Geologiska Föreningen i Stockholm Förhandlingar
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/sgff19

On late Quaternary time and climate

Gerard De Geer
Published online: 06 Jan 2010.

To cite this article: Gerard De Geer (1908) On late Quaternary time and climate, Geologiska Föreningen i Stockholm Förhandlingar, 30:7, 459-464, DOI: 10.1080/11035890809445600

To link to this article: http://dx.doi.org/10.1080/11035890809445600

On late Quaternary time and climate.

By

Gerard De Geer.

One of the greatest lacunae in the history of the earth has always been the complete deficiency of all definite chronological dates. Certainly many different attempts have been made to obtain at least some approximate computations of the time required for certain geological changes, but none ever resulted in any reliable, not to speak of really accurate dates. Thus it may be of some interest to relate, that among the late Quaternary deposits of Sweden there are a few that show a periodical lamination, which, as I have found by a long series of investigations, is caused by the climatic changes in the course of every year.

The most important of these deposits is the so-called »*hvarfvig lera*», a seasonally laminated clay, which is quite commonly spread over the low grounds of eastern Sweden, of Finland and of the Baltic Provinces. This clay was deposited in the Baltic parts of the late glacial sea along the border of the receding land-ice by the same sub-glacial rivers that left their coarsest material at the margin of the ice, by and by building up the great series of submarginal deltas, which form the celebrated »*åsar*» (pr. osar).

Every mild season the ice-border receded one step, leaving a narrow strip of its dominion to be taken possession of by the sea. Thus, every new annual layer was, in

the direction of the ice-recession, extended a little farther than the layer of the preceding year, like one tile above the other. Of course these transgressional strips of layers are broader when derived from warmer years and narrower when formed during colder ones. In this way the receding ice-border acted as an ideal self-registering thermograph, leaving in the position and configuration of the proximal limit of every year's layer the exact copy of the corresponding ice-border and at the same time a measure of its recession during the last year.

By noting the thickness of the layers at many different points, not too far apart from each other, and embodying these measurements in diagrams, thus making them more easily comparable, I have succeeded in identifying a great number o layers from point to point until I reached the northern limit of each successive layer where every layer rests directly upon the strip of the old sea-bottom, from which the ice had retreated the same year.

At Stockholm and in its neighbourhood more than a hundred sections through the lower layers of the seasonal clay have been examined and identified, thus making it possible to record upon a map in considerable detail all the successive winter limits, or *æquirecesses*, of the receding land-ice in that region. Furthermore, it has been possible to represent upon a series of maps the thickness of every single year's layer by means of *isopachytes* or lines of equal thickness. These lines have been found to be arranged in semicircular curves around a series of centra of the Stockholm-ås, an esker running through the midst of the town and evidently deposited by the same subglacial river as the seasonal clay.

During different years the distance that the ice-border melted away, as well as the thickness of the sediment deposited by the melting water, exhibited considerable variations, showing the corresponding changes in the climate.

To get a general view of these changes for a longer period I have during the last years, with the collaboration of some thirty

students from the universities of Stockholm and Uppsala, undertaken an investigation of a section or line of observations of some 800 *km* in length, running in the direction of the ice-recession all the way form the southernmost part of Sweden up to the very neighbourhood of the ice-shed, where the last remnants of the ice melted away.

This investigation has shown, that when the ice was retreating from southern Sweden the climate was still relatively cold, the annual ice-recession being only about 50 *m*. In complete conformity with this, an arctic vegetation followed the receding ice-border step by step. Somewhat farther to the north in the northeastern part of the province of Småland and the adjacent region of Östergötland the ice-recession went on somewhat faster or at about 100—130 *m* per annum. When the ice-border had reached the middle part of the last named province, it became stationary for 100—200 years, marking this stop by a series of the best developed terminal moraines in Scandinavia. The cause of this break in the great retreat of the ice must evidently have been a somewhat colder climate. That epoch having ceased the ice-recession recommenced though in the beginning at a very slow rate, or during the first 300 years only at 20 *m* per annum. But very soon after that time the climate turned milder and the recession rose to 75, 100, 150 and even to 200 *m* a year. At Stockholm it was already 250 *m*, at Uppsala 300, and farther north even somewhat more, up to about 400 *m*. Yet at several parts of the long section different series of colder years, marked by slower recession, sometimes not exceeding 100 *m*, have been noted.

However, generally speaking, the recession accelerated with the passing of the years, evidently because the climate was undergoing a most remarkable and considerable amelioration. The best index of the rising temperature was doubtless the rate of the ice-melting itself. But of course it is interesting to note that the plants found in the lowermost layers of the peat-bogs,

representing the species that immediately followed the receding land-ice, became mixed up with more and more temperate forms the farther the ice receded. Thus the arctic plants, which once, in southern Sweden, had been the companions of the ice-border, practically disappeared when the latter reached the middle of the country, and gave place to the Swedish fir, *Pinus silvestris*, and other plants associated with this tree.

In the same way the marine fauna living along the ice-border, had its most arctic character when the ice had a greater extension, the most northern forms being found in the late glacial marine sediments of Jylland and southwestern Sweden. At the same rate as the ice-border receded and the climate grew milder, the temperature of the surface water in the sea rose, which accords quite well with the fact that along a great part of the west coast of Sweden several temperate forms occur already in the shell-beds accumulated in shallow water, while arctic relicts are still found in the clays deposited in deeper water. In this way many of the interesting faunistic facts brought forward by W. C. Brögger in his excellent work on the late Quaternary changes of level in the Christiania region will receive a new explanation that brings them in full concordance with the investigations of the synchronous changes of level in Sweden.

By means of the seasonal clay it is furthermore possible to examine almost as accurately as may be wished the changes in the late glacial climate of Sweden. Judging partly from personal experience, partly from what is known about the general geology of these regions, I think it will also be possible to carry out a similar investigation in Finland and Estland (Esthony), thereby determining the dates required for the elimination of more local variations. Thus by and by the normal climatic changes that characterised late glacial northern Europe for several thousand years can be represented by a detailed diagram showing the relative temperature, not only of every century but of decades and also of single years.

Perhaps later on it will also be possible to extend this kind of investigation to some of the other, once glaciated regions, as for instance North America. The coincidence or non-coincidence of the climatological curves representing such different tracts of the earth would show whether their glaciations had been contemporaneous or not, and thus whether the glaciations of the ice-age depended mainly upon general or local causes.

At present I have chosen the year when the ice-border passed through the place where the observatory of Stockholm is situated, as the starting point for the above described late glacial, chronological and climatological record, counting plus-years to the north and minus-years to the south of that point. Still it is to be hoped that this record may be extended from the end of the late glacial epoch up to our present chronology, by means of certain postglacial deposits, the accumulation of which has been influenced by the annual snow-melting in the highland mountains of Sweden.

In this way probably it will be possible at last to settle the question so much discussed among our botanists, whether, as A. BLYTT believed, our flora has immigrated during alternating dry and humid periods or not. Furthermore, we may thus hope to find the deciding test of the theory of E. BRÜCKNER concerning the alternation during every century of about three warm-dry and three cold-wet periods. The data hitherto derived from the late glacial ablation have already thrown much light upon the climatic evolution during the epoch named, from the first immigration of arctic plants to southern Sweden until the time when the central parts were covered with forests of fir. It is easy to understand how useful such a detailed chronological and climatic record will be by determining, on a quite objective physical basis, not only the existence but also the duration of changes, which could scarcely have been made out, even in a general way, from only the — certainly very important but of course always incomplete and somewhat vague — floristic records in the peat-bogs. On the other

hand, it may be hoped, that in the way indicated above the different opinions about the evolution of our flora will gain a firm ground for reconciliation. Space does not allow me here to enter in detail upon these interesting questions which will be more fully discussed on another occasion. It may only be mentioned, that the late glacial climate evidently was not, as often supposed, a mere increase of the actual climatic oscillations about a tolerably stationary mean temperature, but was characterised by a most remarkable, very one-sided and long continued amelioration of the climate.

Even if it should not be possible to obtain the same accuracy for the post glacial record as for the late glacial, still it will of course be of great interest to get a real connection between the already recorded five thousand years from the late glacial epoch and our historical chronology, thus at last obtaining for the first time a real time-scale for the marvellous climatic and geographical changes connected with the ice-age and with perhaps the most remarkable part of the evolution of mankind.