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SHORT COMMUNICATIONS

TENTATIVE EXPLANATION OF THE LATE GLACIAL AND EARLY HOLOCENE CLIMATIC CHANGES IN NORTH-WESTERN EUROPE[1]

B. VAN GEEL[2] & E. KOLSTRUP[2]

INTRODUCTION

In Late Glacial and early Holocene pollen diagrams from north-western Europe a number of changes in the A.P. (arboreal pollen)/N.A.P. (non-arboreal pollen) ratio has been found. These changes represent vegetational changes (viz., the appearance of more or less open vegetation types) usually correlated with the mean July temperatures (VAN DER HAMMEN ET AL., 1967; BEHRE, 1966; WIJMSTRA & DE VIN, 1971). The importance of the possible divergence or convergence between mean summer- and mean winter-temperature, as well as the effect of certain moisture conditions (i.e., a continental versus a more oceanic climate), is somewhat underestimated.

Recently more detailed investigations from the 'Uteringsveen' (CLEVERINGA ET AL., 1977) and the 'Borchert' (BOHNCKE & DEE, in prep.) have shown that a decline of arboreal vegetation may take place even if the summer temperature remains fairly high. In the above-mentioned pollen diagrams thermophilous annuals, helophytes, and aquatics are found in the Earlier Dryas, the Late Dryas, and the Rammelbeek phase. Therefore, it is probable that the reason for the decrease of tree stands might be an alternation of dry summers and cold winters with very little snow cover or perhaps no such cover at all. The discrepancy between the climatic records deduced from palaeobotanical studies and fosil *Coleoptera* faunas (COOPE, 1977; LAMB, 1977) may be ascribed partly to an overestimation by palaeobotanists of the low percentages and decreasing numbers of the arboreal pollen types. Consequently, the results of the above-mentioned studies from the Eastern Netherlands may lead to substantial changes in the interpretation of the Late Glacial and early Holocene climates.

OUTLINE OF THE CLIMATIC CHANGES AND THEIR POSSIBLE CAUSES

The following explanation of the Late Glacial and early Holocene climatic sequences is based mainly on theoretical considerations and only for a minor part on palaeoecological evidence.

In our discussion the following assumptions were made:

(1) The short-term climatic changes (Bølling – Earlier Dryas – Allerød – Late Dryas – Friesland phase – Rammelbeek phase – late Preboreal) during the Late Glacial and early Holocene were caused by an inertness and a varying intensity of the West-East circulation pattern when the westerlies gathered strength and moved in a poleward direction during periods of increasing temperature and wasting of the ice caps.

(2) It is supposed that there were important changes in the circulation pattern in Europe without synchronous changes in the physical or astronomical cause or causes (changes in the earth's orbital geometry (HAYS ET AL., 1976) or increasing

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[2] Hugo de Vries-Laboratorium, Afd. Palynologie, Sarphatistraat 221, 1018 BX AMSTERDAM, The Netherlands.

amounts of solar energy emission?) at the transition from the glacial to the interglacial period. In other words, there may have been a constant increase in solar energy emission or, at least, the solar energy emission was never the restricting factor for an amelioration of the climate during the Late Glacial and early Holocene.

The climatic development may thus be explained in the following way: during the Upper Pleniglacial there was a relatively weak atmospheric circulation during the summers, and the winters were probably dominated by easterly winds (LAMB, 1977). The westerlies had not yet reached N.W. Europe but were far south of their present position. The increased solar energy emission during the later part of the Upper Pleniglacial caused the temperature to rise, so that the ice-masses began to melt.

During the Bølling the increasing solar energy emission caused a further rise of the temperature and some thermophilous species of plants immigrated into the area. Owing to the higher temperatures, the rate of evaporation increased, but drought was as yet not a restricting factor in the development of vegetation.

During the Earlier Dryas a threshold had been exceeded because the increasing summer temperature had caused a further increase of the rate of evaporation and the soil had gradually become drier, so that the areas that remained fairly moist became relatively more important for the persistence of the vegetation. In general dry conditions prevailed, thus giving the climate a more continental character. Frost cracks were formed during the winters (MAARLEVELD, 1976) and it became difficult for the trees to survive the winters without a protective snow cover.

At the beginning of the Allerød the depression tracks reached N.W. Europe. The climate became moister and this, together with the milder winter temperatures and the presence of snow enabled *Pinus* and *Betula* to survive during the winters. The summers were moist enough for the formation of peat. During the later part of the Allerød accumulation of snow took place in mountainous northern areas because of the increased falls of snow.

During the beginning of the Late Dryas the depression tracks were still in contact with the ice-cap in Northern Europe and caused a further growth of the glaciers resulting in a general decline of both the summer and the winter temperatures. Because of the increase in the extent of the snow- and ice-covered areas high atmospheric pressure became dominant in northern latitudes during the Late Dryas and the atmospheric circulation became weaker and the westerlies moved southwards. During the later part of the Late Dryas the same climatic conditions most probably prevailed as in the Upper Pleniglacial just before the Bølling, except for the higher mean temperature which was above 12°C in July. The still increasing solar energy emission again caused a rise in temperature, thermophilous plants immigrated again during the Friesland phase and a rapid melting of the ice cap took place. In our view the re-advance of the polar waters in the North Atlantic around 10,220 B.P. (RUDDIMAN & MCINTYRE, 1973) might very well be the results of this glacial wasting.

During the Rammelbeek phase a situation very similar to that in the Earlier Dryas was encountered. The occurrence of thermophilous species of plants point to a warm summer, but the precipitation/evaporation ratio was low. Again the moistest areas became the most favourable for the maintenance of the vegetation.

The winters were cold and dry (there was no protective snow cover) and the further spreading of birch and pine was delayed (BOHNCKE & DEE, in prep.).

During the late Preboreal the depression tracks reached north-western Europe again. The amount of precipitation and the milder winters favoured the further spreading of trees. The summers were warm and humid enough for the accumulation of peat.

The above-mentioned theory should only be considered to be an attempt towards a general explanation of the climatic changes during the Late Glacial and the early Holocene. It is certainly too simple and conceivably the physical cause is not the amount of solar energy emission, but some other large-scale phenomenon(a). It seems that in any event changes in the circulation pattern of the atmosphere may be a possible explanation for the changes in climate and consequently of the stands of vegetation during the above-mentioned time-span. The fact that a series of climatic changes similar to those found in N.W. Europe seems to be lacking in North America may be an argument in favour of the above-mentioned model: circulation patterns are restricted geographically.

The ideas presented in this paper are shown diagramatically in the figure. No attempt has been made to indicate any absolute values for the temperature curves. Only the suggested trends are shown.

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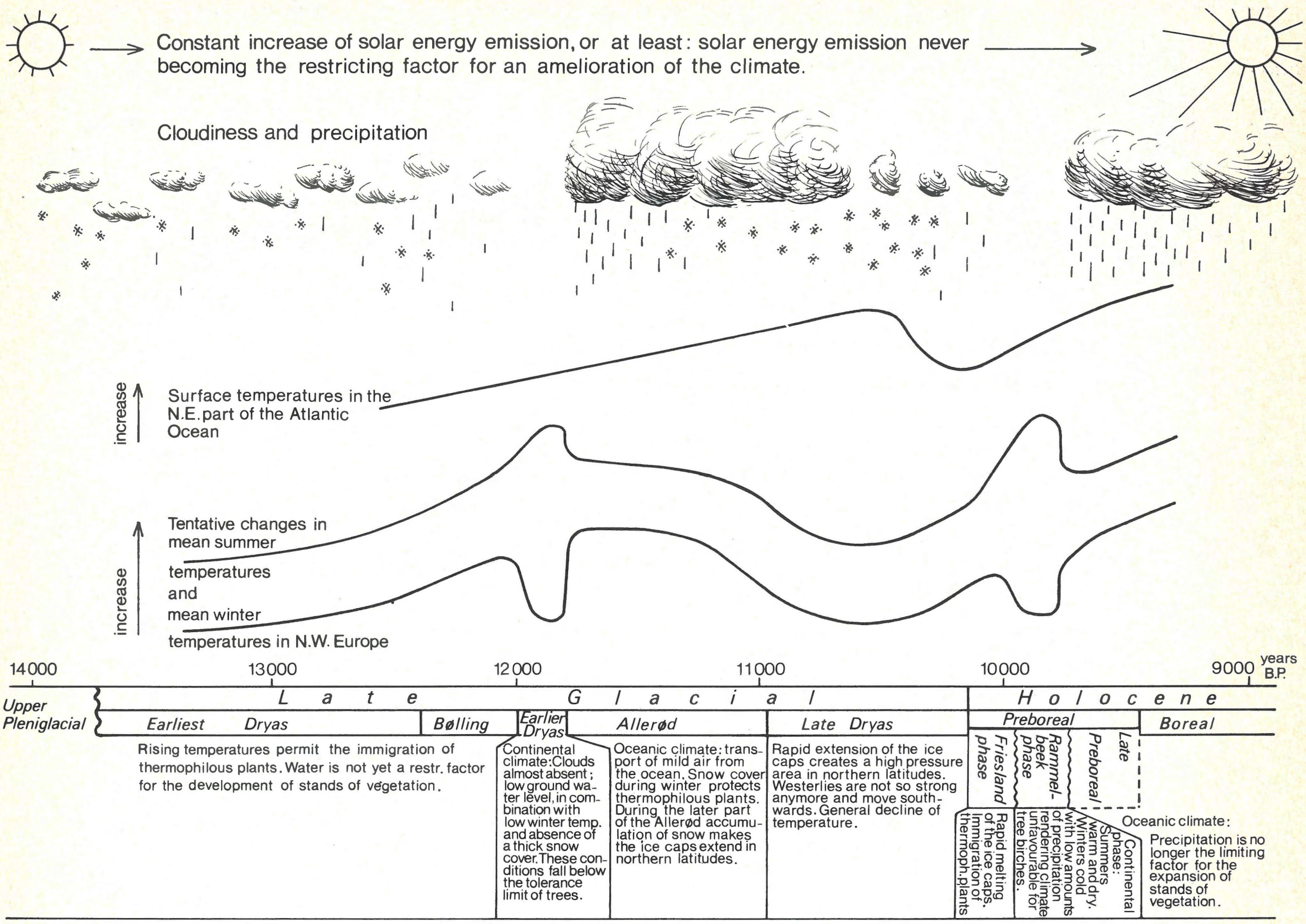

Fig. 1
Tentative outline of the climatic trend during the Late Glacial and the early Holocene in Northwestern Europe.

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