

II.

LATE-GLACIAL AND EARLY POST-GLACIAL SCOTLAND. By  
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I. INTRODUCTION.

It is unnecessary for the writer to emphasise the interdependence of the two sciences, Geology and Prehistory. It is well known that the geologist is dependent on the archæologist for the interpretation of the fossils, be they human remains or implements, found in our superficial deposits, and that geological methods are constantly used by the archæologist. Nevertheless, in spite of the fact that everybody realises that this interdependence theoretically exists, it is remarkable how seldom there is any marked co-operation between the workers in these two fields. This is perhaps particularly so in Scotland.

The remains of our early ancestors come within the sphere of geology in the same way as the study of the fossil remains of ancient plants and animals is part of the everyday task of the geologist. Geology is concerned with the history of the earth, of its fauna and flora. The geologist does not think of stopping his researches at any time before the present day. He is just as active watching the action of man, or of the sea, or of the rivers of to-day, as he is in unravelling the history of a thousand million years ago when our oldest rocks were being formed.

The geologist arranges the events of the past history of the earth in a chronological sequence beginning with the oldest and finishing with the youngest. The largest of the units into which geological time is divided are called *eras*, and these in turn are divided into *periods*, and the periods into *epochs*.

In this paper we shall be concerned with the history of Scotland during the Quaternary Period, the youngest of the subdivisions of the record, and the shortest. Because of the opinion which man has of his own importance the Quaternary is often spoken of as the Age of Man, thereby giving it more or less the rank of an era and comparing it in magnitude with the great eras of geological time. We know, however, that, geologically speaking, the Quaternary was very short and that man actually lived in the preceding Pliocene epoch.

The Quaternary Period is further subdivided into the Recent and

Pleistocene epochs. The latter is the epoch of the Great Ice Age. In its turn it is again subdivided into a great many stages of human culture, mostly by the joint work of the archæologist and the geologist. Here we shall consider Pleistocene and Palæolithic as synonymous. The geologist as a rule thinks in terms of the Pleistocene and the archæologist in terms of the Palæolithic. The geologist often uses both terms, Palæolithic usually referring to the older Quaternary history of the unglaciated parts of our country, whereas the same time in glaciated regions is thought of as the Pleistocene.

Pre-Palæolithic time is undoubtedly the province of the geologist, and in the study of more recent times the archæologist may succeed without geological advice. Nevertheless, so much archæological research has been carried out in post-Palæolithic studies, both in Scotland and in Ireland, with results which are entirely at variance with geological observations, that it seems necessary for the archæologist and the geologist to work together when studying deposits up to, and perhaps including, the Neolithic.

From what has just been written, therefore, it will be clear that, in the writer's opinion at least, the archæologist who tries to interpret the Palæolithic history of Scotland without the collaboration of the geologist will be making a much less profitable contribution to scientific knowledge than is deserved by the amount of work and thought put into his research.

To take a case in point, it has been written in a discussion of the question of the Assynt Caves that, "It will no doubt be asked when the last ice period terminated in this country. *The question is purely a geological one*, but it may be taken that the final melting of the ice occurred many thousands of years ago." (The italics are my own.) In the same note, however, the theory is put forward that the caves were occupied by Palæolithic man, without any geological evidence whatever in its favour.

We have no intention of referring to the great number of references which have been made in non-scientific publications to the occurrence of Palæolithic man in Scotland, but it must be pointed out that in *Nature* (19th September 1936) Mann claimed to have found "a number of rolled stone implements of types similar to those of the palæolithic cultures of England and France" in "the glacial clays and derived gravels" of Shetland. If these deposits do contain implements they should certainly be studied by a group of geologists and archæologists. So far no glacial deposit in this country has yielded human implements and it is highly improbable that the Shetland finds are artifacts.

The glacial history of Ireland is rather similar to that of Scotland, and in recent years a great deal has been written about Palæolithic man in that country, particularly in Sligo and Waterford.

It was in 1927 that Burchell announced the discovery of supposed Palæolithic implements in Sligo, and in the following years about forty papers on the subject appeared in various scientific journals. A careful study<sup>1</sup> by Professors Macalister and Charlesworth of all the sites which were supposed to have yielded implements suggested that what was considered to be an old sea cave in one locality (Coney Island) is in reality a very recent product of the marine erosion which is still so actively in progress on that coast. Actually, the cliff-face has been cut away since the middle of the nineteenth century, for, as Macalister and Charlesworth have shown, the concrete foundation of a building now overhangs the cliff.

The recent age of the other sites is also undoubted, and the supposed implements were demonstrated to have been formed by marine erosion within the last hundred years.

Recent studies in south-east Ireland in the cave which yielded the remains of the Kilgreany man have shown that the human remains are in all probability of comparatively recent date, although the cave did contain a Pleistocene fauna.

In the present paper we shall consider what the geologist has to say about Scotland and neighbouring countries during the Pleistocene or Palæolithic epoch. The Palæolithic history of northern Britain is closely linked with the events of southern Britain at a time when this country was connected with the Continent across the present Straits of Dover and southern portion of the North Sea.

## II. PRE-PALÆOLITHIC SCOTLAND.

The history of the time immediately preceding the Palæolithic in Scotland is rather difficult to interpret. The evidence which has survived the passage of the great ice-sheets consists for the most part of the drowned valleys or fiords of western Scotland, the buried channels of pre-existing rivers in certain parts of the Midland Valley, and the coast-line of the sea in pre-glacial times. We cannot speak with any degree of precision of the ages of these features. We conclude that they came into being before the Ice Age and also that the fiords and buried river channels are earlier than the pre-glacial beaches.

An examination of the condition of the country at this time is

<sup>1</sup> *Proc. Roy. Irish Acad.*, vol. xxxix. (1929-31).

extremely important, as it has a close bearing on the possibility of pre-glacial life surviving the Ice Age.

The buried valleys mentioned above differ from the sea lochs in that they are filled with sands and gravels. These sands and gravels are archaeologically of the first importance, but we shall not pursue the subject further at this stage as it will be discussed later in another connection. Here we are concerned with the fact that they indicate that at some time shortly before the Ice Age sea-level stood about 300 feet lower than it does now.

Then followed a period, also pre-glacial in age, when the sea stood some 170 feet higher than it does now. The existence of this sea is proved by the presence of well-marked raised-beach platforms in some of our western islands—such as Mull, Colonsay, and Oransay—and in parts of the mainland. Pre-glacial platforms occur at other heights: 135 feet (Colonsay); 100–160 feet (Mull); 140 feet (Ardnamurchan); 100 feet (Islay); 75 feet (Stonehaven); 60 feet (Outer Hebrides); 25 feet (Iona).

The existence of these beaches round our western islands and along different parts of our mainland indicates that immediately before the arrival of the great ice-sheets of the Pleistocene, Scotland was very much as it is to-day. It obviously did not form part of a high continent, as many have said to try and account for the Ice Age.

The raised-beach platforms which we have just been considering must not be confused with the post-glacial beaches which also fringe our coast. That they came into existence before the Ice Age is shown by the fact that their surfaces are striated and moulded by the passage of the ice, and by the fact that they are sometimes covered by boulder clay.

### III. THE PLEISTOCENE.

Strange as it may seem, considering the recent age of the deposits with which we are now dealing, there is no general agreement as to where the line should be drawn between the Pleistocene and the preceding Pliocene. It may seem even stranger that it is found to be equally difficult to point to the boundary between the Pleistocene and post-glacial or recent times.

Indeed, any line between the Pleistocene and recent time must necessarily be arbitrary, for there is no actual break in the continuity of the geological history of Scotland. The evidence which is available appears to point to a more or less regular passage from the Pleistocene to the present. Glacial conditions lingered on in Scotland subsequent

to their final disappearance in England. It is obvious, therefore, that to apply the term "*post-glacial*" to deposits overlying the glacial beds in England is misleading unless the deposits can be shown to be contemporaneous with post-glacial deposits in Scotland. Many of the deposits of "post-glacial" age in England are older than any Scottish post-glacial deposits, and will actually be contemporaneous with some of our glacial beds.

The term *post-glacial* is used in this work for the time subsequent to the District Glaciation of Scotland, to be described later. Among the deposits which, according to this definition, are post-glacial are (1) moraines belonging to late stages in the glaciation of the high ground; (2) raised beaches; (3) freshwater alluvium; and (4) peat.

#### IV. THE ICE AGE ARRIVES.

A study of the fauna of the Pliocene indicates that the climate was becoming increasingly colder.

With the beginning of the Pleistocene both fauna and flora became definitely Arctic, and the Glacial Period of intense cold arrived. During this Ice Age most of the British Isles was under ice. It is fortunate, however, that the southern margin of the great ice cap did not reach as far south as the English Channel. As a result we now find in the south of England the remains of the fauna of the ice-free region. In the north are the records of glaciation in the form of glacial deposits and glacial moulding and markings. It is for us to try and correlate the deposits of these two entirely different regions. This is the great problem of the Pleistocene.

The standard of comparison for Pleistocene deposits is the record of the Thames Valley, which was entirely ice-free. There the complete record of the Pleistocene is preserved in the gravels of the river terraces and in the steps between the terraces. Many fossils and implements found in caves and fissures in other parts of the country have been correlated with their equivalents in the Thames Valley.

Without going into details of the Thames succession, which is at present undergoing active revision by Mr Lacaille, we may recall that there are here three main terraces. Of these the oldest (Boyn Hill Terrace) contains derived Chellean (Abbevillian), earlier Clactonian, earlier Acheulian, and Clactonian, Acheulian, and Early Levalloisian artifacts in the older and newer parts. The fossil mammals of the terrace include the warm climate animals: *Elephas antiquus*, *Rhinoceros megarhinus*, *Bos*, hippopotamus, lion, deer, horse, dog, etc. The Middle

or Taplow Terrace contains Levalloisian implements. Such newcomers as *E. primigenius* (mammoth), *R. tichorinus* (woolly rhinoceros), and the musk ox put in an appearance at this stage. The Low Terrace (youngest) contains an abundant Arctic fauna and flora. In addition to the newcomers mentioned in the Middle Terrace the reindeer and elk now occur.

From the above we may safely conclude as our starting-point for further correlations that the glaciation of northern parts of Britain was heralded in the south by the arrival of the cold-living species of mammal in Late Middle Terrace and Low Terrace times. Further, in the gravels of the Low Terrace at Ponder's End there occurs an Arctic peat bed, containing Arctic mosses, Arctic birch, and Arctic willows, which is dated very late in the Palæolithic. Recently, however, King and Oakley have suggested that the Ponder's End stage is somewhat older and that it was connected with a Mousterian glaciation.

#### V. THE MAXIMUM GLACIATION.

The advent of the Pleistocene glaciation from the gradually cooling conditions of the preceding Pliocene was naturally first felt in the Highlands of Scotland. Glaciers developed in the mountains north of the Midland Valley and crept out on all sides until they coalesced in an immense ice-sheet covering the whole of Scotland and extending out into the sea.

It was probably not long after the first accumulation of snow in the Highlands sent its glaciers below the snow-line that other powerful centres of dispersal were initiated, in the Southern Uplands for example, and in the English and Welsh mountains.

It is not our purpose here to consider the movement of this vast ice-sheet in detail. Suffice it to say that the ice from all the centres flowed as far south as a line joining the Thames and the Severn. This limit is shown in fig. 1, where it separates the closely dotted southern part of England from the openly dotted portion. After a long halt at this position the ice melted northward with amelioration of climate.

*The Older Drift.*—There is now general agreement among geologists that the drifts which cover the southern part of the English glaciated region, in the Midlands, and in East Anglia, are older than the drifts of northern England, of most of Ireland, and of Scotland.

The area now covered at the surface by this Older Drift, as it is called, is that between the lines of the two ice-margins in fig. 1. For our present purpose it will suffice to say that there are several glaciations

represented by the deposit which is given the general name of *Older Drift*. We shall refer soon to these different glaciations.

With the northward retreat of the ice-margins from the southern limit of the Older Drift, Palæolithic man and his mammalian companions also moved north. How far they went in this direction and

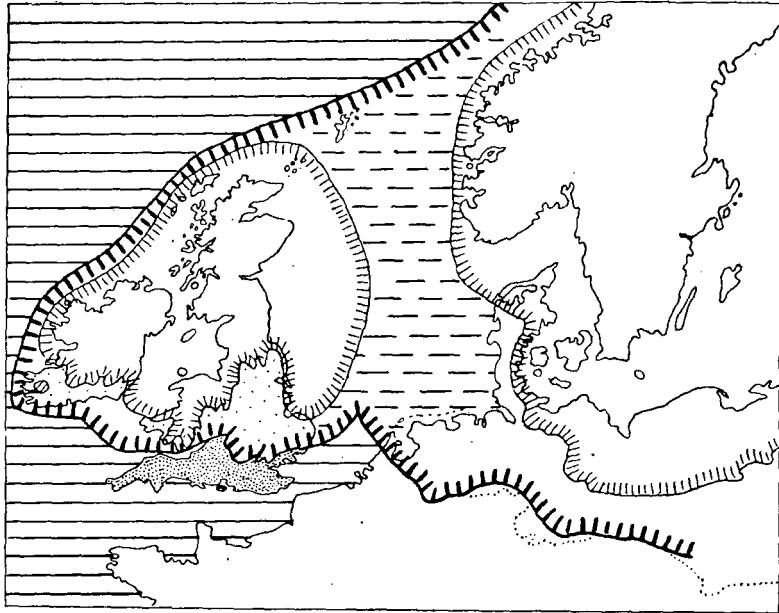


Fig. 1. Sketch-map showing the limits of the Older Drift (heavy ornament) and Newer Drift (lighter ornament) Glaciations. The heavily dotted area in England south of the Older Drift was unglaciated and the sparsely dotted areas are covered by Older Drift. (After Charlesworth.)

how far the ice retreated is a question of the greatest importance to Scottish geologists and archæologists.

*The Newer Drift.*—The next record in the glacial history of Britain is of a readvance of the great ice-sheet southward until its margin coincided with the limit shown by the thinner line in fig. 1. The material deposited by this readvance forms the *Newer Drift* and it occupies the region to the north of the Older Drift.

*The "Standard" Succession in South-East England.*—With this brief outline of the glacial history up to this point before us we may now glance at the course of events which occurred in south-east England. This is necessary for the proper understanding of what we may expect later in Scotland if we are to arrive at a true correlation of our glacial

stages and the different human cultures. It is from the study of south-east England that we shall learn the age of the Scottish glacial invasions.

The following tabular summary indicates the ages and sequence of glacial and interglacial deposits of the Suffolk and Norfolk region of south-east England:—<sup>1</sup>

- |   |   |
|---|---|
| 12. Newer Drift . . . . .                 | Upper Palæolithic.                          |
| 11. Hillwashes.                           |   |
| 10. Morston Raised Beach.                 |   |
| 9. Brick-earths.                          |   |
| 8. Upper Chalky Drift . . . . .           | Levalloisian.                               |
| 7. Brick-earth.                           |   |
| 6. Gravels with mammoth.                  |   |
| 5. Brick-earth and river gravels.         |   |
| 4. Chalky-Jurassic Drift . . . . .        | ? Early Middle Acheulian and Clactonian 11. |
| 3. Glacial sands and gravels.             |   |
| 2. Norwich Brick-earth (North Sea Drift). | ? Chellean.                                 |
| 1. Cromer Forest-bed . . . . .            | Early Chellean (Abbevillian).               |

There is good reason to believe that in the above table there are four glacial episodes. Starting with the youngest at the top these are:

12. Newer Drift (Hunstanton Brown Drift).
8. Upper Chalky Drift.
4. Chalky-Jurassic Drift.
2. Norwich Brick-earth.

Since Scotland was entirely covered by the ice-sheet responsible for the formation of the Newer Drift (Magdalenian) it will be sufficient for us to consider in more detail the question of how its age is determined. This has a very important bearing on the problem of the age of certain archæological finds.

The Early Magdalenian Age of the Newer Drift is proved by several lines of argument. In what follows we shall be following closely in the trail blazed by Professor Charlesworth of Belfast.<sup>2</sup>

(1) In the Cae Gwyn caves Aurignacian implements occur beneath the Newer Drift. These caves occur in the Vale of Clwyd in North

<sup>1</sup> Prof. P. G. H. Boswell, *Proc. Prehistoric Society*, July–December, New Series, vol. ii. part 2 (1936), p. 149. See also the same author in *Proc. Geol. Assoc.*, vol. xlii. part 2 (1931), p. 87, and Pres. Add., Section C, British Assoc., York meeting.

<sup>2</sup> For example, in *Quart. Jour. Geol. Soc.*, vol. lxxxv. (1929) p. 335.



Wales, 400 feet above sea-level, and in them bones of Pleistocene animals were found with a flint of Middle Aurignacian Age. The cave-deposits are overlain by the Newer Drift, which must, therefore, be younger than Middle Aurignacian.

(2) A few feet away in the Ffynnon Beuno caves (380 feet) a fine proto-Solutrean point and a Middle Aurignacian graver were found with Pleistocene bones. These in turn were overlain by Newer Drift.

(3) The Creswell caves occur in the Lower Permian Limestone in north-east Derbyshire in the area covered by the Older Drift and some distance south of the Newer Drift. Two of the caves yielded Upper Palæolithic implements, and Pleistocene animals were found in another (Mother Grundy's Parlour). Mousterian implements of quartzite and Upper Palæolithic flints with a number of Solutrean and proto-Solutrean implements were also found. In Mother Grundy's Parlour there are Azilian or Azilio-Tardenoisian tools, and a Magdalenian javelin head occurs in the Pin Hole Cave side by side with Late Palæolithic flints.

Here, therefore, in caves *outside* the Newer Drift we find a sequence found nowhere within the Newer Drift region, a sequence from Aurignacian to Azilio-Tardenoisian.

(4) The sequence in the Thames Valley to which we have previously referred culminates in the cold fauna and flora of Early Magdalenian Age at Ponder's End. The cold period seems undoubtedly to be the equivalent of the Newer Drift glaciation.

(5) Implements regarded as Mousterian by the finder, Mr J. Reid Moir, have been recovered from the Chalky Boulder Clay of East Anglia. This discovery necessarily implies a Late Palæolithic Age for the Newer Drift, since the latter is younger than the Chalky Boulder Clay.

(6) Further, the same investigator has more recently discovered implements claimed as Upper Palæolithic in the Newer Drift of the Hunstanton cliffs.

(7) The same condition of affairs holds on the Continent, for no Magdalenian relics have been found north of the moraines (Warthe and Brandenburg) which bound the Newer Drift in Germany.

We have now given evidence to show that several ice-sheets spread from Scotland into England. The glacial history of north-east Scotland indicates that this part was overrun by three ice-sheets, and considering the great changes both in the direction of the ice-flow and in the positions of the ice-sheds during these different phases it seems very likely that extensive deglaciation took place between the different advances of the ice. Unfortunately up to the present we have not been able to

correlate these interglacial periods with those in the south, but interglacial beds have been found, and the plants contained in them indicate a period of mild climate.

#### VI. THE AURIGNACIAN OSCILLATION.

It has been shown above that the ice-sheet responsible for the formation of the Newer Drift was of Early Magdalenian Age. There can be little doubt that when the ice-margin in England reached the line of the moraine shown in fig. 1 the ice completely covered the whole of Scotland and extended a considerable distance into the present coastal seas.

Pleistocene animals of earlier date than the Newer Drift occur within this line in the caves opened earlier or embedded in the drift itself. There is evidence, therefore, that the Magdalenian ice-sheet was preceded by an interglacial period. According to Professor Charlesworth this is the Aurignacian oscillation of Continental writers. In the region now covered by the Newer Drift, Reid Moir has discovered a land-surface yielding artifacts of Middle Aurignacian facies, comprising burins, scrapers, points, and cores. It was during this period that the Morston raised beach was formed.

The question for us to consider next is how far north the ice-margin retreated during this oscillation. In North Wales Aurignacian man occupied the Cae Gwyn and Ffynnon Beuno caves, and quartzite implements of Chellean type are claimed to have been found beneath the Newer Drift in Durham.

In the Victoria Cave, 140 feet above sea-level not far from Settle, Yorkshire, in the area of the Newer Drift, there are three principal horizons:

3. Upper cave-earth with a mixed fauna.
2. Thick stiff grey clay, sometimes laminated.
1. Lower cave-earth containing a rather warm fauna including *E. antiquus*, *R. leptorhinus*, *Hippopotamus*, and *Bos primigenius*.

Horizon 3 contains two layers:

- 3b. Romano-British.
- 3a. Neolithic.

Of these, 3a contained a harpoon and kit of implements of Azilian type, but Breuil also recognised cylindrical rods of reindeer antler which he assigned to the Magdalenian (between Middle and Upper Magdalenian). They were probably derived from the lower cave-earth, and according

to Miss Garrod "they probably represent the most northerly range of the Magdalenian hunters."

The remains of the Scottish representatives of Palæolithic animals are very scanty but of great importance. They consist, as is well known, of the mammoth (*E. primigenius*), the woolly rhinoceros (*R. tichorinus*), and the reindeer (*Rangifer tarandus*). Some would add the primitive ox, the horse, and the red deer to this list, but the evidence for the occurrence of these is far from convincing.

The first Palæolithic fossil bed is that at Kilmaurs, near Kilmarnock, containing the remains of mammoth and reindeer. Professor Gregory and Dr Currie were of opinion that the Kilmaurs bed was of Mousterian date and contemporary with the Chalky Boulder Clay of England. A Scottish interglacial bed cannot very well be contemporary with an English glacial period. The same authors continue their correlations thus: "To the Mousterian Age may also be ascribed the sands forming the 170-foot terrace along the Kelvin Valley at Hungryside sand pit near Cadder to the west of Kirkintilloch, which yielded, from a bed of 50 ft. of sand, the bone of a woolly rhinoceros." This question of the age of these sands is of vital importance and will be discussed later. The great mistake made by Professor Gregory and Dr Currie is that they considered the age of the sands to be given by the fossil rhinoceros, whereas the latter must have been picked up from an older horizon.

As has been stated by Professor Ritchie, the woolly rhinoceros probably belonged to the mammoth-reindeer fauna. Ritchie considers that this indicates a period corresponding to the Low Terrace of the Thames Valley, and therefore post-Mousterian. "The known ingredients of the first Scottish glacial fauna, then, compel us," he says, "to place it in the Würm ice period of the Continental workers, and the subsequent appearance of a major glaciation further suggests that it belonged to the opening of that period, and was succeeded by a glacial advance which marks the height of the Würm development. In archaeological chronology the first Scottish glacial fauna may be said to belong to Upper Palæolithic times, at the close of the Mousterian culture period, and to precede the glacial advance, the retreat of which is associated in Central Europe with Aurignacian culture."

From what has been said it will be realised that during an interglacial period the ice-front retreated from the southern limit of the Older Drift at least up to the Midland Valley of Scotland. Had Palæolithic man followed the mammals northward during this oscillation his remains would now be found in positions similar to those in which the remains of these animals were found, *i.e.* for the most part

under boulder clay or in caves which had been opened during this period. So far neither his bones nor his implements have been found in Scotland, and it is possible that he did not follow the retreating ice-margin.

According to Professor Boswell the following is a summary of the conditions at the border regions of glaciated and unglaciated Britain.

Early man passed through his apprenticeship as an implement maker in the periods of increasing cold preceding the first glacial episode. During the first interglacial Chellean (Abbevillian) man advanced into such parts of the British area as were available to him, and although few unabraded Chellean (Abbevillian) artifacts are found, derived and abraded implements occur in later deposits. Over the greater part of England the second glacial episode was that of the maximum glaciation, and Chellean (Abbevillian) and perhaps Early Acheulian man, both users mainly of core-tools, retreated before it. With amelioration of climate the second interglacial period followed. The remains of early man are most satisfactory during this period. Acheulian man (both Middle and Upper) hunted the straight-tusked elephant, the hippopotamus, and the leptorhine rhinoceros. With the arrival of colder conditions again, man producing flake implements principally appeared. The northern part of England was now under ice. After the formation of the Cromer moraine and the Chalky Boulder Clay the ice retreated on a large scale, as we have already pointed out, and Aurignacian man was able to penetrate the now ice-free country as far north as Derbyshire and North Wales, where he was accompanied by Arctic and Tundra animals. Although there were later readvances of the ice, eastern and southern England were open for continuous colonisation from the time of the fourth glaciation onward.

#### VII. LATER STAGES IN THE ICE AGE.

The ice, after its advance to the line of the Newer Drift (Early Magdalenian) shown in fig. 1, retreated northward again as it had done previously. It can be imagined that a considerable interval of time must have elapsed after the Early Magdalenian ice-sheet had begun to melt and before Scotland was free from its mantle of white. If that had been the final withdrawal of the ice from our country, post-glacial human and faunal remains in Scotland would of necessity be post-Early Magdalenian and most likely post-Palæolithic.

However, Scotland has still the records of a long glacial history after the retreat of the above ice-sheet, even after the retreat of the ice-sheet north of the English border. Firstly, the Magdalenian ice-sheet retreated

as far north as the Midland Valley and was followed by another readvance into England. On this occasion it may only have reached as far as the Lake District, but during the whole of the time the Firth of Clyde and the western seaboard of Scotland were covered by moving confluent glaciers. How far they actually stretched into the coastal waters we do not know, but the Firth of Clyde glacier was sufficiently powerful at this stage to reach across the waters of the North Channel and of the Atlantic between Scotland and Ireland, and push them

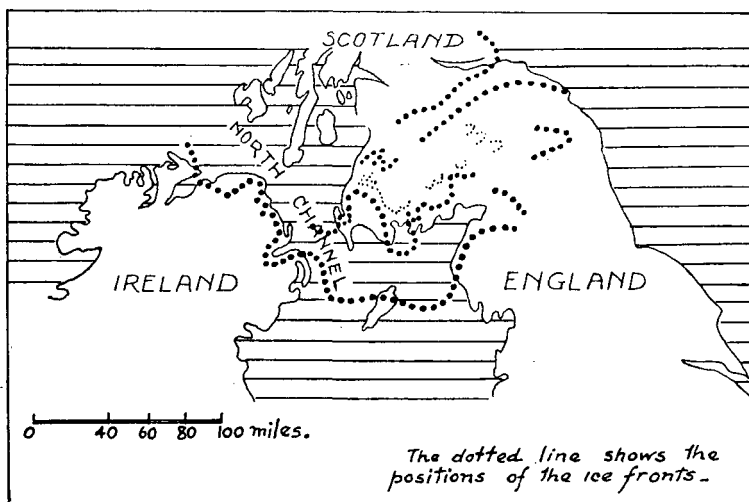


Fig. 2. Sketch-map showing the extensions of the Scottish ice across the North Channel during the readvance about 12,400 years ago. Later readvances during the retreat are also shown. (After Charlesworth.)

westward and southward until the ice came ashore in Donegal and Antrim.

The retreat phenomena from this stage onward have been studied in detail by many geologists, notably by Professor Charlesworth, whose work we have already mentioned. Here we need only say that the readvance of the ice, which we have just been considering, brought the margin forward to Lough Foyle and Belfast and to the Isle of Man and Cumberland.

Again the ice retreated, and at a later date it once more overran the North Channel right to the Antrim coast. At this stage there is evidence that the whole of the Midland Valley was occupied by confluent Highland glaciers. The Southern Uplands formed a local ice-sheet, and their glaciers flowed north and south along the main valleys (fig. 3).

From its limit against the Southern Uplands, and in the Firth of Clyde between Kintyre and Ireland, this relatively late ice-sheet melted out of the Midland Valley and coastal seas. Finally the Highland ice split up into two great glaciers occupying the valleys of the Clyde and Forth.

Without going into any detail we may point out that it was during the retreat of these glaciers that the glacial lake deposits of the Clyde and Midland Valley were formed. The lake sands and gravels in the

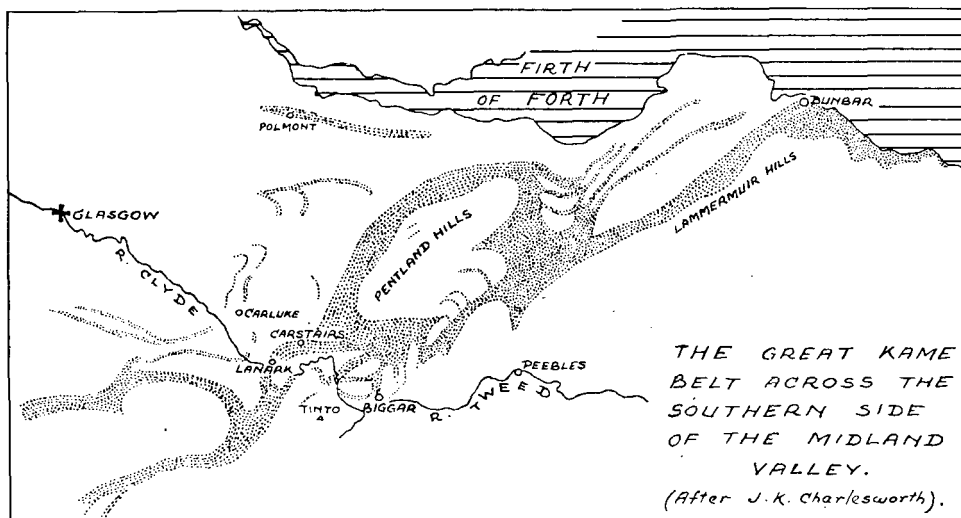


Fig. 3. The Great Kame belt across the southern side of the Midland Valley.

Kelvin Valley which have become famous because of their containing the remains of the woolly rhinoceros were deposited when the Kelvin drainage was prevented from flowing westward. The deposits, therefore, are the products of the last phase of the glacial history of the Midland Valley.

#### VIII. LATE-GLACIAL HISTORY OF SCOTLAND.

The above discussion of what may appear as purely geological phenomena has been necessary in order to form a connected picture of the events leading up to the freeing of our country from the great ice-sheets. We now come to what in the writer's opinion is the most vital chapter in the Late-Glacial history of Scotland. It is the period when Scotland was once more opened up to continuous colonisation. During the earlier parts of the period glaciers were still abundant in

many districts and they actually pushed their way right down to the sea-level of the time.

The geological records of the events are preserved in the raised-beach terraces and notches which abound around our coast, and in the moraines and boulder clays which were deposited from the local glaciers. The history of our country during this time is undoubtedly one of great importance. It leads on without a break to the time when

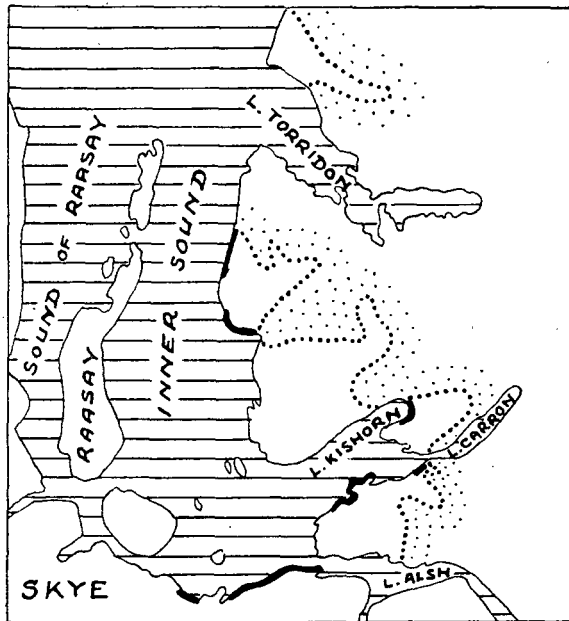


Fig. 4. Map of the mainland of Scotland east of Skye, showing the outer limit of the moraines of the District Glaciation and the relation between these moraines and the 100-foot raised beaches. (After Wright.)

Scotland became inhabited by a scattered population, and from that time onward the record of the human occupation, though interrupted by gaps, is more or less well known and does not offer nearly the same chance for the grave error possible among older cultures.

First of all we shall discuss the higher raised beaches which occur at heights of about 100 feet, 75 feet, and 50 feet above sea-level. The submergence responsible for these was confined to a zone round the Highlands. The 100-foot beach, which is a conspicuous feature on many parts of our coast, is unknown in England and Ireland. In some cases the 100-foot beach is found on the outer parts of the western fiords of Scotland, but is absent from the inner reaches (fig. 4).

In a discussion of the age of these beaches it is necessary to refer to the Late-Glacial history of some parts of western Scotland. Undoubtedly the most interesting district to which to direct attention is the island of Mull, where the researches of Professor E. B. Bailey and Dr W. B. Wright have brought to light many points of primary importance.

In Mull during Late-Glacial times almost every important glen bordered by ground about 1250 feet was occupied by a glacier. The eastern part of Mull is characterised by the absence of Late-Glacial beaches in the hollow connecting Lochs Don, Spelve, Uisg, and Buie. They are completely absent from Glen Forsa and the valley of Loch Ba, although both of these hollows lie below 100 feet.

In the case of Loch Ba and Glen Forsa the glacial outwash fans discharged from the glaciers were formed *after* the withdrawal of the sea responsible for the high beaches in other parts of the island—that is, these 100-foot and 75-foot beaches were elevated at the time the glaciers reached the position of the outwash gravels. In the case of these two glens the fans descend gently to about 30 feet, below which height the deposits have been resorted during a very much later period, that of the Mesolithic beach.

It is clear, therefore, that during Late-Glacial times the sea withdrew from the 100-foot level to the 75-foot level, and still further to at least 30 feet above high-water mark, before the glaciers withdrew from the glens.

Even more spectacular than these examples is that furnished by the low ground around Loch Don and Loch Spelve. This low ground during Late-Glacial times was covered by a piedmont glacier which

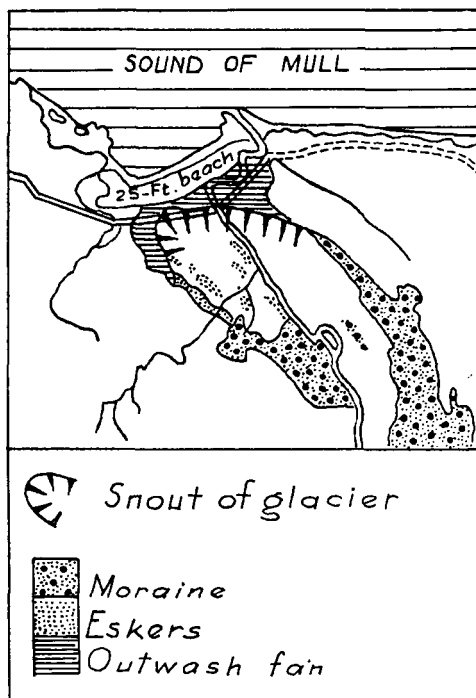


Fig. 5. Sketch-map of the lower part of Glen Forsa, Mull, showing the deposits of the valley glacier, and indicating their relation to the Mesolithic raised beach. The glacier itself is partly reconstructed. (After fig. 66, Mull Memoir, Geol. Surv. Scotland.)



prevented the sea from covering this ground, and for about a mile the notch of the 75-foot beach has been cut in the outer face of the moraine. The beach is completely absent within the line of the moraine.

That the ice did not keep out these high-level seas all the time, however, is indicated by the fact that shelly muds were first laid down in Loch Spelve and the glacier readvanced across them, and, picking them up, incorporated them among its own deposits.

It is obvious, therefore, from the above remarks that the Late-Glacial chronology is particularly clear. The 100-foot and 75-foot raised beaches are *synchronous* with the Moraine or District Glaciation of the Highlands.

Exactly the same story is told by the glacial history of many of our mainland glens. For example, the 100-foot sea had access to Loch Lomond and the Gareloch during an interstadial period, and during the readvance of the Loch Lomond glacier to the position of the Glen Fruin moraine and of the Gareloch glacier to the Rhu moraine the deposits which it had laid down in the lochs were dredged up and mingled with those of the readvancing glacier. The study of the outwash gravels between Dumbarton and Balloch suggests that the sea had actually left Loch Lomond before the readvance of the ice.

In the east of Scotland, at an earlier period than we have just been considering, sea-level had fallen to about 75 feet at Dunbar and to about 50 feet at St Abbs Head in Late-Glacial times.

The arctic sea of these high-level beaches in Scotland may be correlated with the cold Yoldia Sea of the Baltic region.

#### IX. CORRELATIONS.

Having now reviewed the events of the Pleistocene, and having considered certain broader aspects of the local glaciation, we are in a position to go a little farther afield and attempt correlations with the events in Europe.

This is all the more necessary because it is that aspect of the subject which has appealed most to non-geologists, and it has been done with results which would appear to be at variance with the facts. It is undoubtedly the case that for the archæologist in particular this has always had a peculiar fascination.

The question of the method which has been used for determining the length of time in years during and since the Ice Age has recently been discussed by the writer in *Science Progress*, and need not be referred to further here. A tabular summary, however, of the results arrived at is given (Table I).

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TABLE I.—THE LATE-GLACIAL AND EARLY POST-GLACIAL STAGES IN THE BALTIC REGION. THE NUMBERS GIVE THE YEAR BEFORE A.D. 1900. (Based on Daly.)

|        |              |                         |
|--------|--------------|-------------------------|
| 7500   | Post-Glacial | Littorina Sea           |
| 8700   |              | Ancylus Lake            |
| 9700   | Finiglacial  | Yoldia Sea              |
| 10,200 |              |                         |
| 13,700 | Scanian      | Baltic Ice-Lake         |
|        | Danish       |                         |
| ?      |              | Covered by ice          |
|        | German       |                         |
| ?      |              | Peak of last Glaciation |
| 25,000 |              |                         |

The multiplicity of the glaciations in Britain has been emphasised in the previous pages. As far as Scotland has been treated, five stages in the glacial history have been mentioned. These were, in order of age, beginning with the oldest: the Older Drift glaciation, itself composite; the Newer Drift glaciation; the North-East Antrim-Isle of Man-Cumberland readvance; the Lammermuir-Stranraer-Antrim coast readvance; and the District or Moraine glaciation.

In the Baltic region of Europe there is evidence in what is usually considered as the fourth glaciation of at least three phases—the Dani-glacial, the Gotiglacial, and Finiglacial phases. Recently it has been suggested that there are three substages older than the Finiglacial (Bothnian). These have been called the German, Danish, and Scanian

substages, beginning with the oldest. The multiplicity of the earlier stages of the Continental glaciation is also firmly established.

It was in the year 1854 that A. Morlot recognised the first interglacial bed, and the same author put forward the view that there had

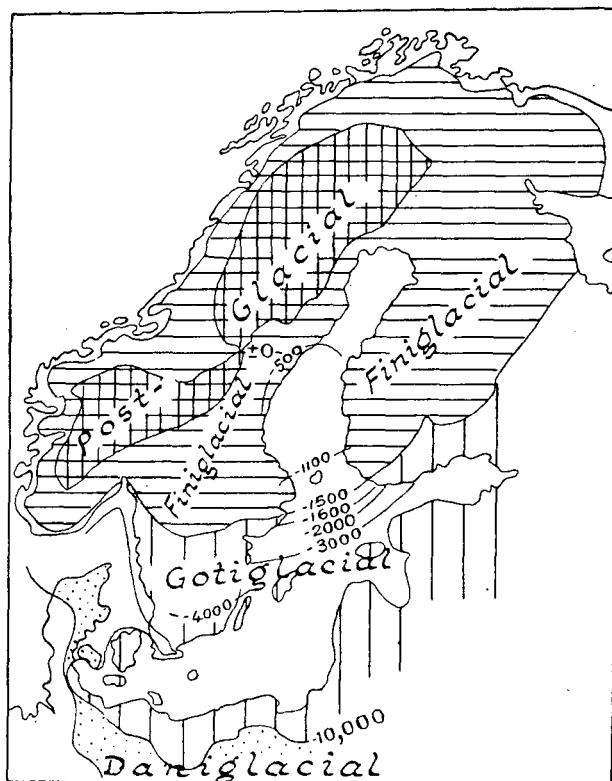


Fig. 6. Sketch-map showing the retreat stages of the last ice-sheet in Scandinavia and the lands around the Baltic. The numbers give the year before the close of the Ice Age when the ice-edge stood at the position of the number. (After Sauramo.)

been three glacial periods separated by two interglacials. For a long time his view had only a few supporters. Later, James Geikie came to be recognised as pre-eminently the defender of interglacial periods. He believed in the existence of no fewer than six glacial periods separated from one another by true interglacial periods. He found more support for his views abroad than at home.

It has long been known, chiefly through the work of Penck and Brückner, themselves disciples of Geikie, that there have been four great phases of extension of the Alpine glaciers. These have been given

the following names, beginning with the oldest: (1) Günz Glacial Period; (2) Mindel Glacial; (3) Riss Glacial; and (4) Würm Glacial. These were separated from one another by interglacial periods of different durations and different climates.

Following the Würm phase there were deposited a number of moraines of stadial, or substage, rank, marking oscillations in the retreat of the glaciers. These moraines have been termed Neo-Würmian. The more important stages in this retreat, all of which we may consider to belong

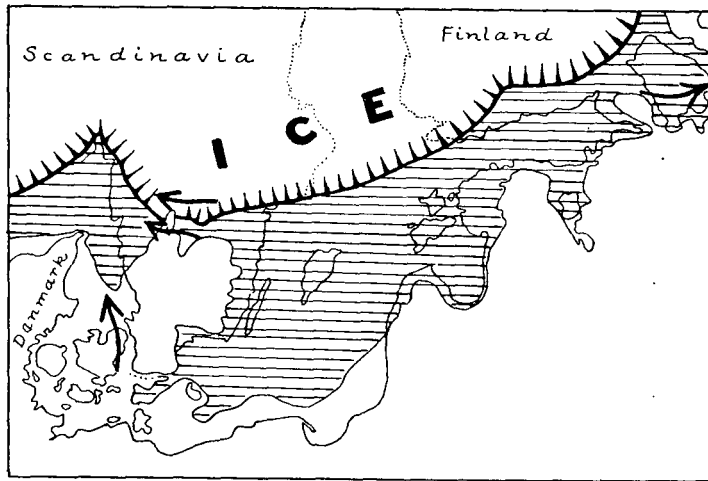


Fig. 7. Baltic Ice Lake about 8800 B.C. (After Sauramo.) Arrows are overflow channels at different stages.

to Post-Glacial time, have been called: (1) Achen recession; (2) Bühl Stadium; (3) Gschnitz substage; and (4) Daun substage.

The amount written on the subject of the correlation of British and Continental glaciations is large, and it is bewildering in the differences which exist between the different authors. No useful purpose would be served by reviewing the different theories. Instead, the writer will adopt the one which he thinks is the nearest to the truth.

Without going into detail, a glance at the maps and the following table will make clear the broad stages in which the British and Continental glaciations were synchronous:—

|  |                    |
|--|--------------------|
| District Glaciation . . . . .                | Post-glacial.      |
| Lammermuir-Stranraer phase . . . . .         | Finiglacial.       |
| North-East Antrim-Cumberland phase . . . . . | Gotiglacial.       |
| Newer Drift . . . . .                        | Daniglacial.       |
| Older Drift (composite) . . . . .            | Older glaciations. |

Bearing these correlations in mind we shall now refer in somewhat greater detail to certain phases of Baltic history.

Before the existence of the Yoldia Sea (above correlated with Late-Glacial sea in Scotland) the Baltic area was occupied by an ice-dammed

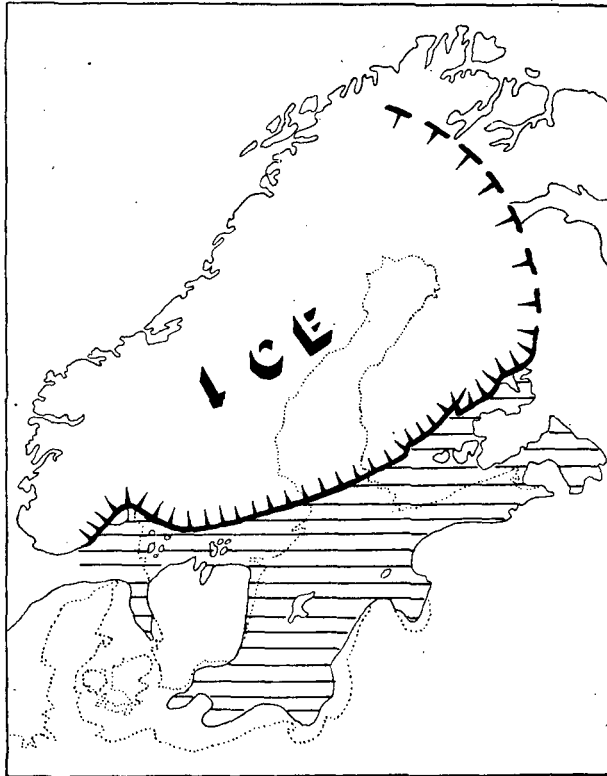


Fig. 8. Sketch-map showing the extent of the Yoldia Sea about 7900 B.C.  
(After Sauramo.)

lake called the Baltic Ice Lake. During the retreat of the ice from Denmark to the Ra moraines and Salpausselka, southern Sweden and the Danish Sounds stood higher than they do to-day, and there was no connection between the Baltic and the North Sea. During the early phases of this ice-lake the waters discharged through the Danish Sounds, but later they escaped through the Planta Valley south of Mount Billigen. The final discharge of the Baltic Ice Lake took place about 100 years after the second Salpausselka stage in Finland, the level of the water in the Baltic became the same as that of the ocean outside, and the Yoldia Sea stage began. The Yoldia Sea stage, which lasted less than

500 years, was brought to an end by uplift of the land in central and southern Sweden, and a new phase, the Ancylus Lake, of long duration was ushered in. The Ancylus Lake came to an end about 5000 B.C., and, therefore, overlapped Post-Glacial time by about 1000 years. The new sea which then occupied the Baltic is called the Littorina Sea, and the climate of this period was more genial than that of to-day.

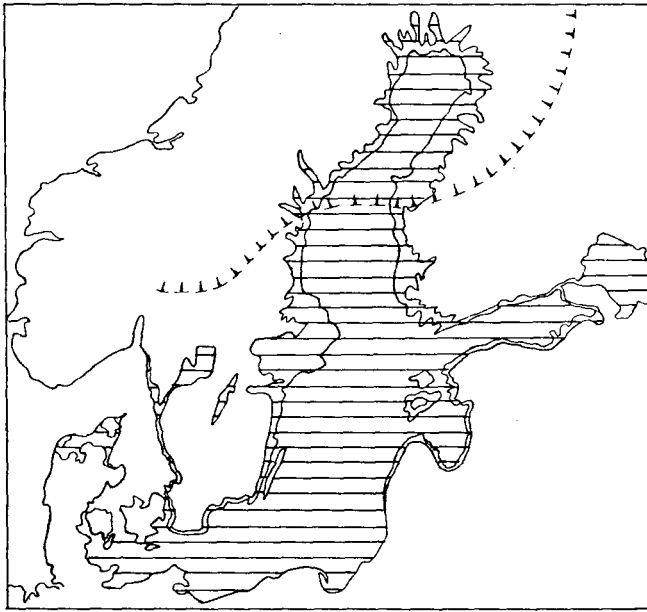


Fig. 9. The Littorina Sea at its maximum, about 4000 B.C. The broken T-line across the Gulf of Bothnia represents the approximate position of the ice-front during the preceding period of the Ancylus Lake about 7400 B.C. (After Sauramo.)

O. Montelius, the famous Swedish archæologist, placed the maximum of the Littorina transgression at about 4500 B.C. Finnish geologists are more inclined to put it about 4000 B.C.

The Littorina Sea gradually changed to the present Baltic, the proportion of its salinity diminishing as the contraction of the Sounds increased with upheaval of the land.

#### X. POST-GLACIAL SCOTLAND.

Although the main object of the present paper is to give an idea of the glacial history of our country it would obviously be incomplete if it did not show how this history was connected with that which followed.

It will be recalled that the conditions of our country immediately before the Ice Age were also briefly summarised.

We have now arrived at a very important stage in the evolution of Scotland—the period of time when man first arrived on our shores; and from this time onward the story is one of continuous human occupation.

We have already seen that towards the end of the Ice Age, in what we have spoken of as Late-Glacial times, the sea-level in Scotland was higher than it is now. We have also pointed out that there was a considerable emergence of the land (a fall of sea-level) before the ice finally disappeared.

In the present section it is proposed to discuss another beach, much more important than the others from the archæological point of view, which is generally called the *25-foot beach*, although this is rather a misnomer. It is proposed to designate this beach the *Mesolithic Beach*.

The *Mesolithic Beach*, it must be emphasised, is not a product of the submergence of the land responsible for the formation of the higher beaches. The two periods of submergence have been separated from one another by an important emergence during which there flourished the submerged forests and peat beds seen in many places around our coast.

It is generally thought, too, that this period of uplift of the land, when the sea stood some 100 feet *lower* than it is to-day, must have been of considerable duration.

The *Mesolithic Beach*, therefore, is more recent than the submerged forests. The latter occur beneath the deposits of the beach. The submerged forests in their turn are more recent than the higher beaches.

From the archæological point of view the *Mesolithic raised beach* is the most important beach in this country; for it is on it, or within its materials, that the earliest human implements in Scotland have so far been obtained.

It is the general opinion of geologists that the *Mesolithic Beach* represents a long period of time, probably much longer than that occupied by the sea at its present level. It is well known that glacial striæ are beautifully preserved on the coastal rocks in many parts of Scotland. There they have been exposed to wave-action since the elevation of the raised beach, and by human standards this is a long time. Yet around these same coasts the sea during *Mesolithic times* is believed to have cut a rock platform up to 100 yards in width. Wright has said that

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this sea, which he calls the Early Neolithic sea, was the cliff-maker *par excellence*. In the cliffs behind the beach occur the caves in which in many cases the earliest inhabitants of our country sheltered.

The present writer is not convinced that the raised-beach platform was cut by the sea which deposited the fossiliferous gravels. In another

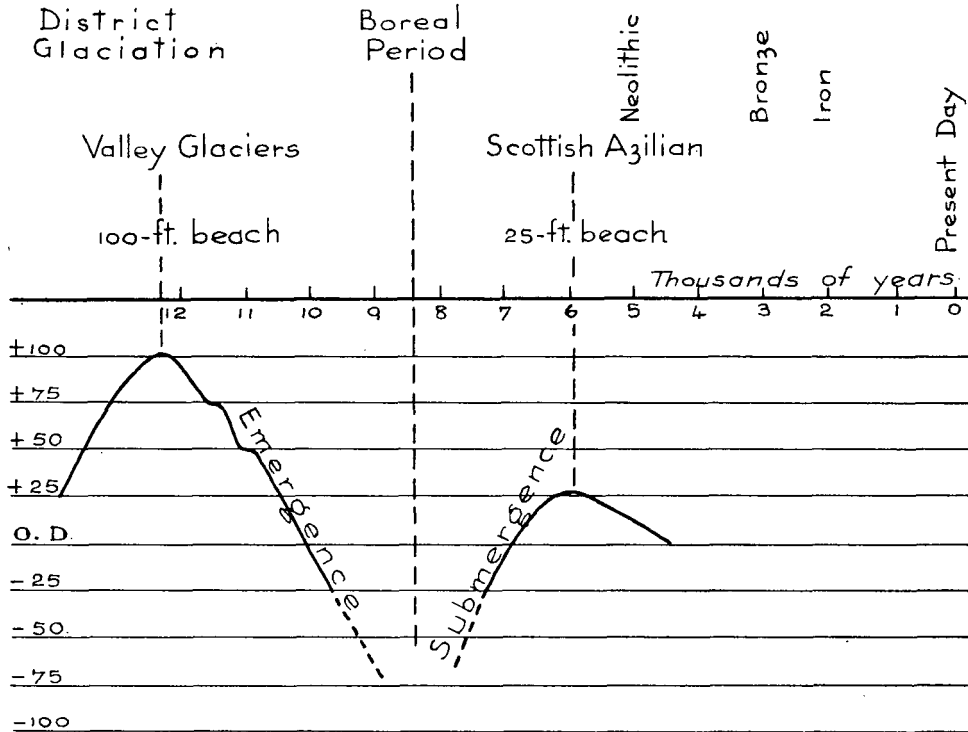


Fig. 10. Curve and time-relationships of the Scottish raised beaches (based on M. Macgregor and A. G. MacGregor).

section of this paper (Tables I and II) he has attempted to give the length of time in years since the Ice Age, and if this dating is approximately correct it would seem that since the Ice Age there has not been enough time for the cutting away of so much solid rock as is indicated in the raised platform around our coasts. This is a question, however, which we cannot discuss fully here. Suffice it to say that the writer believes that the rock platform of our 25-foot raised beaches is of Pre-Glacial, or it may be Interglacial Age, and that from an archæological point of view it is mere coincidence that the *Atlantic* sea-level coincided with the earlier sea-level.



Although the *Atlantic* raised beach is very often spoken of as the 25-foot raised beach, its height above sea-level is by no means constant. Its greatest elevation is about 40 feet, or slightly more, and this occurs over a considerable area between Loch Linnhe and the Firth of Clyde (Campbeltown, Ardrossan). The height gradually decreases outwards from this central region until the beach reaches present sea-level in Lewis and to the north of Caithness. In the Orkneys there is an absence of Post-Glacial raised beaches, and if they were ever formed in the islands they are now submerged beneath the sea.

The varying height of the beach has in the past led to a certain amount of confusion, and the *Atlantic* beach has often been spoken of as the 50-foot beach. This mistake led Professor James Geikie to say that the Azilian deposits of western Scotland must be post-Neolithic in age, since Neolithic remains have been found in a beach which he called the 50-foot beach. The latter, however, is the *Atlantic* beach and not the 50-foot beach mentioned earlier in this paper.

#### THE AGE OF THE 25-FOOT BEACH.

With regard to the age of the 25-foot beach many different opinions have been held, and it has even been thought that it has different ages in different parts of the country. Some would say that it is as old as the Magdalenian, because the Abbé Breuil, who studied the flint implements found in the beach at Campbeltown, said that they resemble the Magdalenian culture. It is hoped that in a future paper Mr A. D. Lacaille will discuss the actual culture-age of the Campbeltown flints collected by the present writer. All we need say in this connection at present is (a) that it has already been demonstrated that during Magdalenian times the great ice-sheets spread as far south as the limit of the Newer Drift, and (b) that Breuil never intended his statement of Magdalenian aspect to be interpreted as an indication of Magdalenian Age. Such an age is geologically impossible.

In western Scotland, where implements have been found in the raised-beach materials, they are of three cultural types: (1) Azilian; (2) Azilio-Tardenoisian; and (3) Neolithic. The flints found in the same beach in Antrim have been identified as belonging to various periods of the Mesolithic, as well as to the Palæolithic. It has been said that at Campbeltown the beach is Palæolithic; at Oban and elsewhere in the neighbourhood, Azilian; and farther south and in Antrim, Campignian, etc. The late Professor Gregory has even

suggested that in southern Scotland the 25-foot beach may be of Bronze Age.<sup>1</sup>

As far as the writer sees the evidence, the cultural aspect of the beach materials will give no indication whatever of the age of our 25-foot beach. It is one of those cases where the archaeologist is dependent on the geologist and botanist in order to date his implements.

*Geological Evidence.*—The connection between the 25-foot raised beach and the climatic optimum was established as long ago as 1892 by the famous Irish naturalist, R. Ll. Praeger, from the study of the life of the time as it is recorded in the deposits on the Antrim coast. Praeger was able to show that certain characteristic species which lived in the 25-foot sea had a more northerly range than they have to-day, and his conclusion has since been amply confirmed. We must refer briefly to Praeger's results at this stage.

According to Praeger the typical succession of the post-glacial beds in Northern Ireland is as follows:—

- |    |   |   |
|----|---|---|
| 6. | { | Raised beach.   |
|    | { | Upper estuarine clays (formed about 30–40 feet below S.L.<br>and now about 19 feet below H.W.M.). |
| 5. |   | Lower estuarine clays (formed in shallow water).  |
| 4. |   | Submerged peat (27 feet below present H.W.M.).  |
| 3. |   | Sands and gravels.  |
| 2. |   | Re-assorted boulder clay.   |
| 1. |   | Boulder clay (glacial).   |

This section of the post-glacial deposits in the Belfast district differs from the section of the famous raised beach at Larne in that it now occurs below sea-level. The two sections are related to one another in the following way:—

| <i>Larne.</i>                         | <i>Belfast.</i>        |
|---------------------------------------|------------------------|
| Gravelly soil (22 feet above H.W.M.). |                        |
| Coarse gravel.                        |                        |
| Sandy layers . . . . .                | Upper estuarine clays. |
| Coarse gravel.                        |                        |
| Black muddy gravel.                   |                        |
| Black sand (H.W.M.).                  |                        |
| Lower estuarine clay . . . . .        | Lower estuarine clays. |
| Black sand.                           |                        |
| Coarse black gravel.                  |                        |

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<sup>1</sup> *Proc. Soc. Ant. Scot.*, vol. lxiv. (1929–30) p. 263.

In 1931 the following set of beds was exposed in making Milewater Dock, Belfast:—

|   | Feet. | Inches. |
|---|-------|---------|
| Surface clays and sand . . . . .                  | 16    | ..      |
| Estuarine clays . . . . .                         | 12    | ..      |
| Red sand . . . . .                                | 3     | ..      |
| Peat with trees . . . . .                         | 3     | ..      |
| Red sand . . . . .                                | 7     | ..      |
| Grey sand . . . . .                               | 2     | ..      |
| Red sand with Irish deer . . . . .                | 3     | ..      |
| Gravel resting on red sand (unbottomed) . . . . . | 2     | 6       |

The section was described by Professor J. K. Charlesworth and Dr Erdtman. The resemblance to Praeger's section is striking, for in both the estuarine clays were 12 feet thick and rested on sand, which in turn rested on peat. The pollen investigation of the peat by Erdtman indicates that it is of Boreal Age. Erdtman also finds that the top of the peat underlying the raised beach at Portrush on the northern coast of Antrim is suggestive of Early Atlantic times, so that the maximum submergence of this part took place after the beginning of the Atlantic.

The Antrim examples have been specially mentioned because they are historically the most interesting, but the same results have been obtained from the studies of peats below the raised beaches in many other parts of Britain as well as on the other side of the North Sea. The pollen analysis of peats beneath the carse clays of the Forth and Tay valleys indicate an Atlantic Age for the post-glacial submergence. The peat beneath the clays at Forgandenny (south of Perth) is of Boreal Age, whereas the peat overlying the same deposits dates from the Sub-boreal and Sub-atlantic.

We may, therefore, with a fair degree of confidence assume that the submergence of the country which resulted in the most conspicuous and most archaeologically interesting of all our raised-beach deposits is of *Atlantic* Age. We may now use this dating as our starting-point for the discussion of the ages of the implements found in Scotland within the deposits of the beach.

*Archæological Evidence.*—We have no intention of referring to all the literature on the subject of the first settlers on our raised beach. Most of this is contained in the *Proceedings* of this Society, but reference may be made to a recent valuable summary of the evidence from northern Antrim by W. B. Whelan in *International Geol. Cong., Washington, 1933, p. 1209.*

TABLE II.—EARLY POST-GLACIAL TIME IN THE BALTIC REGION.

| Thousands of years B.C. |                       | Sub-boreal    |
|-------------------------|-----------------------|---------------|
| 3                       | <i>Post - Glacial</i> | Littorina Sea |
| 4                       |                       |               |
| 5                       | <i>Post - Glacial</i> | Ancyclus Lake |
| 6                       |                       |               |
| 7                       | <i>Finiglacial</i>    | Yoldia Sea    |
| 8                       |                       |               |
| 9                       | <i>Scanian</i>        |               |

In 1918 Francis Buckley commenced his pioneer investigations of the microlithic implements of the Marsden Moors, near Huddersfield, in northern England. He determined the exact horizons of the implements, and this enabled Woodhead to study the plant remains which occurred in association with the implements. The following is the section which they were able to draw up:—

- 5. Romano-British layer—pottery.
- 4. Bronze arrow-heads.

3. Cotton-grass peat, containing in the lower layers horn-cases of *Bos primigenius*.
2. Tree layer with leaf-shaped arrow-head—Neolithic.
1. Grey sand resting on rock and containing two layers (floors) with human implements:
  - (b) Late Belgian Tardenoisian flints (patinated) with birch charcoal.
  - (a) Early Belgian Tardenoisian flints (unpatinated) with birch and ash charcoal.

The peats of these human floors were found to contain pollen grains of birch, oak, and alder, and to have pollen grains of pine on the surface.

Since the above early researches a great deal has been done on the age of the peats resting on the implementiferous (Tardenoisian) sands of northern England, and we now know that the first settlers in Northumberland and Durham were the Tardenoisians and that they arrived during the warm dry conditions of the Boreal Period. In the Pennines the Mesolithic culture is of Upper Boreal Age, but on the north-east coast it may be Lower or Middle Atlantic. Descriptions of their settlements and implements, as well as of the associated peats, will be found in the several writings of Raistrick. In the well-known section at Peacock's Farm, Shippea Hill, Cambridgeshire, which has been studied pollen-analytically by Godwin, the transition between the Boreal and Atlantic Periods occurs immediately above the Tardenoisian level. The Tardenoisian industry of this site is of late date, probably English Late Tardenoisian (Belgian Middle Tardenoisian?). That the English Late Tardenoisian was contemporaneous with the Continental Middle Tardenoisian is suggested both by typological studies and pollen-analysis, for the latter is also of Late Boreal Age.

A people possessing a culture rather similar to that of these *pre-Atlantic* Tardenoisians of northern England settled on the sand-dunes resting on the Atlantic raised beach in southern Scotland some thousand of years *after* the Boreal Period. Within this Scottish beach, as is well known, occur the implements which are supposed to be older than the Tardenoisian and certainly they are older than the Scottish microlithic industries, but the essential point is that we now know that the raised beach which we are discussing is of *Atlantic* date, and therefore the first people to arrive in Scotland must be considerably younger than the *pre-Atlantic* settlers (Tardenoisians) of northern England.

If, therefore, we are to continue to use the terms *Azilian* and *Azilio-Tardenoisian* for the implements of the 25-foot raised beach, it must be clearly understood that they are used with a purely cultural meaning and give no indication whatever of the age of the implements. The writer suggests that these terms should always be prefaced by *Scottish*—thus Scottish Azilian instead of Azilian. The question then is, What is the age of the Scottish Azilian or Scottish Azilio-Tardenoisian? As a corollary to this is the question of the age of the Scottish Tardenoisian. Clearly the former are much younger than the English Tardenoisian. They may still be Mesolithic but belonging to the end of the period, or they may be Neolithic. There is much to be said for calling them Early Neolithic, but since there are in our country the two distinct cultural types (*a*) of the raised-beach deposits and (*b*) of the true Neolithic with polished implements and pottery, it seems better to retain the term Mesolithic for the implements of the raised beach. Contemporaneous settlers around the Baltic are generally believed to be Mesolithic. In this connection it may be pointed out that there seems to be ground for believing that the Irish Asturian develops a Neolithic aspect in the younger implements. In the north of England too the Mesolithic people abandoned most of their coastal sites at the end of the Boreal and beginning of the Atlantic. They moved inland and mixed "their culture with that of the Neolithic stock" (Raistrick, 1934, *Trans. North. Nat. Union*). Some writers believe the Scottish Tardenoisian implements are survivals of the true Tardenoisian technique into the Bronze Age. It is undoubtedly true that the microlithic implements are often associated with implements of Neolithic aspect. On the Continent too, at Zonhoven, trapezes, which are the dominant implements of the Late Tardenoisian, are known to have been flaked from polished (Neolithic) axes.

In the previous pages we have demonstrated that man is a comparatively recent acquisition to Scotland. In the same way it may be argued that the fauna and flora is also post-glacial. We do know, however, that the plants and animals migrated northward across the English border during at least one important interglacial. Of the animals, reindeer, mammoth, and woolly rhinoceros came north during the oscillation between the Older and Newer Drift glaciations. There is no evidence, however, that man came with them. Complete extermination befell the immobile forms of life that existed during the interglacial periods. We say this in spite of the fact that to-day living things exist in the glaciers of the Alps and in the great ice-sheets of Greenland and Antarctica.

The Early Post-Glacial fauna of Scotland is known from the remains embedded in certain drifts in the Midland Valley and in caves, notably in the caves near Inchnadamph in the north-west Highlands, where glacial conditions lingered for a long time.

The fauna of the Mesolithic Raised Beach is well known from the remains contained in the refuse heaps of early man in western Scotland and from the fossils in the beach itself. We do not propose to enumerate the different forms of life which existed in these times. This aspect of the subject is dealt with in Professor Ritchie's book *The Influence of Man on Animal Life in Scotland*, and in his paper "Scotland's Testimony to the March of Evolution" (*The Scottish Naturalist*, November-December, 1930, p. 161).

As pointed out by Professor Ritchie, the Late-Glacial fauna found its progress to the north cut off by the northern ocean, so that it had to remain under conditions not suited to it, and it became mixed with animals normally living under different conditions. Some of the Early Post-Glacial animals survived for a long period. The reindeer, for example, first of all accompanied by the mammoth and later by the red deer and elk, may have persisted until the twelfth century. The first reindeer that followed close on the heels of the retreating ice developed into a woodland race and became extinct with the destruction of our forests, which was begun in the Bronze Age. Associated with the reindeer in northern Scotland were Arctic lemming, Arctic foxes, bears, wolves, lynxes, and Irish elk, as well as wild horses, wild oxen, and red deer.

Shortly after the stocking of Scotland took place Britain became cut off from the Continent, and further introductions were confined to such mobile forms as birds and to the accidental dispersal of certain plants. The animals which have survived the few thousand of years since our country became populated have not remained as they were when their introduction took place. Evolution, which we usually think of as an extremely slow process, has produced considerable changes. Professor Ritchie has shown that in the case of our breeding mammals some eight distinct species and over thirty geographical races have developed under the very eyes of man. Evolutionary changes have been more marked in the case of the birds, for there are now in Scotland about thirty-two breeding species which are different from their closest European relatives. St Kilda itself has a distinct bird as well as two distinct mammals.

The present paper is an attempt to give an idea of the length of time that has elapsed since the ancestors of our present fauna and flora were introduced into Scotland.

## SELECTED REFERENCES.

Dr W. B. Wright has summarised our knowledge of Glacial and Post-Glacial Scotland in his book *The Quaternary Ice Age*. In the present summary attention is directed to a few important works published since 1914. The list is not intended to be complete, for the works mentioned contain bibliographies. Dr Wright has also reviewed the question of the Scottish raised beaches in a general paper on "The Raised Beaches of the British Isles" (First Report of the Commission on Pliocene and Pleistocene Terraces. International Geographical Union, No. 11, 1928, p. 99).

Two important Late-Glacial studies have been published by Professor J. K. Charlesworth: (1) "The Glacial Geology of the Southern Uplands, West of Annandale and Upper Clydesdale" (*Trans. Roy. Soc. Edin.*, vol. lv. part i. 1926, p. 1); (2) The Readvance, Marginal Kame-Moraines of the South of Scotland, and some Later Stages of Retreat" (*ibid.*, No. 2, p. 25).

Reference may also be made to J. B. Simpson's paper "The Late-Glacial Readvance Moraine of the Highland Border West of the River Tay" (*Trans. Roy. Soc. Edin.*, part iii. No. 24, 1933, p. 634), and to A. Bremner's summary of the glacial phenomena of north-east Scotland in "The Glaciation of Moray and Ice Movements in the North of Scotland" (*Trans. Geol. Soc. Edin.*, vol. xiii. part i. 1931, p. 17). The present writer published a brief note on "Dating the Ice Age in Britain" in *Science Progress*, No. 117, July 1935. In this the reader will find a short account of varve clays and of the method used in determining the age in years of the Ice Age in Scandinavia.

On the lines of the classic researches of Geikie, Lewis, and Samuelsson on Scottish peats (summarised in *Science Progress*, October 1907, and in *Bull. Geol. Inst. Upsala*, 10, 1910) we may mention G. Erdtman's work "Some Aspects of the Post-Glacial History of British Forests" (*Jour. Ecology*, vol. xvii. 1929, p. 112).

The Late-Glacial and Post-Glacial fauna of Scotland with suggested correlations of glaciations and human cultures are dealt with in "The Vertebrate Fossils from the Glacial and Associated Post-Glacial Beds of Scotland in the Hunterian Museum, University of Glasgow," by Professor J. W. Gregory and Dr E. D. Currie (*Monographs of the Geological Department of the Hunterian Museum, Glasgow University*, ii. 1928), and in "The Fauna of Scotland during the Ice Age: Presidential Address," by Professor J. Ritchie (*Proc. Roy. Phys. Soc. Edin.*, vol. xxi. part iv. 1929, p. 159).



With a close bearing on the origin of Scottish fauna and flora is Professor Charlesworth's "Some Geological Observations on the Origin of the Irish Fauna and Flora" (*Proc. Roy. Irish Acad.*, vol. xxxix. B, No. 16, 1930, p. 358).

In conclusion the writer wishes to thank Mr A. D. Lacaille for reading the manuscript of this paper and for making valuable suggestions in connection with the archaeological dating of the various stages of glaciation and of the Thames chronology. His suggestions have been incorporated in the text.