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WIND DIRECTIONS AND COVER SANDS IN THE NETHERLANDS

In many publications dealing with the Pleistocene of the Netherlands the term *cover sand* is used (Edelman 1947; Edelman and Cromelin 1939; van der Hammen 1951; Maréchal and Maarleveld 1955; Pannekoek 1956; Vink 1949). This term is applied to the eolian sand deposits overlying older sediments in the shape of a cover. The cover sands are not restricted to the Netherlands but can be pursued southward through Belgium as far as Northern France (Maréchal 1956) and northward — through Germany as far as the surroundings of Hamburg (Dücker and Maarleveld 1958; Erbe 1958) which shows that these sands are found north of the loess belt and south of the Würm-moraine area.

Within the cover sand area three regional distinctions can be made, viz:

1. cover sand as valley infilling of very wide glacial depressions or troughs. Here the cover sand reaches its greatest thickness. Edelman and Cromelin (1939) described a thickness of over 10 m;

2. cover sand of the somewhat higher situated flat areas such as the ground moraine plains of the Northern Netherlands and Northwestern Germany. Here, like in the very wide glacial depressions, cover sand occurs in a continuous layer and averages in thickness 0,5—1,5 metres. In many places thickness increases in the direction of the North Sea;

3. cover sand of the elevated and hilly areas, such as push moraines. In these areas cover sand deposits are less common. The greater part of the cover sand occurs here as ridge-like deposits (fig. 1).

As concerns grain-size cover sands often show a distinct maximum ranging from 105 to 210 micron. However also coarser cover sands occur whose maximum ranges from 210 to 420 micron and finer cover sands with a grain-size maximum from 50 to 105 micron. Grain-size analyses showing two maxima are also frequent. In the Northern- and Central Netherlands, sand is found to show a maximum averaging 50—75 mic-

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ron and 150—205 micron. In the Southern Netherlands, especially in the direction of the loess area, granular maxima averaging 16—50 and 105—150 micron are often found. In the vicinity of the loess the maxima are shifted on the side of the finer fractions (Edelman and Maarleveld 1958).

In a cover sand profile there is generally an increase of the coarser particles from bottom to top. The lowest part shows a distinct succession of medium-grained sandy and loamy layers to extremely fine-grained sandy ones (fig. 2). The finer cover sands are called Older cover sands. Overlying these Older cover sands are coarser sands mostly containing thin bands of coarse sand or fine gravel up to 8 mm in diameter, while particles > 210 micron are fairly abundant. According to Erbe (1958)

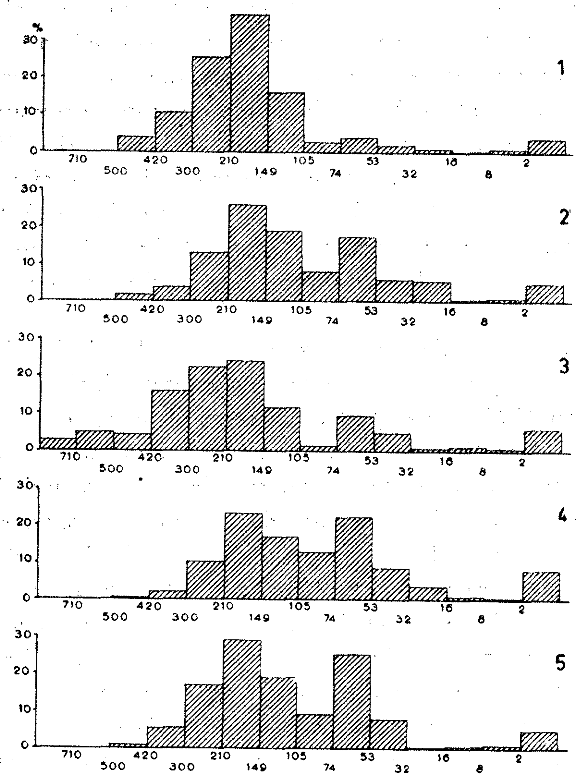

Fig. 2. Grain-size distribution of the layers of a cover sand profile (Pesse, Netherlands) according to Dücker and Maarleveld (1958)

1. Younger cover sand II = Younger Dryas; 2. Younger cover sand I = Alleröd (bleached layer); 3. Younger cover sand I = Older Dryas; 4. Older cover sand = Bölling (bleached layer); 5. Older cover sand = Pleniglacial

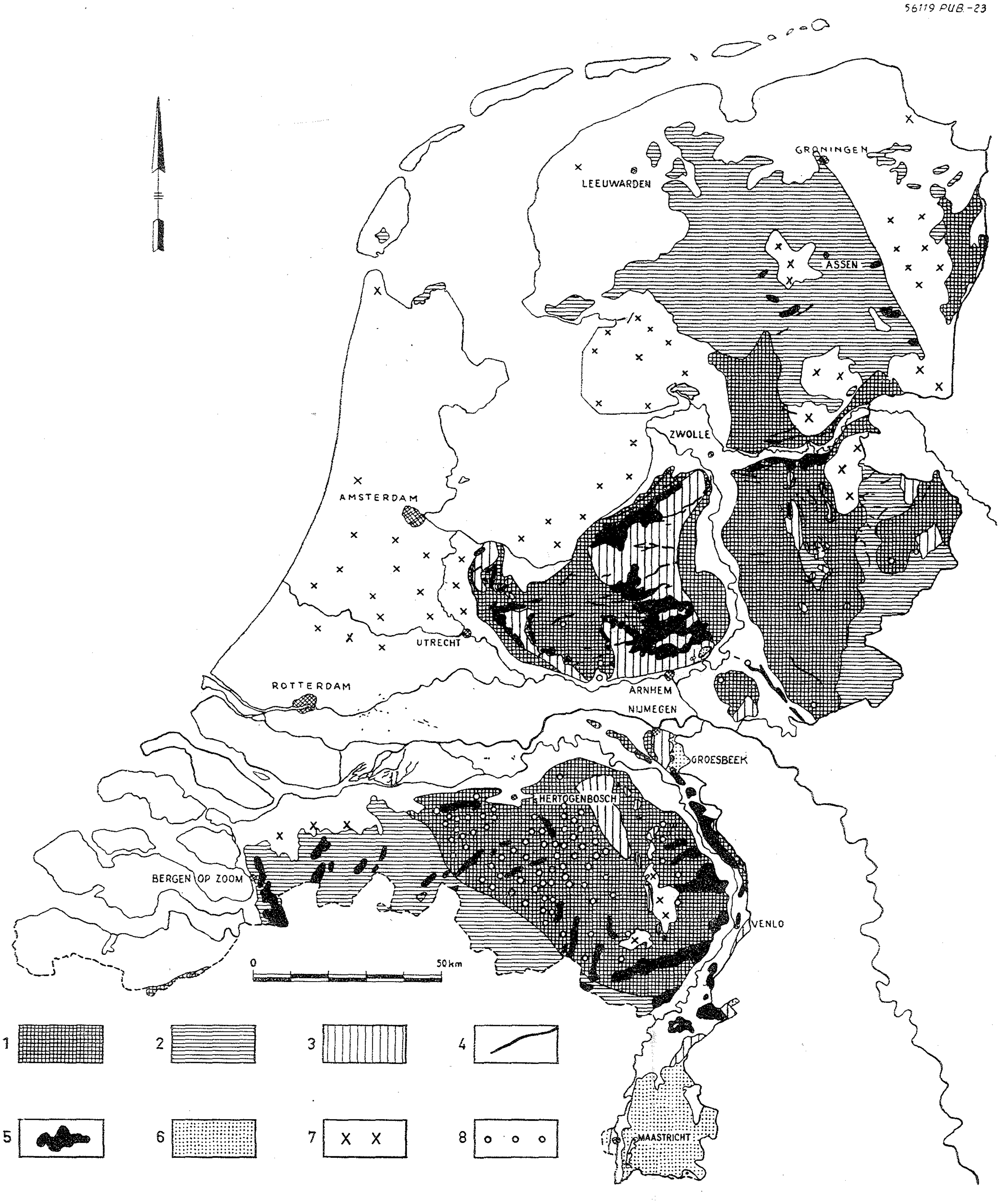

Fig. 1. Distribution of cover sands in the Netherlands, according to Maréchal and Maarleveld (1955)
1. cover sands as valley infilling of very wide depressions or troughs; 2. cover sands in plains; 3. cover sands in elevated and hilly areas; 4. ridges; 5. Holocene inland dunes; 6. subsurface loess; 7. cover sands overlain by younger deposits; 8. loess overlain by younger deposits

the coarser sands are generally somewhat finer near the top than in the bottom part. These coarser sands are called Younger cover sands.

On the support of pollen-analytical research, van der Hammen (1951) pointed out that the Older cover sands are older than the Bølling Interstadial. These sands have been deposited during the same period as the Youngest loess. According to radiocarbon-dating they are probably younger than 29 000 (+5000; —3000) years (Wiggers 1955) and deposition took place during the last severely cold part of the Würm time [1].

The coarser Younger cover sands are of Late-glacial age and were deposited after the Bølling time. In many places of this cover sand there is a thin bleached layer as described by Hijszeler (1947) from near the village of Usselo and known as Usselo-layer The whole layer or only its lower part often contains more particles $<$ 60 micron than the Younger cover sand on top of or below the Usselo-layer (Dücker and Maarleveld 1958). The Usselo-layer generally has a thickness of 10—15 cm (pl. 1) and contains mostly many *Pinus* charcoal particles. Also curious finger-shaped channels are found in it which may have been formed by some small animals (pl. 2). These finger-shaped grooves are filled with sand or sand mixed with charcoal. Near Usselo this layer has been closely studied and it was found that the layer merges into gyttja and peat thus enabling exact pollen-analytical dating which proved that the bleached layer dates from the Allerød time (Hijszeler 1957). Radiocarbon-dating of the charcoal gave an age of 8930 $\pm$ 160 B. C. (Geochronometric Laboratory — Yale University, New Haven), so the charcoal dates from the transition from Allerød to Younger Dryas.

In several places of the Netherlands, Belgium and Germany the charcoal containing layer have been found to contatin artefacts. They belong to the Magdalen VI (Tjonge group) and are of the same age as the artefacts of the Ahrensburg-Borneck II site (Hijszeler 1957).

Also at the base of the Younger cover sand sometimes occurs a bleached layer. This layer is rarely found and there are some indications showing that it represents a soil profile from the Bølling time. If both these bleached layers are present it is possible to divide the Younger cover sand into one deposit formed during the Older Dryas and another former during the Younger Dryas (Younger cover sand I and II, see table I).

[1] However it is to be noted that there probably also exist some still older similar sand deposits of Würm age. For example sand layers resembling the Older cover sands overlying the Eemian.

Table I

Sequence of cover sands and prevailing wind directions during the end of the Würm-time

	Periods	Cover sands	Cultures [1]	Climate [2]	Prevailing wind directions	Radio-carbon data B. C.
Late Glacial	Younger Dryas	Younger cover sand II charcoal	Ahrensburg Ahrensburg-Borneck II	rel. oceanic	west-southwest	8300
	Allerød	bleached layer (Usselo-layer) standstill	Bromme, Usselo, Rissen			8900
	Older Dryas	Younger cover sand I			northwest-west	9800
	Bølling	bleached layer standstill		rel. continental		10400
Pleniglacial		Older cover sand			northwest	

[1] According to Hijszeler (1957).
[2] According to Van der Hammen (1951).

The cover sands nearly always show an almost horizontal stratification. The surface of the Older cover sands is nearly horizontal. The Younger cover sands show more relief and are often ridge-shaped. At first sight these ridges show a crotchety pattern. Distinctiness in both shape and elevation of the ridges depends on the age and the grain-size composition of the material. Highest upward are the ridges containing coarser material. Therefore ridges in loamy deposits are only weakly developed.

As regards age it has been pointed out that ridges dating from the Younger Dryas show the most distinct shapes and are also the highest. The somewhat older ridges from the Older Dryas are often difficulty recognizable and in many places they have been deformed by wind blow. The height of these ridges practically never exceeds 2 metres.

Ever since the foundation of the Netherlands Soil Survey Institute, Wageningen, detailed soil maps of cover sand areas in various parts of the Netherlands have been prepared. On these maps are indicated a. o. the soil profile, thickness and nature of the humusy topsoil and the moisture conditions. There is a close relationship especially between the last mentioned feature and geomorphic features. Maps derived from the soil map and indicating the position with respect to the ground-water level, the so-called ground-water influence classification map, gives a fairly good picture of the elevations and depressions in a cover sand region. In the Central Netherlands a large part of the Gelderse Vallei was mapped under the supervision of Ir R. P. H. P. van der Schans. Since that time a survey supervised by Ir J. C. Pape was made in the same area for the new soil map of the Netherlands on scale 1 : 50 000.

On the basis of these maps the morphology of the cover sand deposits was scrutinized again. Attempts were made to trace in the field the relatively high soils indicated on the soil map or to reconstruct their original conditions, in order to be able to map the cover sand ridges. The map thus obtained shows plainly that, in spite of the inconsiderable elevations of the higher grounds (practically not over 2 metres), the landscape consists of many ridges forming a fairly regular pattern (fig. 3).

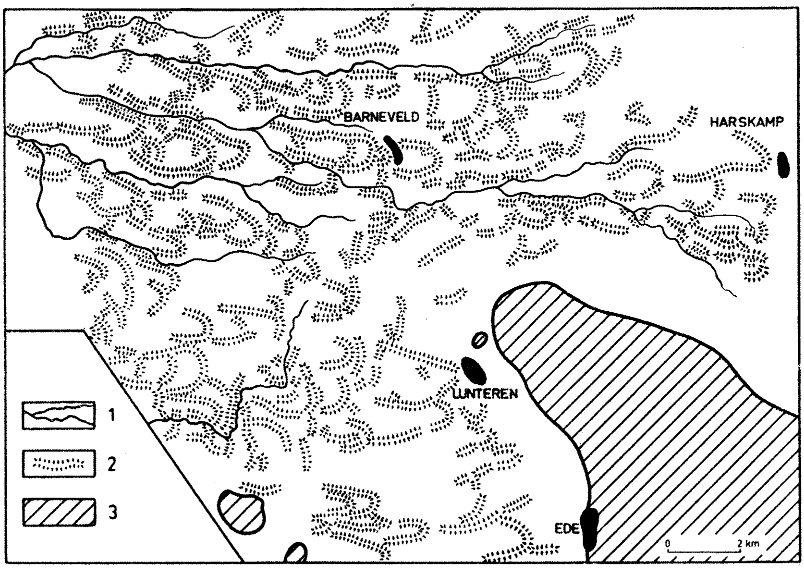

Fig. 3. Ridges of Younger cover sand I in the region of Ede and Barneveld (Gelderse Vallei)

1. brooks; 2. ridge; 3. push moraine

These ridges consist of Younger cover sand overlying Older cover sand. During fieldwork the possible occurrence of Usselo-layers was carefully watched. Notwithstanding careful attention only in three cases was the occurrence of an Usselo-layer ascertained. In thase cases the ridges, in which Usselo-layers were found, were exceptionally high and these layers were always found near the surface and assimilated with the tilted topsoil (personal communication of Ir. van der Schans). It does not appear hazardous to conclude that the ridges indicated on the map of a part of the Gelderse Vallei (fig. 3) consist of Younger cover sand I and originate from the Older Dryas. From the shape of the ridges (fig. 3) one may infer that they doubtless are parabolic dunes. The dunes are chiefly U-shaped and open to the north-west and the west. The „wings" of the dunes are best preserved while recognition of the intermediate arched parts is often difficult.

An example is the parabolic dune in fig. 4 where various phases can be distinguished. For example the ridge of Kraats has been strongly destroyed by wind, so it is to-day only a very slight elevation. In the next phase, the ridge of Rozendaal was formed. This ridge has also been destroyed to some extent. Finally the Hul-Harn ridge was deposited which is still

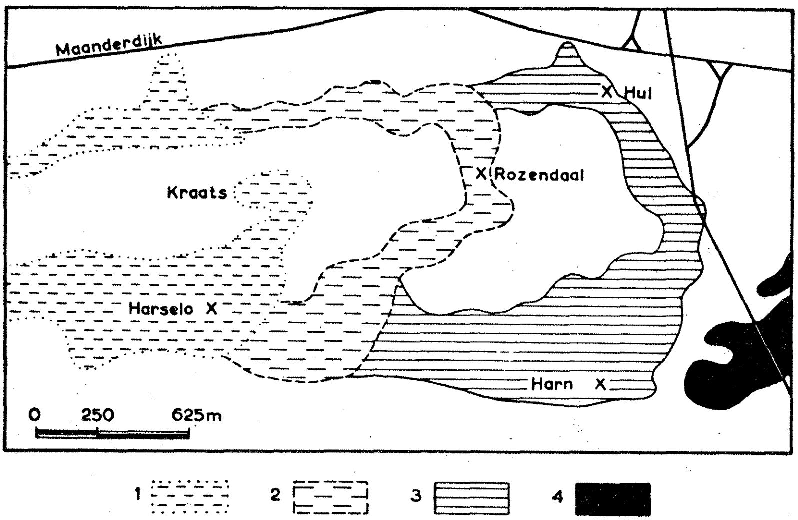

Fig. 4. Dune of Younger cover sand I during different phases
1. first phase; 2. second phase; 3. third phase; 4. last phase

fairly easily recognizable. The uninterrupted wings of the whole dune-complex are distinctly recognizable in the field (Maarleveld 1958).

East of the Gelderse Vallei appears the glacial landscape of the Veluwe. Here also occur various sand ridges (fig. 5) which previously were wrongly identified as esker. In twelve places the Usselo-layer was found to lie below the ridges. The fact was confirmed by two radiocarbon-datings (Maarleveld 1951, 1956). Formation of sand ridges must have been

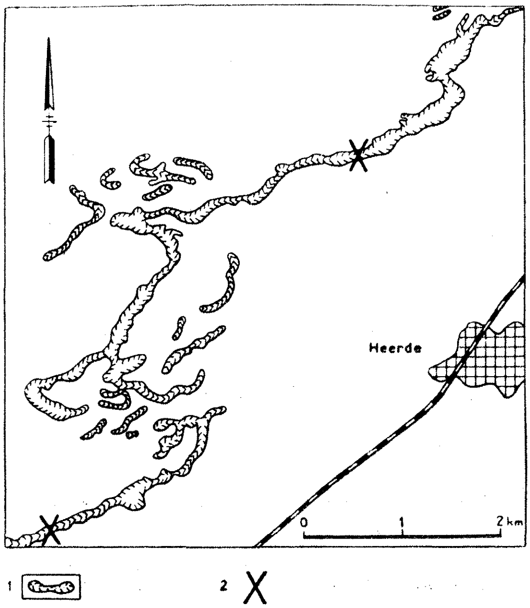

Fig. 5. Dunes of Younger cover sand II west of Heerde (Veluwe)

1. dunes; 2. Usselo-layer found at the base of the dune

prevented by vegetation growth under improving climate at the beginning of the Holocene; therefore the origin of these ridges must be dated as Younger Dryas; they consist of Younger cover sand II. Usually these ridges are roughly U-shaped. The wings are often very elongated so that longitudinal forms are predominant.

For a better understanding of wind direction during the formation of these deposits, the position of the dunes is of great importance (Högbom 1923; Kádár 1938; Poser 1951). The position of the parabolic dunes from the Older Dryas indicates that these dunes were formed mainly by northwestern to western winds (fig. 3, 6).

Vink (1949) concluded to a northwestern wind direction during the deposition of loess in the Veluwe which deposits lie to the lee side of the push-moraine. In this loess region however no loess is found in the fairly wide northwest—southeast extending valleys. Here the wind was not impeded and in constrast with the leeward valleys only accumulations of cover sand were possible. Since this loess as well as the Older cover sand were both deposited during the same period northwestern winds must be held responsible for the deposition of this cover sand (tabl. I).

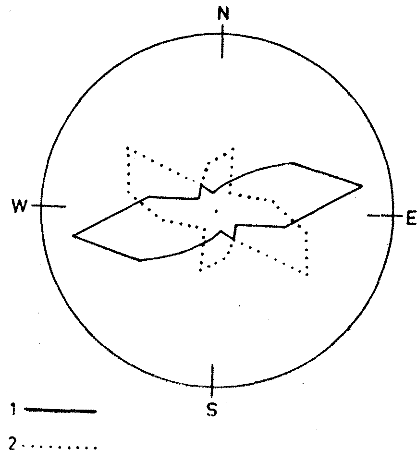

Fig. 6. Orientation of dunes in the middle part of the Netherlands

1. ridges of Younger cover sand II (Younger Dryas);
2. ridges of Younger cover sand I (Older Dryas)

From the position of the ridges formed in the Younger Dryas period the prevailing wind direction appears to have changed from northwest-west to west-southwest, which change took place in the Older Dryas (fig. 6). The distribution of volcanic ash from the Laacher district of maars (Eifel, Germany) indicates that already in about the middle part of the Allerød (±9 500 B. C.) the prevailing wind directions were west to southwest (Frechen 1953; Gross 1954; Straka 1958). So the important change in the prevailing wind directions must have taken place after the Older Dryas period and consequently during the first part of the Allerød time.

On the basis of pollen-analytical data, Van der Hammen (1951) found that the climate in the beginning of the Allerød still had a relatively continental character (birch-forest time) followed by a pine-forest time or a birch-pine-forest time. At the same, expansion of *Empetrum* and *Ericaceae* took place.

When contemplating the results of investigations of prevailing wind directions during the Late-glacial, as derived from geomorphic data, it appears that these are in perfect accordance with those derived from pollen-analytical data. Both results indicate a climatical change in the Netherlands during the Allerød. According to pollen-analyses the change was from relatively continental to relatively oceanic and according to geomorphic data the prevailing wind directions changed from northwest-west into west-southwest [2].

Especially owing to the recognition of the Usselo-layer it is nowadays possible to get more reliable data concerning deposits dating back to pre- and post-Allerød time. It seems unlikely that this layer should be restricted to Northern France, Belgium and Northwestern Germany. Therefore it may deserve to be payed some more attention to, in other countries. It is to be hoped that this will lead to a better understanding of the climate during the Late-glacial.

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[2] On the basis of investigations of exposures in dunes in the region between Darmstadt and Frankfurt a. Main (Germany) Klute (1949) concluded to a change of prevailing wind directions from WNW to WSW. Presumably this change took place during the Late-glacial (Walther 1951) too.

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Photo by M. C. Nater

Pl. 1. Usselo-layer near Tilburg

1. Usselo-layer

Pl. 2. Part of Usselo-layer near Ede