Younger Dryas climatic changes and aeolian depositional environments

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INTRODUCTION

The onset of the Younger Dryas stadial in the southern Netherlands is reflected by the presence of frost cracks and initial ice-wedge casts in several exposures (fig. 1 and 2). These periglacial features indicate, at least local, permafrost conditions and a decline of the annual temperature from $-1°C$ to -2 / $-5°C$ during the Allerød–Younger Dryas transition. Permafrost (development and) degradation is deduced from the presence of well-developed periglacial loading structures (fig. 2). The disappearance of the permafrost has been dated between 10 880 and 10 500 yr BP. (Bohncke et al., 1993).

DESCRIPTION AND DISCUSSION

The Younger Dryas temperature drop caused major environmental changes. Evapotranspiration decreased and surface runoff and peak discharges of the rivers probably increased. For the Maas valley it was concluded that the meandering river suddenly transformed in a braided system at the Allerød–Younger Dryas transition (Pons, 1957; Kasse et al., 1994). Associated with these fluvial changes, aeolian activity became more important on the braided floodplain, not only in the Maas valley, but also along the Schelde river (Schwan, 1991) and other small rivers in the Netherlands. Because of the prevailing WSW-wind sand was blown from the floodplains on the right banks of the rivers. Between Venlo and Nijmegen, east of the Maas river (fig. 1) an extensive, more than 40 km long and up to 4 km wide, sand-sheet belt developed with a parabole dune morphology. This sand sheet and dune belt strongly resembles active cold-climate dune complexes along the Kobuk river in Alaska (Koster, 1992). Downstream of Nijmegen this Younger Dryas sand sheet/dune

Fig. 1. Location map of the Bosscherheide exposure and other locations mentioned in the text.

belt is covered and/or surrounded by Holocene fluvial deposits (Pons, 1957; Berendsen et al., 1994). Along the Schelde river, north of Antwerpen (fig. 1), a comparable sand sheet was formed (35 km long, 4 to 5 km wide).

The Younger Dryas aeolian sands in the Netherlands have been divided previously in a lower and an upper part dominated by wet aeolian and dry aeolian deposition respectively (Vandenberghe et al., 1987: exposure Notsel; Schwan, 1991: exposure Ossendrecht; Bohncke et al., 1993). Such a wet to dry aeolian transition has been studied recently in the Maas valley (exposure Bosscherheide, fig. 1 and 3). At the start of the aeolian sand deposition, around 10 500 yr BP (Bohncke et al., 1993), a peaty bog environment was present, which shortly before 10 500 yr BP had been flooded because of the higher peak discharges of

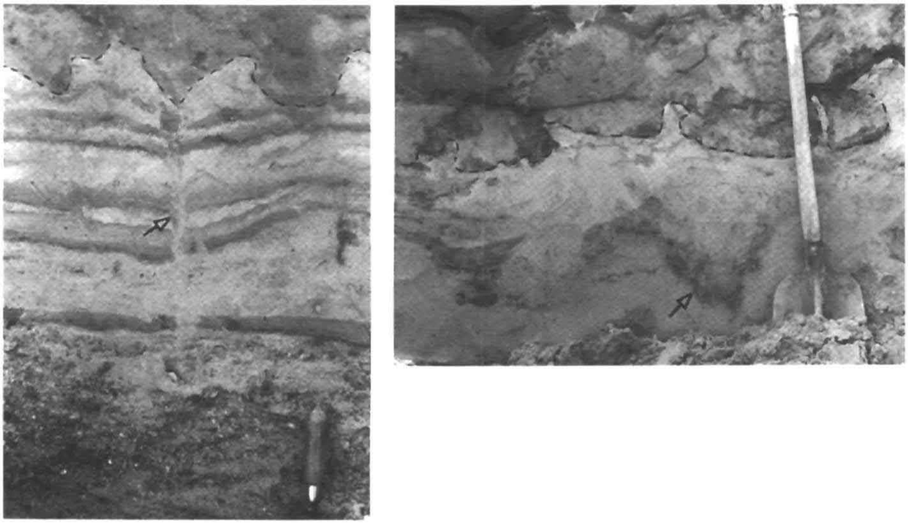

Fig. 2. Younger Dryas frost crack and initial ice-wedge casts (see arrows) at Besscherheide formed by deep seasonal frost or local permafrost. Dashed line markes the base of periglacial loading structures due to permafrost degradation. Handle of trowel is 10 cm; spade is 120 cm.

the Maas at the beginning of the Younger Dryas. The peat was covered gradually by the migrating aeolian sand, forming embryonic dunes, 90 cm high and ± 10 m apart. In the wet interdune areas of the embryonic dunes sand, silt and organic material accumulated. Bioturbation by roots and the presence of twigs and other pieces of wood (probably of *Betula*) point to a (sparse) vegetation on the dunes and in the interdune areas. In the second phase of sand deposition, the wet interdune areas were levelled and the sand body was raised above the phreatic level. From then on predominantly dry aeolian deposition prevailed with plane horizontal bedding and low-angle cross-bedding (fig. 3). High-angle cross-bedding, formed by dune slipface progradation, is commonly very rare in the Younger Dryas aeolian deposits.

A twofold character of the Younger Dryas stadial with a cold (and humid) first part and a milder (and dry) second part has been proposed by Vandenberghe (1991), Ralska-Jasiewiczowa et al. (1992) and Bohncke et al. (1993). However, the change in the Younger Dryas sequence with a marshy and wet aeolian lower part and a dry aeolian upper part does not necessarily implicate a synchronous climatological change from a more humid into a more arid climate, at ca 10 500 yr BP, as postulated by Bohncke et al. (1993). The transition of the peaty and wet aeolian sand into the dry aeolian sand in exposure Bosscherheide is gradual, so the boundary is time transgressive. Therefore, it can be concluded that the wet and dry depositional environments occurred beside each other at the same time. Having a general width of 2 km and assuming a migration rate of 5–10 m/year for vegetated parabole dunes (Zagwijn, 1984) the eastward migration of the Younger Dryas sand belt may have lasted be-

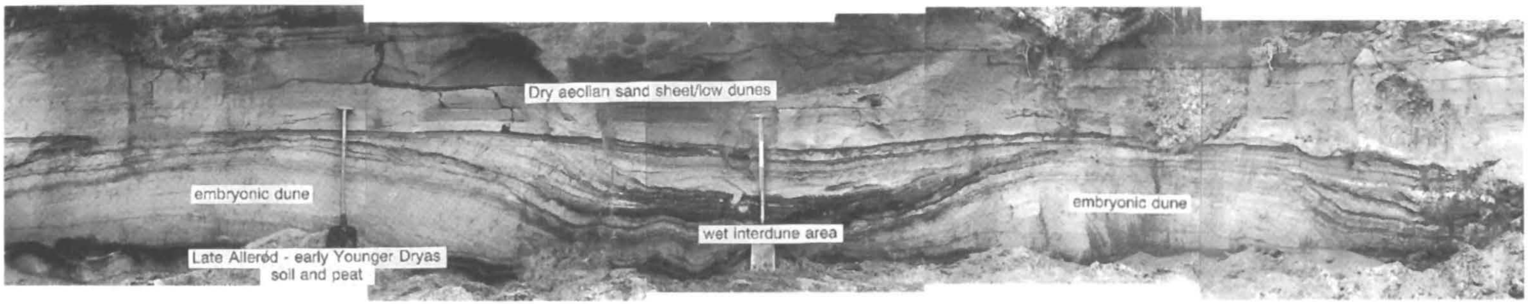

Fig. 3. Composite photograph of the Younger Dryas aeolian unit overlying the late Allerd-early Younger Dryas soil and peat (Bohncke et al., 1993). The aeolian sands are subdivided in a wet aeolian (embryonic dunes, wet interdune areas) lower part and a dry aeolian (sand sheet and low dunes) upper part. Spade for scale is 120 cm.

tween 200 and 400 years. This means that reconstruction of the moment of the climatic changes based on the sedimentary record is hazardous.

The sequence described above, being peat at the base, overlain by wet aeolian sand, dry aeolian sand sheet deposits and dunes, originated by the migration of the Younger Dryas aeolian depositional system over an older, wet surface. Such a sedimentary sequence is not unique for the Younger Dryas period. Comparable sequences have been described in the Late Holocene inland dunes (Schwan, 1991) and in the Middle Age coastal dunes of the western Netherlands (Zagwijn, 1984). From these aeolian sequences, triggered by a change in fluvial regime (Younger Dryas), or by human activity (inland dunes), or by climate (young coastal dunes), the following 3-step depositional model can be established (cf. Zagwijn, 1984). Each aeolian sequence starts with the levelling of the existing substrate. Higher areas (e.g. older dune ridges) are deflated, while low, wet areas are filled with aeolian sand. In the second step, deposition continues in large-scale sand sheets dominated by predominantly horizontal bedding. Finally, in the third step dunes dominated by low-angle and trough cross-bedding are formed on the sand sheet because of the stabilizing role of the vegetation.

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