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The climate of the Younger Dryas in the Netherlands (extended abstract)

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Abstract

The Younger Dryas is to be considered as a biostratigraphic zone which in the Netherlands started 10 900 (radiocarbon) years ago and ended 10 200 BP. It is subdivided in two parts. The first half (up to 10 500 BP) is characterized by severe, continental conditions which resemble those at the end of the Pleniglacial; a permafrost was present. The second half shows milder conditions as a transition to the Holocene; permafrost disappeared at about 10 500 BP.

The 'Younger Dryas' in its context

Since the name 'Younger Dryas' is used nowadays in a number of different disciplines, it is not superfluous to reflect on its meaning. In the original definition, 'Younger Dryas' indicated a phase of cooling just before the beginning of the Holocene as revealed by pollen associations which express the vegetation pattern (reference sites in Denmark recapitulated by Iversen 1954). Afterwards, the decline of the vegetation during the Younger Dryas has been found in many pollen diagrams.

Other proxy-data also testify to colder conditions during the Younger Dryas. A classical example is the re-advance of ice sheets and Alpine glaciers which have often resulted in well- developed moraines. More recently a similar cooling trend is described from signals in the marine record as well as in the löss sequences on the Chinese Löss Plateau (An et al. 1993).

It is important to note that each kind of proxy-data has its own characteristics and thus responds differently to a climatic change. It means that, according to the kind of proxy-datum, differences are to be expected in 1) the intensity of the reaction to a climatic change, 2) the threshold values for the initiation of the response and 3) delay times between the climatic event and the proxy response. As a result, it is well possible or even likely that on a global scale a certain proxy-datum manifests itself differently and not simultaneously with others.

From these considerations it appears that, in order to avoid confusion on the exact meaning of the name 'Younger Dryas', and unproductive discussions on its exact age, preference should be given to its original significance as a *biostratigraphic unit* (cf. Vandenberghe & Bohncke 1985). It goes without saying that such a biostratigraphic zonation is induced by climate. However, the use of 'Younger Dryas' as a chronozone (Mangerud et al. 1974) is not suitable because of the different ages reflected in different kinds of proxy-data and inferred for different regions.

Subdivision of the Younger Dryas

The decline of the vegetation at the boundary between Allerød and Younger Dryas due to deteriorating climatic conditions has been recorded in many pollen and macro-remain diagrams. In the southern Netherlands examples are reported from De Hamert (Teunissen 1983), Notsel (Bohncke et al. 1987) and Bosscherheide (Bohncke et al. 1993). From radiocarbon datings at these three localities the age of this transition has been determined at 10 900 BP. The re-establishment of the vegetation induced by the Holocene warming is well determined and dated at other locations in the southern Netherlands, for instance at De Borchert at 10 150 BP (Van Geel et al. 1981) and at Halle at 10 220 BP (Vandenberghe & Bohncke 1985). Figure 1 shows this boundary at 553 cm core depth. Thus from paleovegetation reconstruction, the age limits of the biostratigraphic Younger Dryas could be fixed at approximately 10 900 and 10 200 radiocarbon years BP respectively.

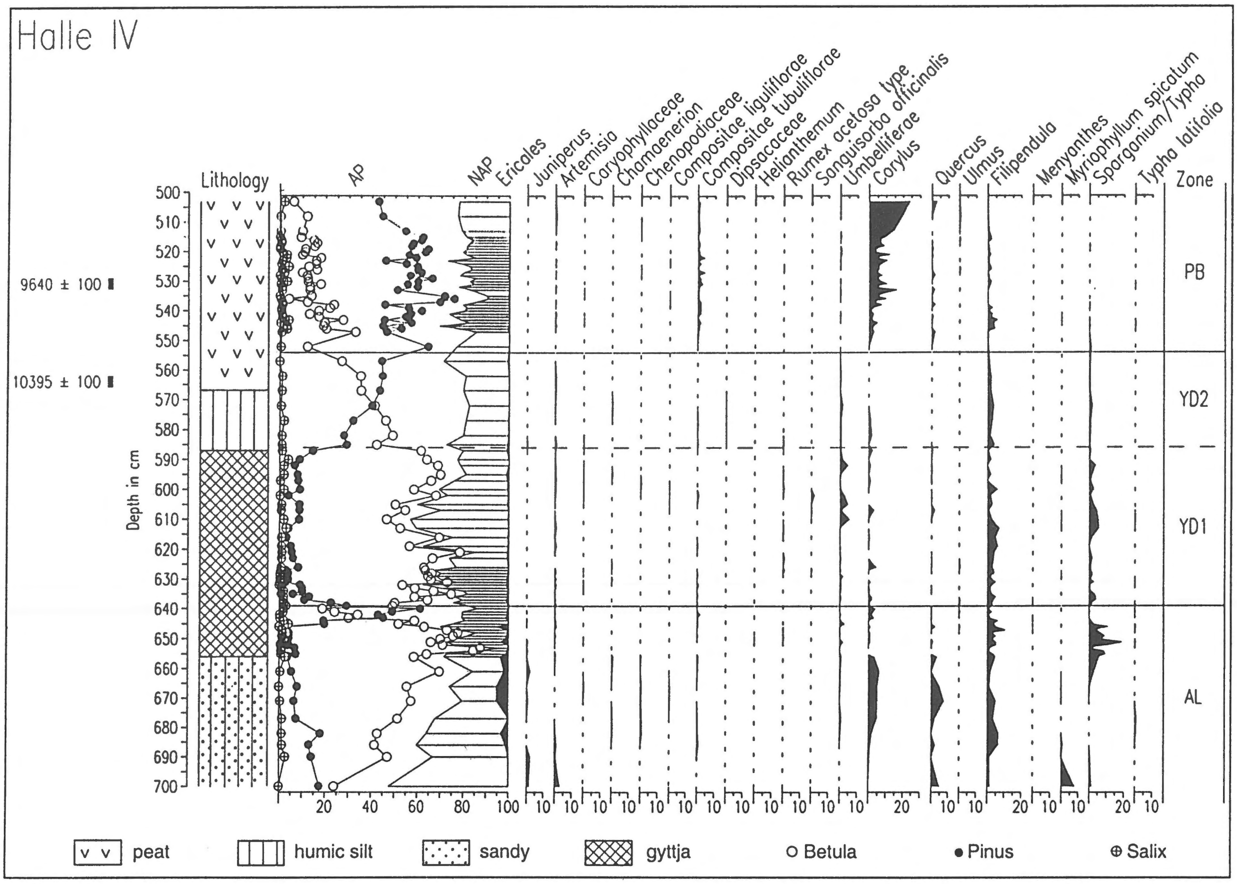

Fig. 1. Late Glacial and Early Holocene pollen sequence at Halle (after Vandenberghe & Bohncke 1985). PB = Preboreal; YD = Younger Dryas; AL = Allerød; AP = arboreal pollen; NAP = non-arboreal pollen.

The non-uniformity in the course of the Younger Dryas in the Netherlands was first demonstrated in the pollen diagram at Halle (Vandenberghe & Bohncke 1985; Fig. 1). It shows an older part with near absence of *Pinus* and dominance of *Betula* in the tree population and a younger part in which *Pinus* is dominant. The crossing of the curves of *Pinus* and *Betula* at that locality occurs shortly before 10 395 ± 100 BP. This twofold subdivision of the Younger Dryas is confirmed at Bosscherheide where the older part is represented by cryoturbated fluvial deposits and the younger part by non-deformed eolian deposits (Bohncke et al. 1993). It has also been reported from other regions (e.g. Berglund et al. 1984; Björck & Digerfeldt 1984; Duplessy et al. 1986).

Climatic conditions during the Younger Dryas in the Netherlands

Mean summer temperatures

The reconstruction of the summer temperatures is based on the paleovegetation characteristics. More particularly, the occurrence of some plant species and the development of forest give some clues. Pollen diagrams show that during the first part of the Younger Dryas the previously developed forests largely declined but at some places could persist (e.g. Van Leeuwaarden 1982). Furthermore, *Myriophyllum spicatum*, *Juniperus* and *Typha* sp. occurred sparsely. It is inferred that summer temperatures fell to about 10 °C in the early part of the Younger Dryas. In the later part forests restored generally while plants like *Juniperus*, *Myriophyllum* and *Typha* became more abundant. Therefrom,

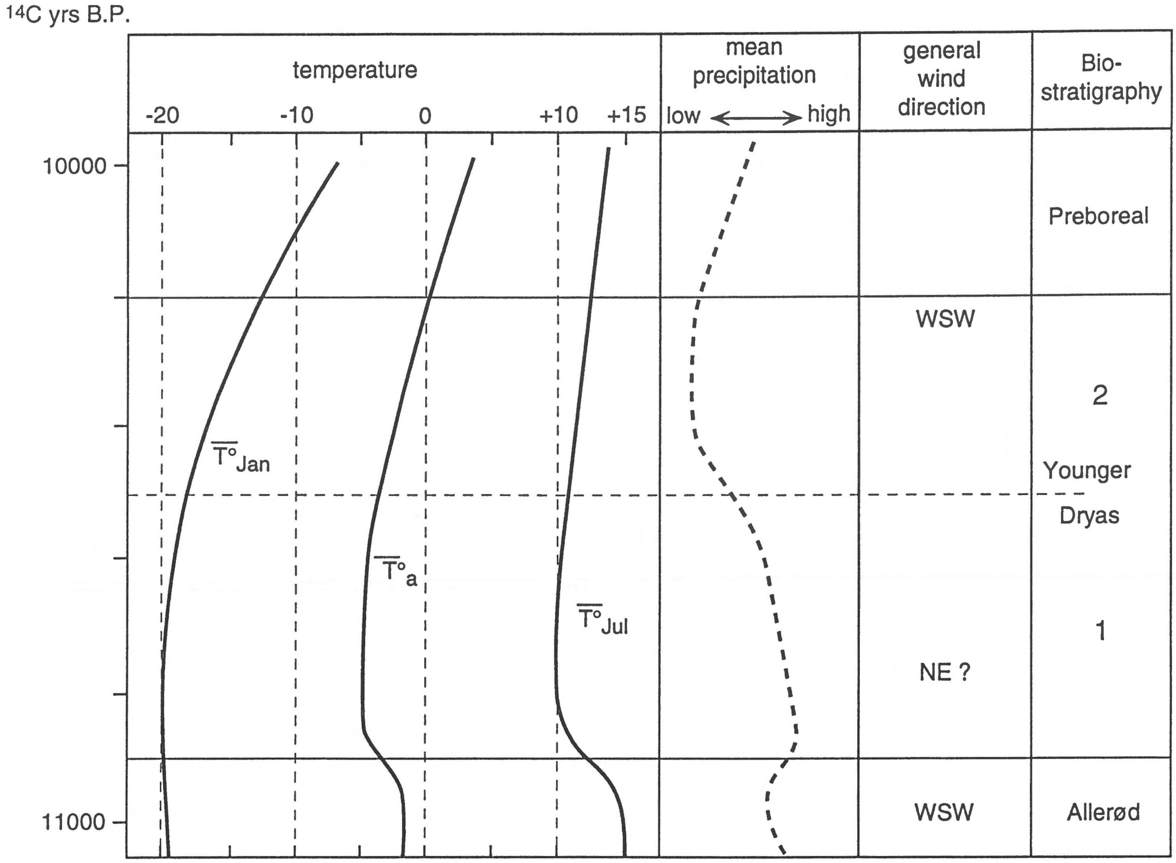

Fig. 2. Reconstructed paleoclimatic parameters during the Younger Dryas in the Netherlands

it is derived that summer temperatures rose distinctly above the previous values (Fig. 2).

Mean annual and winter temperatures

The intensity of frost action is manifested by the occurrence of periglacial deformations (Vandenberghe 1983). Conditions of deep seasonal freezing prevailed during the Allerød (Huijzer 1993). At the end of the Allerød at first a decrease in winter temperatures is interpreted to have taken place (Bohncke et al. 1993). The older part of the Younger Dryas shows traces of further intensified frost action, as indicated at several localities for instance by the presence of cryoturbations of the regularly spaced type with constant amplitude and flat bottoms. Besides, at Notsel and Bosscherheide initial forms of ice-wedge casts have been found (Vandenberghe et al. 1987; Bohncke et al. 1993). Periglacial mounds have been described from the northern Netherlands (De Groot et al. 1987). The occurrence of the described type of cryoturbations points to former permafrost (Vandenberghe 1983). Ice-wedges generally point to a (spatially) continuous permafrost. For this reason and taking into account the sandy to gravelly character of the subsoil, Huijzer (1993) assumes a mean annual temperature of max. −8 °C. However, the primary nature of these wedges as well as their rare occurrence may indicate that the permafrost only occurred at favourable sites. In that case, the mean annual temperature should have been around −5 °C and the mean winter temperature around −20 °C. Another reason for the immature development of the ice-wedges may have been the short duration of the temperature conditions necessary for ice-wedge development. Indeed, at Bosscherheide it has been shown that permafrost developed after ca 10 800 and disappeared before 10 550 ± 60 BP (Bohncke et al. 1993). In any case, it is concluded that during this period conditions for the development of continuous permafrost were marginal and depending on local circumstances so that a mean annual temperature of $-6.5\ ^\circ C \pm 1.5$ is concluded.

In the upper part of the Younger Dryas, only indications for deep seasonal frost have been found (e.g. frost cracks described by Van der Tak-Schneider 1968). Traces of permafrost are absent, even at favourable sites. These data allow to estimate a mean annual temperature between 0 and $-2\ ^\circ C$. Mean winter temperatures between -12 and $-16\ ^\circ C$ are derived from this mean annual value and from the summer temperature derived above (Fig. 2).

Precipitation

At present, data on paleoprecipitation are still qualitative. During the Bølling and Allerød, high bankfull discharges are reconstructed indicating a generally high precipitation. The first part of the Younger Dryas is characterized by wide occurrences of overbank deposits and high lake-levels (e.g. Bohncke et al. 1988). This does not mean, however, that precipitation was still higher than before because impeded drainage due to (dis)continuous permafrost could account for these morphological effects as well.

The second part of the Younger Dryas is characterized by a strikingly decreased river activity and considerable inland dune formation. This points obviously to drier conditions for at least part of the year.

Wind direction

The mean direction of the prevailing winds during the second half of the Younger Dryas is determined from the orientation of parabolic dunes. In the central Netherlands, Maarleveld (1960) concluded to a WSW wind direction, while the parabolic dunes along the Maas indicate a similar general direction (Bohncke et al. 1993).

Maarleveld (1960) assumed the same general wind direction at the end of the Allerød so that this direction could also be valid for the first part of the Younger Dryas. However, no positive arguments are available. Moreover, the temperature conditions of that period show much resemblance to those of the Late Pleniglacial when an eastern circulation prevailed (Vandenberghe 1991). Therefore, it is not unrealistic to suppose, at least for the winter period, predominantly (north)eastern winds during the first part of the Younger Dryas. Reccently, however, Renssen and Lautenschlager (1995) showed by climate similations that the cooling during this period could have existed with prevailing westerly winds.

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