brick-earths, boulders of Sarsen sandstone occasionally occur.<sup>2</sup> These seem to be confined to the gravels at medium and lower levels, and to be absent from that higher part of the Hampshire sheet which I have attempted to connect with the main and higher sheet of Thames gravel.

In the same paper, and in the restoration maps accompanying it, I have endeavoured to show that the emergence of the principal part of the South of England, and the retreat of the sea within the Valley of the Weald, the denudation of that valley, and the eventual reversal of the drainage in it, was posterior to these *Cyrena* Brick-earths of the Thames Valley, and occupied that long period which I call the later part of the Post-glacial one; and I also endeavoured to show that the non-glacial Boulder-clay of the Sussex coast, in which very large blocks derived from the West occur, belonged to this later Post-glacial period. I have already pointed out that this clay, like the Hesse, had it been formed during the Glacial period, could hardly have failed to present those physical features which are common to all Glacial-clay formed in the neighbourhood of soft strata, and especially of the Chalk; and it is most important that it offers in the molluscan fauna of the deposit which it overlies similar corroborative testimony of Post-glacial age as does the Hesse clay. Like the latest part of the Crag, all the Glacial beds of the East of England yield some mollusca which are not known living, and others whose present habitat is in distant and northern areas such as the North American coast, Greenland, etc. The oldest of these, the pebbly sand of Norfolk and Suffolk (the shallow water equivalent, as I regard it, of the Cromer Till), has some of both of these classes; the East Anglian Middle Glacial has this feature even more marked,

<sup>1</sup> Quart. Journ. Geol. Soc., vol. xxvii., p. 20.

<sup>2</sup> For some examples see GEOL. MAG., Vol. III., p. 296.

while the yet newer deposit of Bridlington has two of the first and several of the latter class, and the fauna of all of these three formations presents more or less affinity to that of the Crag, the molluscan remains in all being thoroughly fossilized. The bed, however, which underlies this Sussex clay presents the greatest contrast to these Glacial deposits and to the Crag, as it contains a somewhat numerous molluscan fauna, in fine preservation, which is not only hardly fossilized at all, but consists entirely of species still living, and living, moreover, in contiguous or but little distant seas, and those Southern ones. These living species nearly all occur on our present Southern coast, while of the rest a few are confined to the Lusitanian, and one or two to the Mediterranean coast;<sup>1</sup> affording pretty clear evidence that at a period not very far back, but anterior to those ice conditions to which the great blocks occurring in the overlying clay are due, a warmer and more Lusitanian-like sea washed the southern shores of Britain.<sup>2</sup> Associated with the mollusca in this bed occur Mammalian remains which present none of those older features attaching to the remains from the *Cyrena* Brick-earths of the Thames Valley, and of course still less of those attaching to the pre-glacial forest beds of Norfolk; and which, although neither the Reindeer nor Musk-ox are among them, are grouped by Mr. Dawkins<sup>3</sup> with the ordinary Post-glacial Mammalian fauna of Britain, as distinguished from the Thames Brick-earth group.

This non-glacial Boulder-clay appears to me to be of even later age than that of Hesse; and to present evidences of erratic transport requiring much more ice-power, some of the blocks described by Mr. Godwin-Austen and by Sir Charles Lyell being enormous. Tracing the sequence of events from quite different evidence to the above, I endeavoured to show in the before-mentioned paper that this Sussex clay was formed near the close of those Post-glacial changes to which I trace the present condition of the South and South-east of England;<sup>4</sup> that is to say, just about the stage when the Weald was completely deserted by the sea, and its drainage reversed into its present direction; in the gravels of which drain-

<sup>1</sup> A list of 38 species from this deposit is given by Mr. Godwin-Austen in *Quart. Journ. Geol. Soc.*, vol. xiii., p. 50, and as many more have since been obtained by Mr. Alfred Bell. Mr. Godwin-Austen in the same paper also notices the Mammalian remains.

<sup>2</sup> In the paper in vol. xxvii. of *Quart. Journ.* before referred to, I endeavoured to show that subsequent to the formation of the Thames Brick-earths, and prior to the accumulation of this Sussex molluscan deposit, an isthmus joining Kent to France had come into existence, which divided the Lusitanian connected waters of the South of England from those of the North Sea. The marine shells of the Post-glacial gravels of East Anglia have a more northerly character than those of the Sussex bed, though agreeing with them in belonging all to living species, that with a few exceptions (which occur in contiguous seas) yet survive in British waters.

<sup>3</sup> *Quart. Journ. Geol. Soc.*, vol. xxv., p. 195. See column headed Bracklesham.

<sup>4</sup> We get no evidence of this late Post-glacial ice-action over Essex, Suffolk, and Norfolk, except it be in Mr. Fisher's 'trail,' because, as it appears to me, these counties were then all land, having, in common with all England, at a still later or pre-historic period, undergone that subsidence which is indicated by the submerged forests round our coasts.



age there occur, according to Mr. Godwin-Austen, some large ice-transported blocks. This seems to me to have been the period when the Reindeer frequented Britain and the South of France, and that to which so many of our river gravels belong.

Whether any geologists may be disposed to agree in the view which I have put forward or not, the question I think demands investigation; and the more this is attempted, the more, I think, geologists will become satisfied of the greater remoteness of the true Glacial period, and of the far longer duration of the Post-glacial, than has been hitherto supposed.

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#### IV.—ON SOME POINTS IN THE GEOLOGY OF THE EAST LOTHIAN COAST.

By G. W. and F. M. BALFOUR,

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THE interesting relation between the Porphyrite of Whitberry Point, at the mouth of the Tyne near Dunbar, and the adjacent sedimentary rocks, was first noticed, we believe, by Professor Geikie, who speaks of it in the Memoirs of the Geological Survey of East Lothian, pages 40 and 41, and again in the new edition of Jukes's Geology, pp. 269. The volcanic mass which forms the point, consists of a dark felspathic base with numerous crystals of augite: it is circular in form, and is exposed for two-thirds of its circumference in a vertical precipice facing the sea, about twenty feet in height.

The rock is traversed by numerous joints running both in a horizontal and in a vertical direction. The latter are by far the most conspicuous, and give the face of the cliff, when seen from a distance, a well-marked columnar appearance, though the columns themselves are not very distinct or regular. They are quadrangular in form, and are evidently produced by the intersection at right-angles of the two series of vertical joints.

It is clear that the face of the precipice has been gradually receding in proportion as it yielded to the action of the waves; and that at a former period the volcanic rock extended considerably further than at present over the beds which are seen to dip beneath it. These latter consist of hard fine-grained calcareous sandstones belonging to the Lower Carboniferous formation. Their colour varies from red to white, and their prevailing dip is in a N.W. direction, with an average inclination of 12–20°. If the volcanic mass is a true intrusive rock, we should naturally expect the strata which surround it to dip *away* in all directions, the amount of their inclination diminishing in proportion to their distance from it. We find, however, that the case is precisely the reverse: as the beds approach the base of the cliff, they dip *towards* it from every side at perpetually increasing angles, until at the point of junction the inclination amounts in places to as much as 55 degrees. The exact amount of dip in the various positions will be seen on referring to the accompanying map.