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On the evidences of Postglacial changes of climate furnished by the peat-mosses of Northern Europe.

By

RUTGER SERNANDER.

About the year 1875, two naturalists demonstrated in the peat-mosses of their respective countries a remarkable succession of strata, in which both these men quite independently of each other traced the effects of periods with alternating insular and continental climate. These two scientists were JAMES GEIKIE in Scotland and AXEL BLYTT in Norway.

BLYTT, who devoted himself most extensively to these investigations, in the course of years expanded his first tentative theory on the Postglacial climatic changes into a magnificent astronomical scheme, embracing the geological successions as a whole.

The foundations of the new hypotheses were evidently insecure, and it is not to be wondered at that the geological world in general regarded the whole merely as a brilliant feat of construction. Undoubtedly it was the want of confidence in BLYTT's general theory on climatic changes, which caused scientific circles to overlook the data on which that theory was built up, viz. the plain evidence furnished by the Norwegian as well as the Scotch mosses as to certain extensive climatic changes in Postglacial times.

If, however, we cast a glance at the results which the survey of peat-mosses and particularly those of Sweden has

gleaned during the two last decades, it will be found, in my opinion, that BLYTT's theory as to the structure of the Scandinavian peat-mosses has been in the main confirmed, and that with his scheme — subject to certain modifications introduced by myself — as a basis, chronological data of immense value can be obtained within the range of the postglacial epoch; the climatic periods in question having left palpable traces of their existence in the great majority of mosses. The problem is, however, a vexed one, and in Sweden, where the problem has been most eagerly debated, the investigators of peat-mosses are at present ranged in two opposite camps, with GUNNAR ANDERSSON (1), E. HAGLUND (2), and H. VON POST (3), on one side, who all concur in denying that any such period as BLYTT has constructed has left visible traces in the Scandinavian Quaternary deposits — and on the other side, A. GAVELIN, J. P. GUSTAFSSON, T. HALLE, H. HEDSTRÖM, G. HELLSING, M. HULTH, KN. KJELMARK, L. VON POST, G. SAMUELSSON, R. SERNANDER, and others, who are convinced they have discovered such traces either in peat-mosses, or in lakes, or in deposits of calcareous tufa throughout the whole of Sweden. Some facts which we have demonstrated in this regard will be communicated in the following.

There is hardly any feature in the structure of our peat-mosses from Scania right away to Lappland, which is so strikingly in evidence as the existence of a forest-bed under the uppermost peat-bed, extending over greater or smaller areas of the mosses. This uppermost peat-bed is in each single case tolerably homogeneous and stands in close correlation with the peat formation caused by the present vegetation of the mosses. In low mosses it consists of marsh-peat, in high mosses of *Sphagnum*-peat.¹

Any breach of homogeneity that may occur consists mainly

¹ High moss (German Hochmoor, Swedish mosse) = *Sphagnum*-moss. Low moss (German Niedermoor, Swedish kärr) = marsh formed principally of *Carex* and *Amblystegium*, but not *Sphagnum*.

in the bottom layers being more hydrophilous, so that in the low mosses they are mixed with lacustrine peat, and in the high mosses they consist of *Eriophorum vaginatum*-*Sphagnum*-peat whereas the upper layers merge into *Sphagnum fuscum*- or *Sphagnetum myrtillosum*-peat. The breadth of each separate kind of peat, in each respective district, is, if we set aside certain extreme cases, fairly homogeneous, being greatest in the case of the *Sphagnum*-peat, usually 1—2 m, smaller in the case of the marsh-peat, usually 0.5—1 m, all measurements being taken in undrained mosses. The forest-bed, in its turn, rests upon older peat-beds or lacustrine sediments, the upper parts of which thin out on a higher level than the stools, which are rooted lowest; thus the forest generation, from which these stools have descended, must have grown under lower ground-water level conditions than those which prevailed when the layers surrounding the forest-bed were formed.

The above-named explorers of peat-mosses from different parts of Sweden have in a series of monographs endeavoured to show that these three layers correspond to three different climatic stages, a comparatively dry period, preceded and followed by two comparatively humid ones. It can easily be shown by means of stratigraphical investigations that this climatic sequence corresponds to the whole final stage of the Postglacial history of the Baltic, the so-called Litorina time — incl. the Limnæa time of MUNTIE — and for these three climatic stages into which this period falls, I have adopted the terms applied by BLYTT, *subatlantic*, *subboreal* and *atlantic*. In the peat-mosses which lie above the boundary of the Litorina-sea, there is found underneath the series above mentioned yet another break in the lacustrine beds, occasionally marked by a lower forest-bed, which indicates an earlier period of arid conditions. We may call this the *boreal* period. By way of illustration we may first take a section of a low moss — *Stånga myr in Gotland* (4, p. 58) and then — as an example of high mosses — *Bara mosse in Scania* (5, p. 390).

Stånga myr in Gotland.

<i>Cladium Mariscus</i> -peat.	Subatlantic.
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<i>Pinus silvestris</i> -stool bed.	Subboreal.
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<i>Phragmites</i> -peat.	Atlantic.
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<i>Betula alba</i> -stools.	Boreal.
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<i>Cladium</i> -peat.	
Mud (Gyttja) and lake marl (Kalkgyttja).	

Glacio-fluvial sand.

Bare mosse in Scania.

<i>Sphagnum</i> -peat.	Subatlantic.
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<i>Pinus silvestris</i> -stools	Subboreal.
Leaf wood stools	

Low moss-Lacustrine peat	
<i>Cladium-Phragmites</i> -peat	
<i>Phragmites</i> -peat	Atlantic.
Litoral mud (gyttja)	
Lacustrine mud	

Litoral mud	Boreal.
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Lacustrine mud	
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Sand.

Late glacial lacustrine clay.

Moraine.

These subboreal and boreal periods with their dry climate, which has occasioned the above exemplified breaks in the succession of our peat-mosses, have left their traces not only in the peat-mosses. The same features of historical development also make their appearance in those of our lakes, which in virtue of certain external conditions have been able to preserve tree-stools at their bottoms. These tree-stools are not seldom found there so far below the bottom of the outlet, that one is forced to the conclusion that several subboreal and boreal lakes must have been without outlet during the greater part of the year. The changes of level in the lakes of Vänstern and Kalfven in Småland, which GAVELIN has most

carefully studied, show the curve reproduced below, fig. 1 (6, p. 51), indicating the variations in their level.

In the case of certain of our calcareous tufas, such as the Skultorp tufa, the dry climate had so reduced the springs, that a distinct break is found between the subatlantic and the atlantic tufa-beds and that mould-beds are found under-

Fig. 1.

Changes of water-level in the lakes Vänstern and Kalfven.

neath the last mentioned tufa-deposit. From HULTH's monograph on the Skultorp tufa in Västergötland, along with the Benestad tufa, the most noteworthy calcareous tufa-deposit in Europe, we borrow the following diagram (7, p. 101):

The Skultorp tufa in Västergötland.

Tufa.	Subatlantic.
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Mould-bed.	Subboreal.
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Tufa with abundant <i>Quercus pedunculata-flora</i> .	Atlantic.
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Mould-beds intercalated with thin tufa-deposit, containing <i>Pinus silvestris</i> .	Boreal.
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Lake marl with tufa-lenses.	
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Tufa with <i>Salix reticulata</i> .	
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Late glacial sand.	
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How this climatic development, according to my views, is correlated to the archeological and botanic-geographical development as well as to the changes of the level of land, will be seen, as far as Southern Sweden is concerned, from the following table (p. 471).

In Finland, as shown particularly by the researches of HERRLIN and SERNANDER, the Litorina time must have had the same historical development as in Sweden. As regards North-West Germany and Scotland the investigations of WEBER and LEWIS point, according to my view, to a postglacial climatic history analogous to that of Fennoscandia. (Cfr the table, p. 472).

Southern Sweden during the recent and postglacial times.

<i>Climatic Periods.</i>	<i>History of the Baltic.</i> [According to Muxuu (8).]	<i>Principal Archeological Periods.</i>	<i>General development of vegetation.</i>
<i>The Subatlantic Period.</i> Climate humid, and, especially at the beginning, cold.	(The Limnea time.) ---	Historical Times. The Iron Age.	Norrlund plants migrate southwards.
<i>The Subboreal Period.</i> Climate dry and warm, much as in central Russia.	---	The Bronze Age.	Xerothermic associations with <i>Stipa</i> etc. common. (In Norrlund the tree-boundary rises, and <i>Corylus</i> goes far above its present boundary).
<i>The Atlantic Period.</i> Climate maritime and mild, probably with warm and long autumns.	The Litorina time.	The passage grave Period. The Period of the Kjökenmøddings. The Period of »Magle Mosse» (5, p. 392).	<i>Picea excelsa</i> and <i>Pinus silvestris</i> immigrate. Rich leaf wood flora with <i>Quercus pedunculata</i> and <i>Tilia parvifolia</i> dominating.
<i>The Boreal Period.</i> Climate dry and warm.			The oak immigrates in Scania-Dania.
<i>The Subarctic Periods of BLYTT.</i> The climatic conditions more or less undetermined.	The Ancylus time.		<i>Pinus silvestris</i> -forests, not seldom with <i>Ulmus montana</i> , <i>Corylus</i> etc. the dominant tree-association. <i>Pinus silvestris</i> immigrates into Scania etc. preceded by a narrow zone of <i>Betula odorata</i> -forests.
<i>The Arctic Period.</i> In Scania a climate like that of South Greenland.	The Yoldia time.		<i>Dryas</i> -flora: aquatic vegetation comparatively rich.

<p><i>The High Mosses of North-West Germany</i> (according to WENDEL).</p>		<p><i>The Peat-Mosses of Scandinavia during the Litorina and the end of the Ancylus times.</i> (According to BYRTE and SERNANDSEN).</p>		<p><i>The three chief Scotch Moss Types.</i> (According to LEWIS).</p>			
				Shetland.	Inland above the present tree-boundary.	Inland at lower levels.	
Jüngerer Sphagnum-torf.		(Limnaea time).	Subatlantic layers.				Recent peat.
Grenztorf.		Litorina time.	Subboreal forest-beds.	Heath.	Two Pine- and Birch-wood-beds; between a Sphagnum-bed.	Pine-forest bed.	Upper forestian.
Stillstandsperiode der Hochmoorbildung.			Atlantic layers.	— — — —	— — — —	— — — —	Upper peat-bog. Second arctic bed.
Älterer Sphagnum-torf.		Ancylus time.	Boreal forest-beds.	Birch-woods with Hazel.			Lower peat-bog.
Moos- und Seggen-torf.						Birch-woods with Hazel.	Lower forestian.
Wald-torf.							
Leber-torf.							First arctic bed.
Dryas-ton.							

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