CHAPTER I

THE NATURAL HISTORY OF THE AREA OF SETTLEMENT

THE RETREAT OF THE ICE-SHEETS

THE withdrawal of the Pleistocene ice-sheets was an event of far-reaching importance. It produced fundamental climatic, floral and faunal changes on a grand scale; it released such vast quantities of melt-water and removed so great a stress from the earth's crust as to induce geographical changes of the first order; and it made wide stretches of Northern Europe available for the settlement of man. The retreat of the ice-sheets and the phenomena which followed in their train form the physical background to the Mesolithic settlement of man in Northern Europe, and are, therefore, fundamental to a full understanding of the cultural developments of the period.

It is generally held that the quaternary ice-age should be considered not so much as a single advance of glaciation as a series of recurrent maxima. Similarly the withdrawal of ice after the last maximum (Wurm II) was not a regular or simple process; it was a slow retrogression arrested periodically by halts and in some regions by readvances. The stages of the retreat of the Rhine glacier have been investigated on the northern slopes of the Eastern Alps by Albrecht Penck, whose conclusions have been confirmed for Switzerland and may be regarded as authoritative for the whole Alps. Penck found that the moraines of the retreating ice-sheet grouped themselves in three main series, each representing an interruption in the retrogression and even a slight readvance; at these three stadia, which he named after local sites, Bühl, Geschnitz and Daun, the snow-line is calculated to have stood respectively 900, 600 and 300 metres lower than at the present day (Penck and Brückner, 1901–9).

Similar periods of halt in the retreat of the Scandinavian ice-sheet have been recognised by Baron de Geer, Sauramo and many other workers, and these allow of conveniently sub-dividing the period of recession. The period during which the ice retreated from the north German moraines, the relics of the last glacial maximum, to the Baltic end-moraine is known as the Daniglacial period, because the recession freed from ice Denmark as well as the rest of north Germany. The next phase of recession uncovered Götland (therefore known as the Götiglacial period) and was terminated by the formation of the Fenno-Scandian moraines. The third major retreat stage, known as the Finiglacial, because it uncovered the greater part of Finland as well as large tracts of Sweden, reduced the inland ice-sheet of Scandinavia to the point when it parted into two separate areas in Jämtland; this point, known as the bi-partition of the inland ice, marks the beginning of Post-glacial[1] time in Scandinavian terminology. The successive retreat stages, interrupted by halts, are illustrated in map form by Fig. 1.

Direct correlation of the retreat stages of the north European and Alpine ice-sheets is not possible, but assuming that such major oscillations could not have merely local causes, it seems reasonable to suggest the following correlation, which may conveniently be expressed in tabular form:

SCANDINAVIA (De Geer)	THE ALPS (Penck and Brückner)
Post-glacial period	
Final stadium previous to the bi-partition of the inland ice	Daun stadium: snow-line below present level by 300 metres
Finiglacial period	Geschnitz—Daun period
Fenno-Scandian moraines	Geschnitz stadium: snow-line below present level by 600 metres
Götiglacial period	Bühl—Geschnitz period
Baltic end-moraine	Bühl stadium: snow-line below present level by 900 metres
Daniglacial period	Achen retreat period

The parallelism to be observed in the table may appear too artificial to be true, but it seems reasonable to suppose that the causes of fluctuation in the retreat of the two ice-sheets were of more than local character and in any case their distance apart is not great. There is interesting confirmation for the correlation of the Baltic end-moraine with the Bühl stadium of the Alps to be found in the various estimates made for their respective ages. The Baltic end-moraine is estimated by Sauramo (1928), on a geochronological basis, to date from roughly 18,000 years B.C. On the other hand Wright (1914, p. 158) arrives at precisely the same date for the Bühl stadium by splitting the difference between the results of Heim, who reached the figure of 14,000 B.C. from a study of the growth of the Muota delta in Lake Lucerne,

[1] This term is generally used outside Scandinavia to denote a longer period of time stretching back to the beginning of the Finiglacial period.

and of Nüesch, who dated the Magdalenian site of Schweizersbild to 22,000 B.C.

The withdrawal of the ice-sheet from Scandinavia is relevant to archaeo-

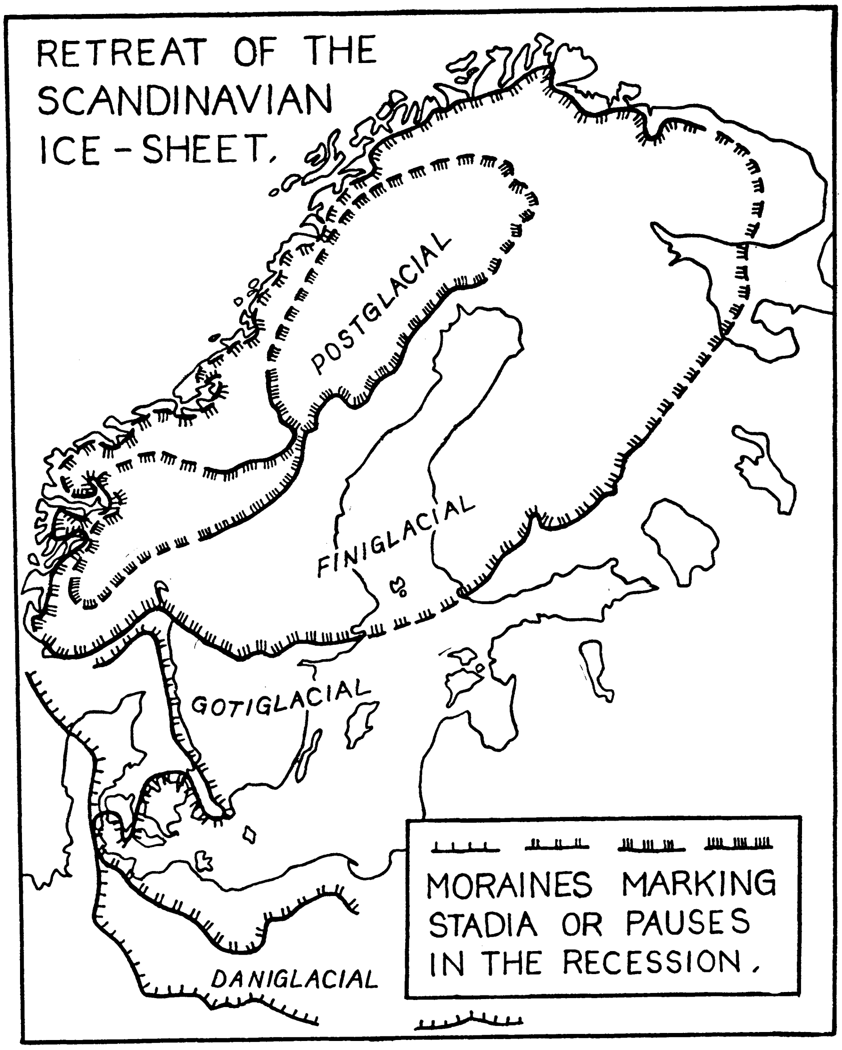

Fig. 1. Showing the retreat stages of the Scandinavian ice-sheet. (After de Geer.)

logy mainly in an indirect way through the changes of sea-level, of climate, of vegetation and of fauna which it induced. But in one respect the relevance is direct; it was only by the withdrawal of the ice that Scandinavia was progressively laid open to the settlement of man. From this it follows that for any archaeological site within the region across which the ice-sheet withdrew, a maximum date can be obtained directly from its position. It is thus certain for this reason, if for no other, that the rock-engravings at Landverk (Arctic Art Group, style A) and Glösa (Arctic Art Group, style B), both in Jämtland, and at Nämnforsen (style B), Ångermanland, date from no earlier than the Finiglacial period, since before this time their sites were under permanent ice-sheets. The stages of regression north of the centre of dispersion have not yet been accurately mapped, and it is, therefore, impossible to date the Jämtland engravings more closely; the Nämnforsen engravings, on the other hand, can hardly be older than the final stages of the Finiglacial period. It is claimed by many authorities (Ekholm, 1925 and 1926; Nordhagen, 1933) that some coastal areas in north-western and northern Norway have been to some extent free from ice not only during the last inter-glacial, but also throughout the last glacial phase. If this is true (and the evidence for certain localities seems decisive) it opens up possibilities for a human settlement of the area older than had previously been thought possible. The question of the former extent of ice in Scandinavia is peculiarly relevant to the dating of the numerous rock-engravings and flint sites of the coastal strip.

GEOCHRONOLOGY

As the ice-sheet withdrew, fine mud sediment was deposited in its melt-waters. The nature and quantity of the sediment varied according to season, the bulk settling during the summer, the finest particles in the winter. Thus by the alternation of relatively coarse and of relatively fine sediment each season's deposit became clearly delimited from the next, forming a distinct lamination or varve (literally layer). Moreover, any variations in the amount of sediment deposited from year to year were inevitably reflected in the relative thicknesses of the varves, which varied as a general rule between 0·2 cm. and 3·0 cm., giving a fairly wide range of variation. Since the annual varves were continuously being deposited and the margin of ice gradually moved away northwards (except for the relatively short stadia marked by the moraines), the sediments resemble at the present time a pack of playing cards sprawling on a table, each card occurring in a definite relation to all the other cards, but all the cards resting one above the other in

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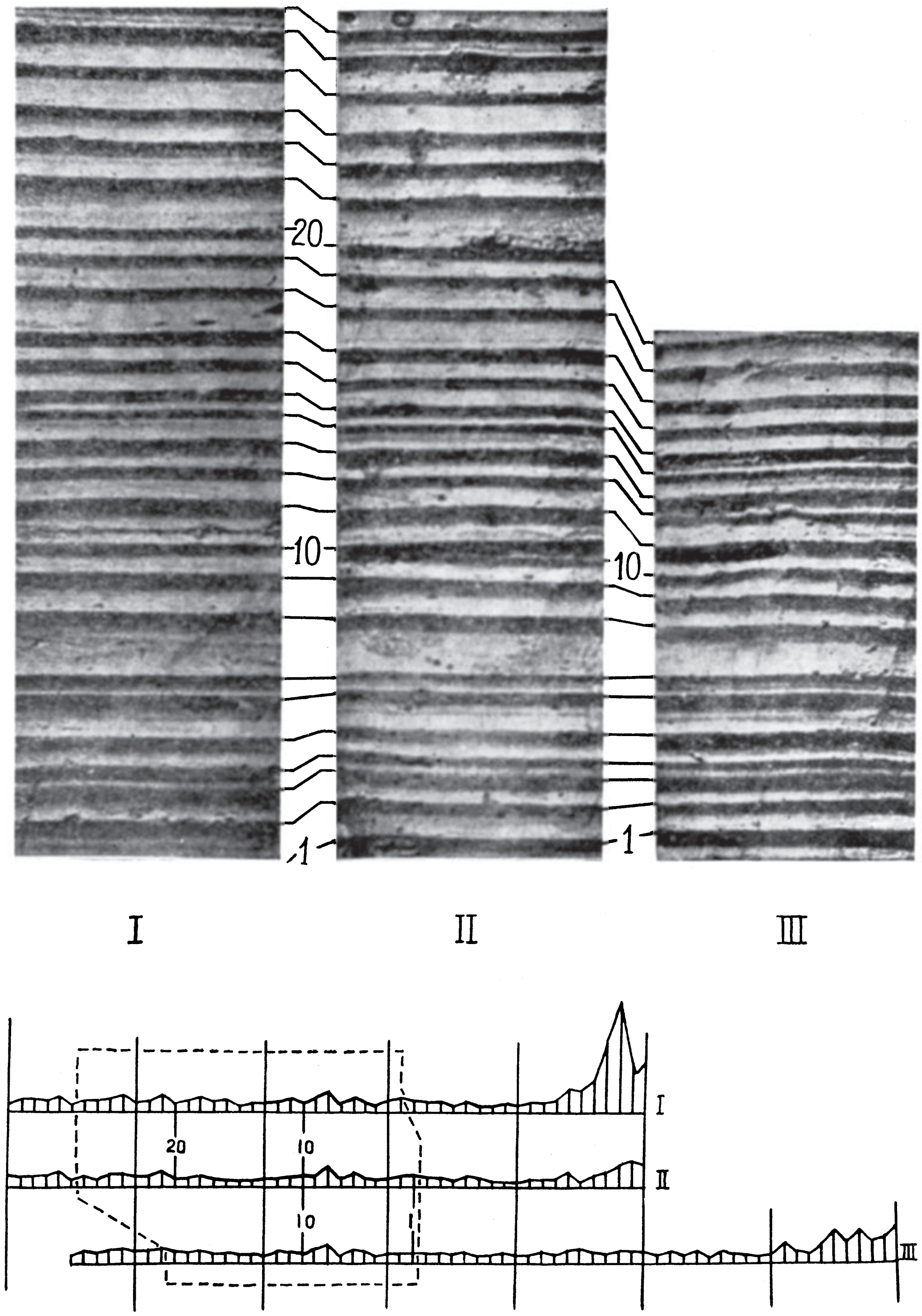

PLATE I. (Above.) Three samples of varved clay from the valley of the Kalajoki River in Ostrobothnia. Sample I is from a locality 6 kilometres and sample II 2 kilometres north-west of the church of Haapajärvi; sample III is from 8 kilometres south-east of the same church. The three samples connect with each other as illustrated.

(Below.) Diagram of the connected clay samples, showing variations in the thickness of the varves. The bottom of the sections is on the right of the diagram. The dotted line encloses the part of the samples illustrated above. (After Sauramo.)

direct vertical succession at no single place. The complete sequence of sediments can be established, therefore, only by the correlation of a number of sections situated at intervals apart. Once this can be achieved, and the number of varves between two points on the course of the retreat of the ice-sheet accurately counted, then clearly the chronology of that particular phase of retreat has been accurately established. It is the chronological potentialities of these sediments that makes them of such significance, not only for the late glacial and post-glacial natural history of Scandinavia, but also for archaeology.

The first to advance the view that there might be a close connection between the clay laminae and the annual deposition of the retreating ice was Baron G. de Geer (de Geer, 1884), and it is to this Swedish scientist that we owe the development of the whole technique of geochronology. It took de Geer twenty years before he succeeded, in 1904, in the task of correlating sections at some distance apart. In the following years he successfully linked up a series of sections, at an average distance apart of about 1 kilometre, extending from Scania to the point in south Jämtland where the inland ice finally parted into two. The wide distribution of individual varves, frequently exceeding 50 kilometres, and the regularity observed in the sequences of varves of varying thicknesses convinced him finally that his original speculations were correct, and in 1910 he was able to read his famous paper "A Geochronology of the last 12,000 years" to the International Geological Congress at Stockholm (de Geer, 1910).

The method of correlation initiated by de Geer and adopted by his followers is extremely simple (Pl. I). The vertical clay sections are cut clean, the varves are numbered and their thicknesses measured. These measurements are then recorded graphically by horizontal lines of proportionate lengths placed one above the other at equal distances against a vertical line. By connecting the unequal extremities a characteristic profile is obtained, which represents accurately the variations in the thickness of the annual sedimentation throughout the section. Correlations between neighbouring sections can then be made by visual comparison of their diagrams, the occurrence in both of a characteristic sequence of varying thicknesses acting as the connecting links. The correct distance between the sections necessary to secure a sufficient overlap can be found only by experience.

The chronological results first obtained in Sweden by de Geer related to the time taken by the ice to retreat from Scania to its point of bi-partition in southern Jämtland, a period of some five thousand years. His pupil R. Lidén was able at a later date to measure the period of time that has elapsed since the bi-partition of the ice (*i.e.* post-glacial time), on the basis of detailed work on the varve series along the Ångerman river, which gives an additional period of 8700 years (de Geer, 1928, p. 310) with a possibility of error that is not thought to exceed 100 years. The method has also been applied to Finland by Sauramo, who finds that the whole country south of the Oulu river was released from its ice-sheet in about 2800 years (Sauramo, 1929, pp. 51–6). Although the work has been done quite independently in the two countries, such correlations as have so far been made between the profiles of varved sediments from Finland and Sweden have revealed closely similar results.

At present geochronology has yielded results of approximate accuracy only, but already it has produced a natural system of chronology for the past twelve millennia that is not approached by any chronology based upon the development of human history. Leaving out of account entirely discredited systems, Egyptian chronology covers only half the period of geochronology and for its earlier stages, at least, commands far less general assent. Such chronology as there is for North-western Europe during the last two millennia B.C. depends ultimately on Egypt by a series of links, each one of which introduces an element of doubt, so that by the time one reaches the shores of the Baltic very little of value remains. In our area and for post-glacial time, geochronology holds the field, and it seems safe to predict that within the next generation it will have furnished a system of natural chronology that may have its effect on the dating of the earlier phases of human history in Egypt and the Near East. The tendency for archaeologists to date simpler cultures in peripheral areas in terms of the richer developments of the cradle-lands of higher civilisation is a natural and understandable one, but it was born of a necessity that no longer obtains. A complete reversal of the process cannot be expected until geochronology has been perfected in its home area and extended over a wider surface of the earth. Final accuracy within Scandinavia will be attained when extensive series of sediments have been correlated exactly, varve by varve, along a number of lines through different parts of Sweden and Finland drawn along the glacial retreat. The study of varve sediments in other parts of the world is already progressing, and important work has been done in the United States and Canada (Antevs, 1922 and 1925), Argentine, Chile, the Himalayas and Iceland (de Geer, 1928, p. 312). The astonishing fact is that, despite the influence of local conditions, a high degree of correlation has been observed between varve series situated in these widely separated areas and the key series in Sweden. This has suggested to de Geer and his followers that there must be some common cause of a cosmic nature, and that "varve-variation in its general features is a function of solar radiation", so that the chronology of the last twelve millennia in the history of Northern Europe has ultimately been provided by the sun.

CHANGES IN THE MUTUAL RELATIONS OF LAND AND SEA

The melting of the quaternary ice-sheet affected relative land and sea levels in Northern Europe in two distinct ways. First the release of the vast quantities of water locked up in the ice-sheet added to the volume of sea-water and tended to raise its level in relation to the land, inducing what is known as a eustatic rise of sea-level. Secondly the removal of the concentrated weight of the ice-sheet resulted in a recovery of the earth's crust or an isostatic rise of land.

Geologists vary in the weight they attach to each of these factors, but of their existence there is room for no serious doubt. To take first the eustatic factor, it will be obvious that the glacial melt-water must have added to the general volume of sea; the only field for argument concerns the proportion of this addition to the total sea-water, and its possible effect on raising the general sea-level. Albrecht Penck has calculated[1] that the melting of the ice-sheet of the northern hemisphere, covering some 490,000 square miles, would release sufficient water to raise the level of all the seas of the world by as much as 66·5 metres or about 210 feet. Antevs (1928, p. 81) estimated its volume in excess of its present size at 32,800,000 cubic kilometres, and stated that its melting would be sufficient to raise the level of the seas by as much as 272 feet. Since the excess volume of the ice-sheet of the southern hemisphere could affect the sea-level by no greater amount than 33 feet, the question of whether the glaciations of the two hemispheres were synchronous does not really affect our argument.

The isostatic theory is equally simple. The modern conception of the earth's crust as a thin skin or a floating raft makes it easy to grasp the essentials of what is meant by isostatic movement of land. The crust is con-

[1] Penck assumes that the northern ice-sheets averaged 1000 metres in thickness. On the evidence of the vertical distribution of glacial erratics and of glacially striated rocks Tanner estimates that near the centre of dispersal in Scandinavia the northern Pleistocene ice-sheet was 3570 metres thick (Tanner, 1930, p. 517).

ceived of as sinking locally under the weight of the ice-cap and recovering gradually as the load decreased with the melting of the ice. Strong presumption for this view is afforded by the fact that in the case of the Scandinavian ice-sheet the area of maximum crustal depression[1] coincides with the centre of glacial dispersal.

It will be obvious that the operation of the eustatic and isostatic factors went on side by side, and that the net result in terms of land movement and geographical evolution can be explained only by the interaction of these factors. An important distinction must be drawn between the two factors involved; whereas the eustatic rise of sea-level was constant the world over, isostatic movement varied according as the locality was central or peripheral to the heart of the glaciated area. In areas subject to the maximum depression by the load of the ice-cap the amount of recovery or isostatic movement was correspondingly greater than in the less affected peripheral areas. The net effect, therefore, of the interaction of the eustatic and isostatic factors on land and sea levels varied according to situation in relation to the centre of glaciation. Whereas in peripheral regions the sea tended to gain on the land, in more central areas the isostatic recovery of the land was always more powerful, after the initial stages, than the eustatic rise of sea-level. The fact that, for a brief period at the beginning, the sea gained on the land even in central areas is explained on the theory that, whereas the release of melt-water had an immediate eustatic effect, a certain time lag elapsed before the isostatic recovery began.

That alterations in the mutual relations of land and sea have in fact taken place in Northern Europe during the post-glacial period is manifest from evidence of two distinct kinds—that relating to the formerly greater elevation of land, and that implying a relatively higher sea-level. The occurrence of land phenomena at present under the sea affords the most satisfactory evidence of the first kind; the so-called 'submerged forests'—really peat-beds containing tree remains—to be seen at low water at many points on the British, North Sea and Baltic coasts, and the submerged peat or 'moorlog' of the North Sea bed are good examples.

Similar to this submarine evidence is that derived from deep borings or excavations in flat areas lying open to the sea. At the base of the flat region enclosed between the rivers Weser and Wümme in the neighbourhood of

[1] Isobases or contours of the depression have been constructed for large parts of Scandinavia, being based upon the altitudes above modern sea-level of the highest terraces.