

G. C. Maarleveld *

Wageningen

PERIGLACIAL PHENOMENA IN THE NETHERLANDS DURING DIFFERENT PARTS OF THE WÜRM TIME

According to the literature hitherto published in the Netherlands on periglacial phenomena during the Würm time these are widespread and also occur in numerous deposits (cf. for example Maréchal & Maarleveld 1955).

In particular, since they are found in horizons of varying age the question arises as to, to what extent we are thereby justified to draw conclusions regarding the number of cold periods during the Würm time and the climate during these phases. In this connection a number of periglacial phenomena are discussed below.

FROST WEDGES AND PSEUDO-FROST WEDGES

Zagwijn (1961) described sands of Early Würm age occurring in the Amersfoort tunnel pit. In its upper part a soil profile was formed during the Brørup time. The layer contains clearly developed frost wedges which, to judge from their location were formed subsequent to the Brørup time. Moreover they are younger than the sand layer that occurs between a peat layer 34700 ± 500 years old (G.R.O. 1259, 1276) and the soil profile of Brørup age. They possibly date from the period in which the Lower Würm loess was deposited elsewhere.

The Lower Würm loess is overlain by a layer with distinct traces of solifluction; this is known as the Würm-, „Schwemm loess”. It also contains very clearly developed frost wedges (cf. v. d. Waals, v. d. Broek, Bakker & Kummer 1962). The deposits of about the same age in the cover-sand area also have fluvatile features and have been described as Niveo-fluvatile (v. d. Hammen & Maarleveld 1952). Investigation of the terrain showed that frost wedges are frequently encountered in this deposit. They are usually in the upper part of the Niveo-fluvatile and in particular were formed after the formation of these deposits. This would imply that they

* Netherlands Soil Survey Institute, Wageningen, Netherlands.

originated during the latest, very cold period of the Würm period (Pleni-glacial B).

In the loess area the „Schwemm loess” is overlain by the youngest loess formation. According to v. d. Waals *et al.* (1962) the periglacial phenomena in this deposit are less clearly developed (minor phase 6) than in the „Schwemm loess” (their major phase 5). In the cover-sand area this is also true of the deposits of about the same age as the youngest loess. Here the frost wedges in the Older cover sand formed after the Paudorf time and before the Bølling time, are mainly found when the material has developed in the form of loam or when the Older cover sand is located in a depression as compared with the immediate vicinity. These frost wedges were formed both during the sedimentation of the Older cover sand and also subsequently (during the Earlier Dryas time). A frost wedge has hitherto only been found twice in deposits of the Late Dryas time. Near Apeldoorn the frost wedge has formed where the deposit is at its lowest point in the valley. The material in the upper part of the frost wedge contains charcoal dating from the end of the Allerød stage ($11\,010 \pm 120$ years; G.R. N. 907).

Forms showing some resemblance to frost wedges also frequently occur in the deposits of the Late Dryas time (fig. 1). They differ from the wedges in that no pressure deformations are found and there is no buckling of the layers. The wedge-shaped phenomena are also indistinct. They may be regarded as pseudo frost wedges (Sekyra 1960).

The origin of the pseudo frost wedges is possibly related to the frequently shallow, frozen ground during the Late Dryas time. The fissures formed in the frozen ground probably ran vertically throughout the frozen layer. All the water inside was drained so that no ice wedge was formed. The water thawed on its way to the subsoil in the deposits close to the fissure. This phenomenon is discussed in more detail in another article (written in collaboration with K. J. Hoeksema, Laboratory for Regional Pedology, Wageningen).

It follows from the above observations that there are indications that the Würm time included at least two periods of very considerable frost wedge formation. The first period is younger than the Brørup interstadial, and the second period post-dates the Paudorf interstadial. The climate was probably very cold and extremely continental during these two periods and there was possibly a thin snow cap (cf. Popov 1962). In the time intermediate between these two periods there was a considerable amount of solifluction, which would indicate that there was heavy snowfall during the winter. It is probable that owing to the thick snow cap fewer frost wedges were formed during this period.

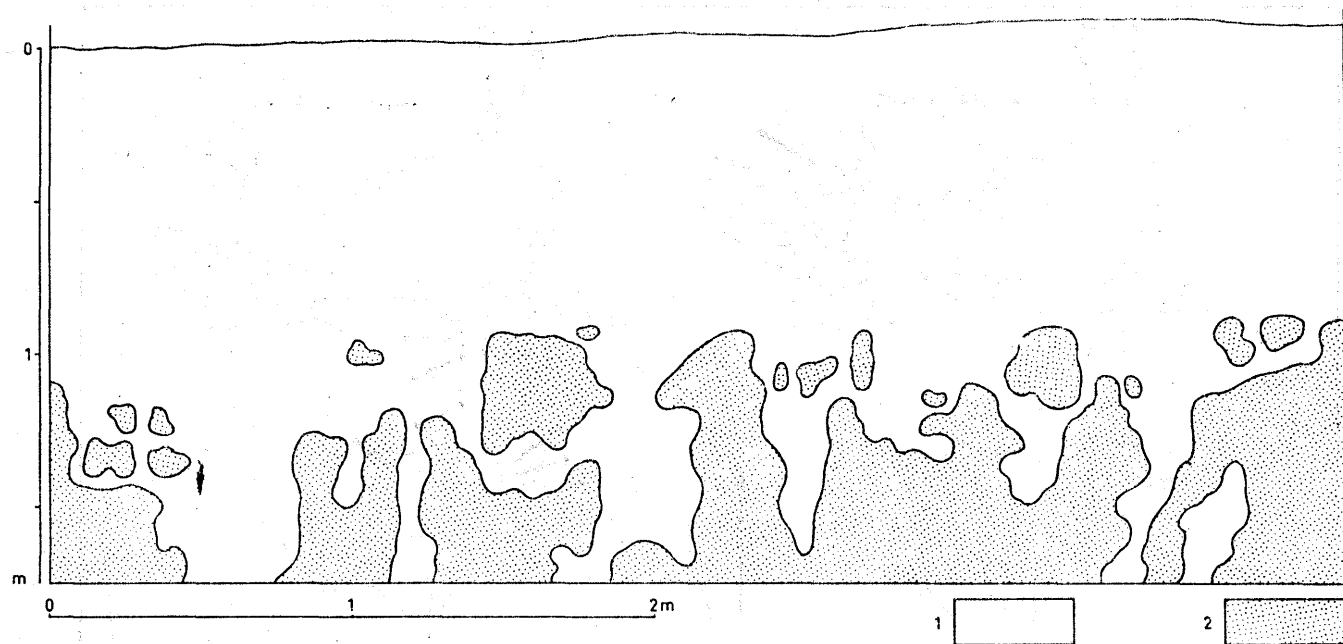


Fig. 1. Pseudo-frost wedges in a sand pit near Venray, according to data of de Haan (1960)

1. non-stratified cover sand; 2. stratified cover sand

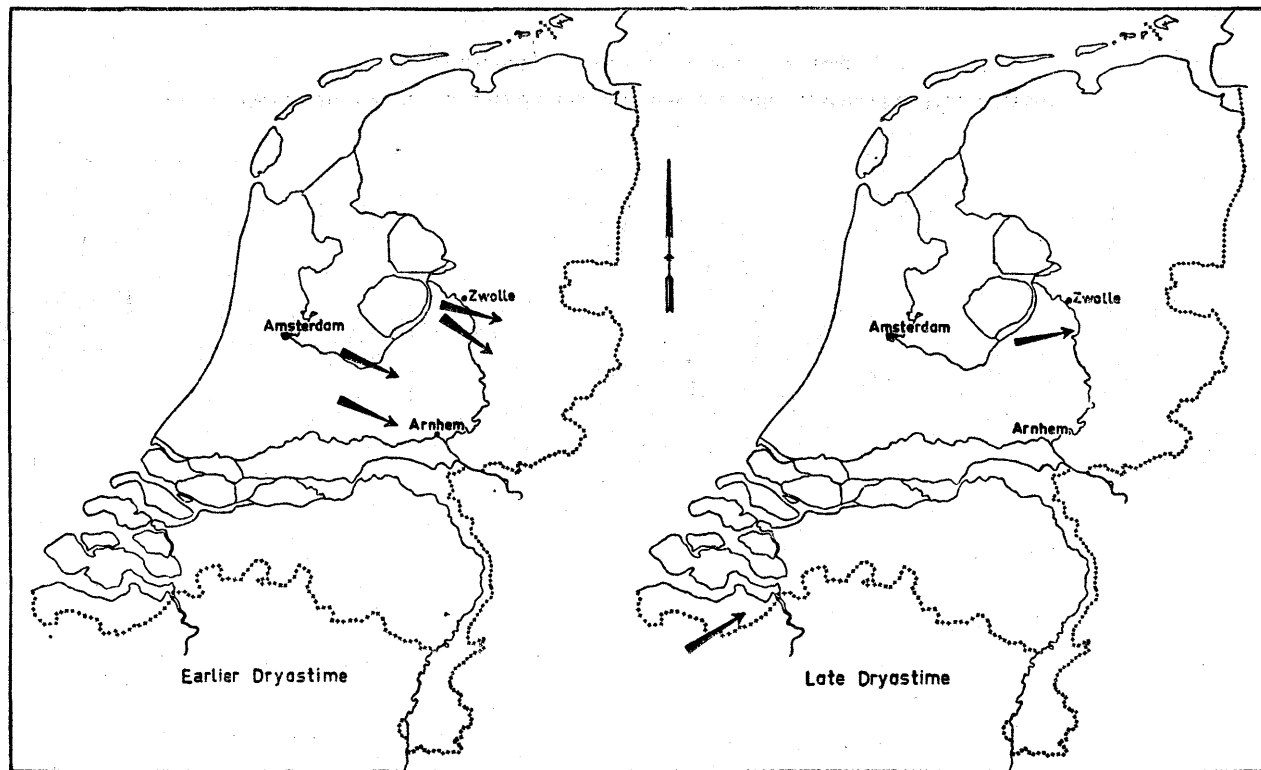


Fig. 2. Direction of wind during dune formation

WIND-FACETED STONES

Wind-faceted stones are encountered below the eolian sandy deposits. It is certain that a large number of the stones were formed after the formation of dry valleys and before the sedimentation of the Older cover sand (cf. also v.d. Hammen 1951; de Jong 1955). Hence they were formed during the latest, very cold period of the Würm time, which must have occurred between the Paudorf interstadial and the period during which the Older cover sand was deposited. It is the same period as that during which numerous frost wedges were formed, and the snow cap was probably thin. The considerable formation of wind-faceted stones fits into the pattern of the then prevailing continental climate.

WIND DIRECTION

Information on wind direction is only available from the very late part of the Würm time (cf. fig. 2). Thus the position of parabolic dunes of the Earlier Dryas time shows that the wind was predominantly north-west during the formation of the dunes (Maarleveld & v.d. Schans 1961).

During the Allerød time the wind backed. During the Later Dryas time the wind direction during dune formation was west to south-west (Maarleveld 1960; v.d. Sluys & Maarleveld 1963).

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