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First Report of a Preserved Weichselian Periglacial Surface in NW Europe — the "P. van der Lijn" Geological Reserve in The Netherlands

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Abstract: Features like frost-cracked stones and boulders, windpolished stones and sorted stones at the surface of an unvegetated geological reserve in the centre of The Netherlands are described and consequently interpreted as indicative of a Weichselian periglacial surface. Up to now this surface was interpreted as a Holocene abrasion platform.

[Erster Bericht über eine erhalten gebliebene weichselzeitliche Oberfläche in NW-Europa — das „P. van der Lijn" — geologische Reservat in den Niederlanden]

Kurzfassung: Durch Frost gespaltene Steine und Blöcke und durch Windschliff polierte und auf der Oberfläche sortierte Steine in einem vegetationsfreien geologischen Reservat im Zentrum der Niederlande werden beschrieben. Sie werden als Anzeichen für eine weichselzeitliche periglaziale Oberfläche gedeutet. Bisher hat man sie als eine holozäne Abrasionsfläche aufgefaßt.

Introduction

In 1942 the second of the polders of the Zuyderzee scheme (the "Noordoost Polder") was drained. During this operation several boulder fields, already well-known to fishermen, emerged. Besides several small plots, two major boulder fields appeared. One near Vollenhove in the east and the other one just north of the by then former island of Urk (Fig. 1). Both localities were known to be related to the penultimate Saalian glaciation. As collecting stones was (and still is) a widespread hobby, these boulder fields attracted quite some attention, even at those times. Here we will mainly deal with the field near Urk.

Earlier studies

Apparently the first paper on one of the boulder fields was published by VAN DER LIJN in 1944. In this paper he gives a short description of the field near Urk. Its overall NE-SW orientation was attributed to an ice-movement in that direction. The fact that striae which he observed on a number of boulders, did not all point in the same direction was ascribed to postglacial reorientation of the boulders. Unfortunately he did not record the observed striae orientations in his paper. VAN DER LIJN furthermore described the freshness of most boulders and noted that most originate from the central Baltic (Hesemann counts 2440, 1360, 1450 were registered; see also ZANDSTRA 1987). The most important theme of VAN DER LIJN's paper however is a plea to set apart a portion of this boulder field as a geological reserve. After the Second World War this idea was realized and as he was the instigator of the idea, this about 5 ha big reserve has been named after him.

A thorough study of tills exposed in the Noordoost Polder was carried out by DE WAARD (1949). In his interesting thesis on these tills he presents a full description of the "normal" or "grey" till and the "red" till floes found in the upper part of the sequence (see also RAPPOL 1987). Most likely it was DE WAARD who first suggested that the boulder fields should be interpreted as abrasion platforms, resulting from the Holocene marine incursion. DE WAARD concluded this from the existence of the boulder fields proper,

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the fact that in some places erratics occur on top of Holocene deposits, as well as from the fact that he saw a genetic relation between the eastern field and the adjoining till cliff of de Voorst. (SW of Vollenhove; Fig. 1). Directional elements in the Urk field, like low, boulder-rich ridges and shallow, elongated depressions were explained by DE WAARD as the result of abrasion and redistribution of erratics by wind and waves. By comparing the number of stones per square metre of surface with the number per cubic metre of till DE WAARD calculated that 3 to 4 m of till had been washed out.

In a study of till fabrics in The Netherlands, BOEKSCHOTEN & VEENSTRA (1967) revisited the site. Because they performed their fabric studies mainly in the upper, cryoturbated part of the till they did not record any preferred orientation (RAPPOL 1983). Concerning the amount of till removed by abrasion they remarked that, because the red till floes contain twice as many stones as the grey till, not more than 1.5 m of till had been washed out. This was substantiated by the fact that they found evidence of cryoturbation and usually this does not reach deeper than 2.0 m in The Netherlands (MAARLEVELD 1976).

Nowadays the geological reserve "P. van der Lijn" is managed by Staatsbosbeheer (Forestry Commission) Emmeloord. It is closed to the public, kept free of vegetation (Fig. 2) in order to enable scientific studies. As this plot had been set aside quite early it has not been strongly influenced by collectors; some large blocks from the surroundings have been added to the reserve.

Observations and discussion

The "P. van der Lijn" geological reserve has been visited during the INQUA Commission on Lithology and Genesis of Glacial Deposits annual meeting in 1986 (VAN DER MEER 1987) and agian shortly afterwards to study the exposed tills in more detail

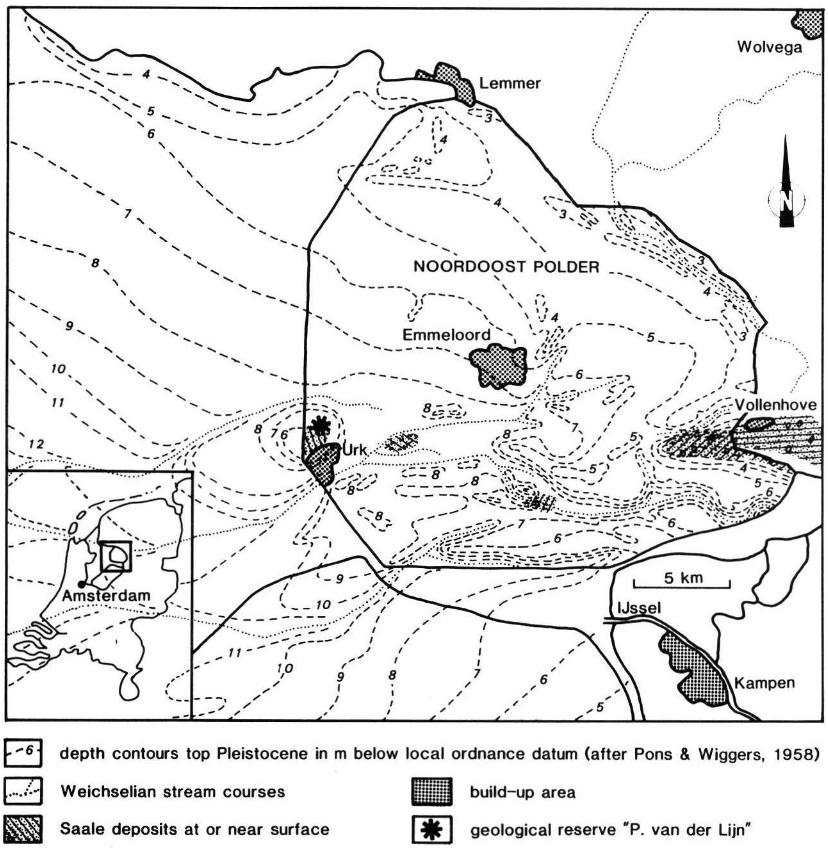

Fig. 1: Location map of the Noordoost Polder. Saale deposits in the northern part of the map, outside the polder, have not been indicated.

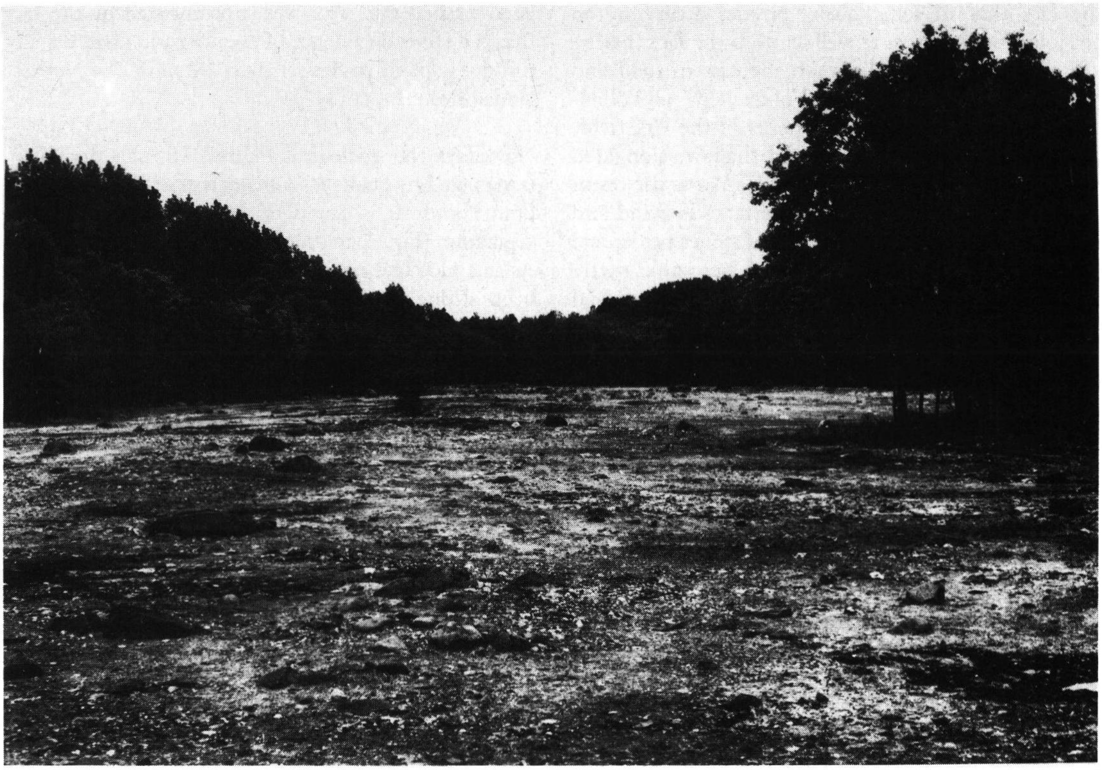

Fig. 2: General view of the geological reserve, note concentrations of boulders.

(RAPPOL et al. 1989). During these visits some peculiarities concerning the supposed abrasional surface of the reserve were noted.

The first of these concerns some large blocks (ca. 1.0 m diameter) that are split along a number of more or less parallel cracks (Fig. 3). The loosened fragments of the boulders have only moved a couple of centimetres relative to each other (Fig. 4). The cracking of these boulders and also of numerous smaller stones is explained by frost action at or close to the surface, as no other process can be envisaged that would have this result. But frost-cracking can only have happened during the Weichselian, because the climate in the early Holocene or after reclamation has not been severe enough. Besides, the occurrence of marine, Holocene sand with shell fragments in the fissures point to cracking prior to Holocene submersion. As the boulders are fresh the cracking could not have happened during the late Saalian, because frost cracking mainly occurs at the surface. Had these fragments been at the surface during the Eemian interglacial they would have been severely weathered.

Secondly, part of the reserve's surface is characterized by a large amount of smaller stones which are arranged in a (vague) sorted pattern (Fig. 5) grading into sorted stripes on slightly inclined surfaces (Fig. 6). This

Fig. 3: Frost-cracked boulder with an overall length of about one metre.
Holocene sand with shells is present between the different slabs.

Fig. 4: Frost-cracked stone with some flat fragments spread a short distance, probably the result of wave action during the Holocene transgression. Note also the diffuse polygonal pattern.

Fig. 5: Sorted arrangement of small stones. This is present in different parts of the reserve.

Fig. 6: Stone rings grading into sorted stripes on slightly inclined surfaces.

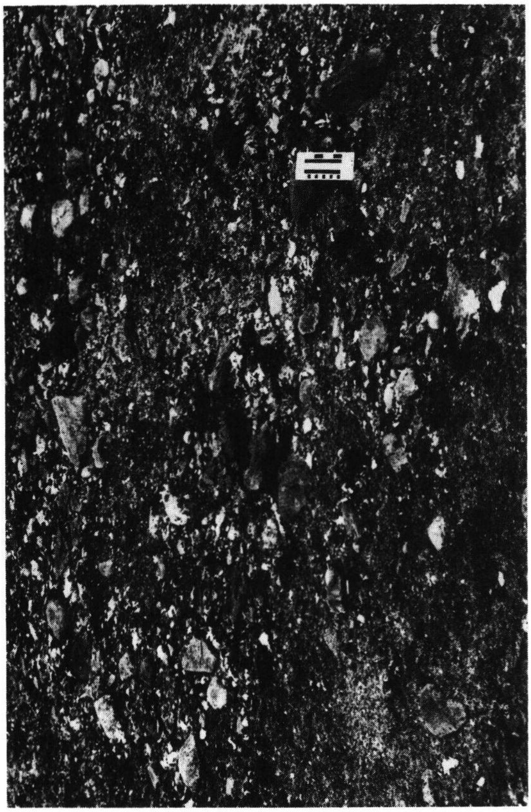

Fig. 5

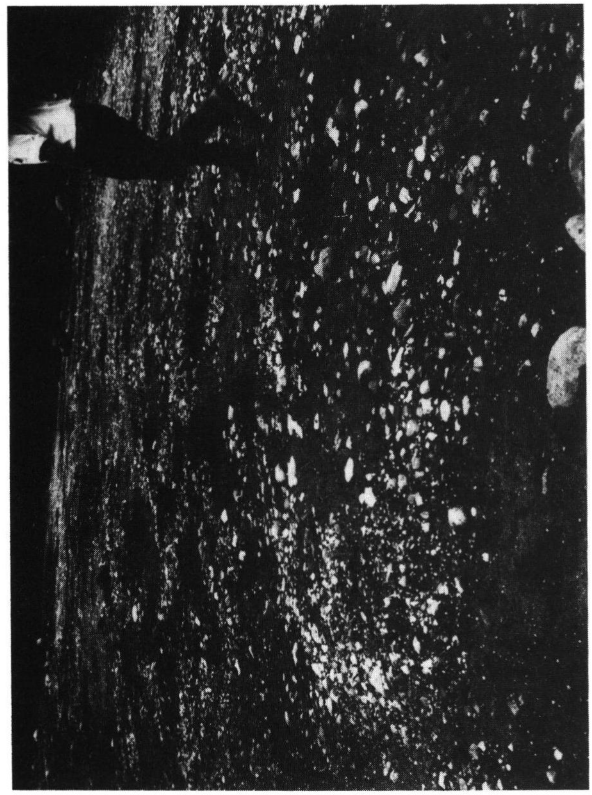

Fig. 6

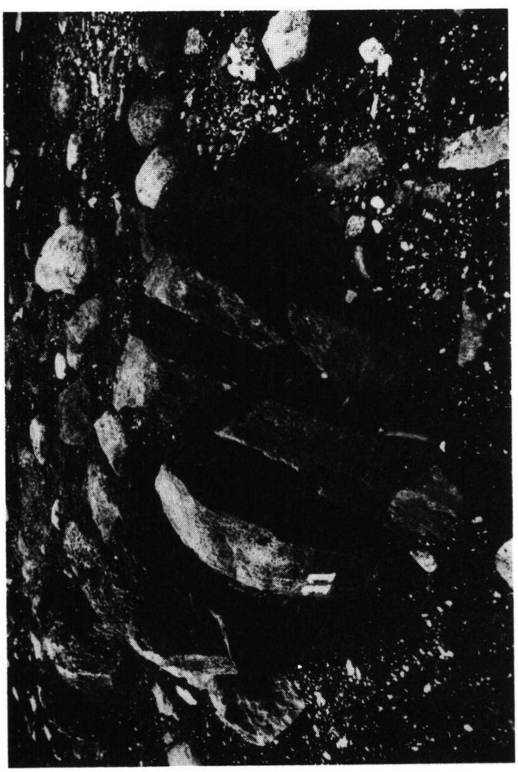

Fig. 3

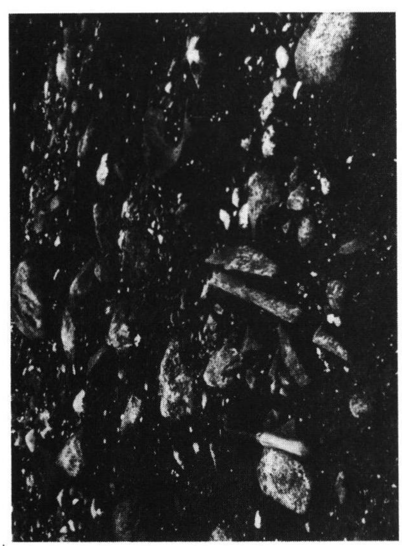

Fig. 4

arrangement cannot be due to wave activity, because rosettes formed by that agent are characterized by a strong and tight vertical arrangement of platy fragments and shells.

The third observation concerns the surface of a number of boulders. These boulders or at least patches of them show traces of windpolishing. This has also been observed by VAN DER LIJN (1944), who remarked on "... the unweathered and often shiny nature of the surface of the stones, sometimes as if they have been polished". The polish itself has been removed to a large extent, this may well be the result of burial by peat and consequently the effect of organic acids. However, the scalloped nature of the surface — well-known from polymineral ventifacts — supports wind action (Fig. 7; see e. g. LAGERBÄCK 1988: Figs. 5, 6; LAGERLUND 1987b: Fig. 3). Ventifacts are widely distributed in the Weichselian late-glacial of The Netherlands (SCHÖNHAGE 1969). According to Mr. OOSTERHOF of the Schokland Museum there is one good dreikanter in the "P. van der Lijn" reserve (pers. comm.).

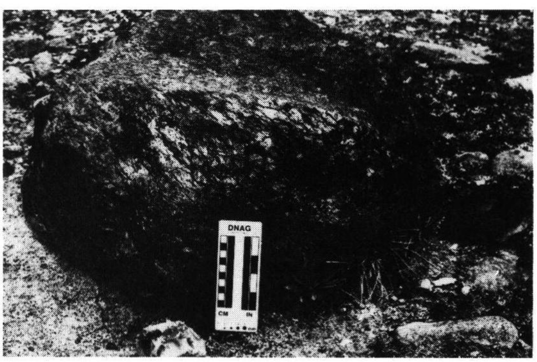

Fig. 7: Boulder with partly preserved windpolish, note the distinctly scalloped surface above the scale.

The observations of frost-cracked stones together with windpolishing and sorting of small stones are well compatible with a periglacial Weichselian environment. They also point to the fact that although abrasion has undoubtedly occurred in the Urk area (e. g. erratics overlying Holocene deposits), it cannot have influenced the whole surface and part of it has virtually escaped marine reworking during the Holocene.

Conclusion and reconstruction

From the above we can conclude that at least part of what used to be called an abrasion flat, and which is now the geological reserve "P. van der Lijn", is in fact a preserved Weichselian periglacial surface. A similar situation with a submerged but well-preserved periglacial surface showing ventifacts and fossil ice wedge polygons is locally present in SW Sweden. (BERGLUND & LAGERLUND 1981; LAGERLUND 1987a, b). In the Dutch sector of the North Sea, W of Castricum (block Q5) a gravelly ridge with ventifacts at its surface is covered by a veneer of Holocene sediments (C. LABAN; pers. comm.). One may conclude then that the preservation of Weichselian periglacial surfaces is by no means exceptional, and well-known from sections. What is exceptional however, is the fact that in the "P. van der Lijn" reserve one can actually walk on and study such a surface.

The observations described above lead to the following reconstruction of events (Fig. 8):

S t a g e A reflects the situation shortly after the disappearance of Saalian ice. The two types of till in their typical configuration have been indicated. Note however, that the boundary between the two till beds may have been wavy, in which case the "floes" represent the basal protrusions of a red till bed.

S t a g e B reflects the Eemian. As this area has not been flooded during the Eemian (map no. 9 in ZAGWIJN 1974) we may assume that during this interglacial only soil formation was active. And as the Eemian did not differ appreciably from the Holocene it is safe to assume that soil development must have been comparable as well. This means that we can count on soil development to have reached a depth of at most two metres. As the red till is more clayey and dense, soil development in these floes was presumably shallower than in the grey, normal till.

During the Weichselian, s t a g e C, lack of vegetation combined with cryogenic processes must have led to removal of the Eemian soil. In this way the surface was lowered by at least 2 metres and fresh stones and boulders accumulated as a lag deposit at the surface. The contours of the top of the Pleistocene (Fig. 1) demonstrate the vulnerable nature of the locality: an exposed, low interfluve in between two small stream courses. The cold climate also led to frost-cracking of boulders, while the lack of vegetation combined with drifting sand and/or snow led to windpolishing. Late-glacial (eolian) coversands are well-known from The Netherlands (MAARLEVELD 1976) and adjoining countries. Sorting processes led to the development of rings and stripes.

Especially these two elements, soil formation during the Eemian and erosion during the Weichselian have been overlooked by earlier students of the area.

S t a g e D reflects the Holocene submergence of the area, which started around 3,700 BP (ZAGWIJN 1986: map 5) and lasted until 1942 AD. Before that peat had been growing in the area from about 5,300 BP onwards (ZAGWIJN 1986: map 3). This peat may have protected the stones against direct reworking by the sea during transgression, organic acids may have been the cause of the removal of windpolish. As the minor displacement of separate fragments of the frost-cracked boulders and stones shows, abrasion certainly did not occur everywhere. Presumably this was mainly active near the edges of the boulderfield. Also fishermen have not disturbed the distribution of stones and boulders, because they avoided the area as their nets got caught in what they believed were the walls of a drowned village (MOERMAN & REIJERS 1925).

The present situation is depicted in s t a g e E. Vegetation is kept out by the management, enabling study of the preserved, Weichselian periglacial surface.

The above is not meant to re-interprete all boulderfields in the Noordoost Polder as Weichselian periglacial surfaces. The other large boulderfield, near de Voorst, is different because it is associated with a distinct till-cliff, which points to an abrasional origin of that field. But as no other boulderfields have been preserved after reclamation, it is impossible to restudy them. However, the abovementioned surfaces with ventifacts in SW Sweden as well as in the North Sea show that preservation of submerged periglacial (Weichselian) surfaces is not at all uncommon.

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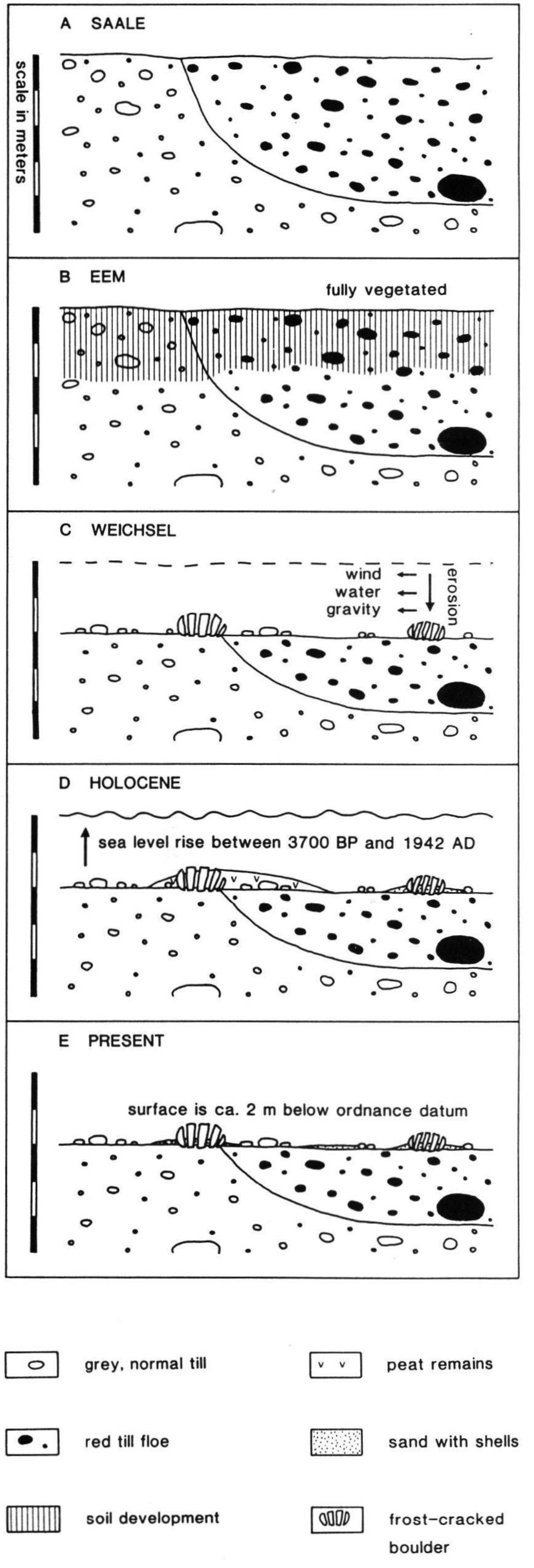

Fig. 8: Reconstruction of the different stages which influenced the development of the surface of the geological reserve.

References

BERGLUND, B. E. & LAGERLUND, E. (1981): Eemian and Weichselian stratigraphy in South Sweden. — Boreas, **10**: 323—362; Oslo.

BOEKSCHOTEN, G. J. & VEENSTRA, H. J. (1967): Over stenenoriëntatie in het Nederlands keileem. — Geol. Mijnb., **46**: 195—205; Rijswijk.

LAGERBÄCK, R. (1988): Periglacial phenomena in the wooded areas of Northern Sweden — relicts from the Tärendö Interstadial. — Boreas, **17**: 487—499; Oslo.

LAGERLUND, E. (1987a): An alternative Weichselian glaciation model, with special reference to the glacial history of Skåne, South Sweden. — Boreas, **16**: 433—459; Oslo.

— (1987b): Weichselisens avsmälting från Skåne. — Svensk Geogr. Arsb., **63**: 9—26; Lund.

LIJN, P. VAN DER (1944): Een eersterangs geologisch natuurmonument bij Urk.-De levende natuur, **49**: 1—7; 's-Graveland.

MAARLEVELD, G. C. (1976): Periglacial phenomena and the mean annual temperature during the last glacial time in The Netherlands. — Biul. Perygl., **20**: 57—78; Lodz.

MEER, J. J. M. VAN DER (1987): Field trip "Tills and end moraines in The Netherlands and NW Germany". — In: Meer, J. J. M. van der (ed.): Tills and Glaciotectonics, 261—268, Rotterdam / Brookfield (A. A. Balkema).

MOERMAN, H. J. & REYERS, A. J. (1925): Schokland. — Tijdschr. Kon. Ned. Aardr. Gen., **XLII**: 151—188; Leiden.

PONS, L. J. & WIGGERS, A. J. (1958): De morfologie van het Pleistocene oppervlak in Noord Holland en het Zuiderzeegebied, voor zover gelegen beneden gemiddeld zeeniveau (NAP). — Tijdschr. Kon. Ned. Aardr. Gen., **LXXV**: 140—153; Leiden.

RAPPOL, M. (1983): Glacigenic properties of till. Studies in glacial sedimentology from the Allgäu Alps and The Netherlands. — Publ. Fys. Geogr. & Bodemk. Lab., Univ. Amsterdam, **34**: 225 p.; Amsterdam. — [Ph. D thesis].

— (1987): Saalian till in The Netherlands: a review. — In: Meer, J. J. M. van der (ed.): Tills and Glaciotectonics: 3—21, Rotterdam / Brookfield (A. A. Balkema).

—, HALDORSEN, S. JØRGENSEN, P., MEER, J. J. M. VAN DER & STOLTENBERG, H. M. P. (1989): Composition and origin of petrographically-stratified thick till in the northern Netherlands and a Saalian glaciation model for the North Sea Basin. — Meded. Werkgr. Tert. & Kwart. Geol., **26**: 31—64; Leiden.

SCHÖNHAGE, W. (1969): Note on the ventifacts in The Netherlands. — Biul. Perygl., **20**: 355—385; Lodz.

WAARD, D. DE (1949): Glacigeen Pleistoceen, een geologisch detailonderzoek in Urkerland (Noordoostpolder). — Verh. Ned. Geol. Mijnb. Gen., Geol. Ser., **15**: 70—246; Den Haag. — [Ph. D. thesis].

ZAGWIJN, W. H. (1974): Palaeogeographic evolution of the Netherlands during the Quaternary. — Geol. Mijnb., **53**: 369—385; Rijswijk.

— (1986): Nederland in het Holoceen. Geologie van Nederland 1. — Rijks Geologische Dienst / Staatsdrukkerij: 46 p.; Haarlem / Den Haag.

ZANDSTRA, J. G. (1987): Explanation to the map "Fennoscandian crystalline erratics of Saalian age in The Netherlands". — In: Meer, J. J. M. van der (ed.): Tills and Glaciotectonics: 127—132; Rotterdam / Brookfield (A. A. Balkema).

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