GEOLOGY AND MORPHOLOGY OF A PART OF THE OOTMARSUM ICE-PUSHED RIDGE

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CONTENTS

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1. INTRODUCTION

The finding of some artefacts on the western flank of the Ootmarsum push moraine ridge (Stapert, this issue) gave rise to a wish for more insight into the geological setting of the area concerned.

The Mapping Department of the State Geological Survey carries out a systematic survey of the whole country. The results are published in a series of maps on a scale of 1:50,000. During the last days of the survey for the sheets Almelo/Denekamp (28 E–29 W), the above-mentioned finds were discovered. These, as yet unpublished, survey results form the basis of this short summary of the geological outlines. More extensive data will be published in the memoir to the sheet 28 E–29 W (Van den Berg, in prep.). Geomorphological data are taken from an earlier published Geomorphological Map of the Netherlands, sheet Almelo/Denekamp, scale 1:50,000.

2. GEOLOGICAL SETTING

The find-spots of the artefacts are located on the western flank of a ridge that forms part of a series of elevations that continues in a northern direction, across the Dutch-German border, into the county of Bentheim (fig. 1). This ridge consists primarily of non-glacial deposits, and was formed by ice-pushing in the Saale period. The morpho-genetic processes which have been of basic importance for the ultimate situation as we know it today can be divided into three groups:

a) During the last stadial of the Saalian Stage (fig. 2) (Zagwijn, 1973), the inland ice sheets slided over a frozen subsoil, causing little disturbance of the subsoil. Periodically, however, the glacier lobes of the same ice sheet were able to cut deeply into the pre-glacial deposits and push them up into ridges. This mechanism is not yet fully understood, although explanations have been offered by Zagwijn (1975) and Jelgersma and Breeuwer

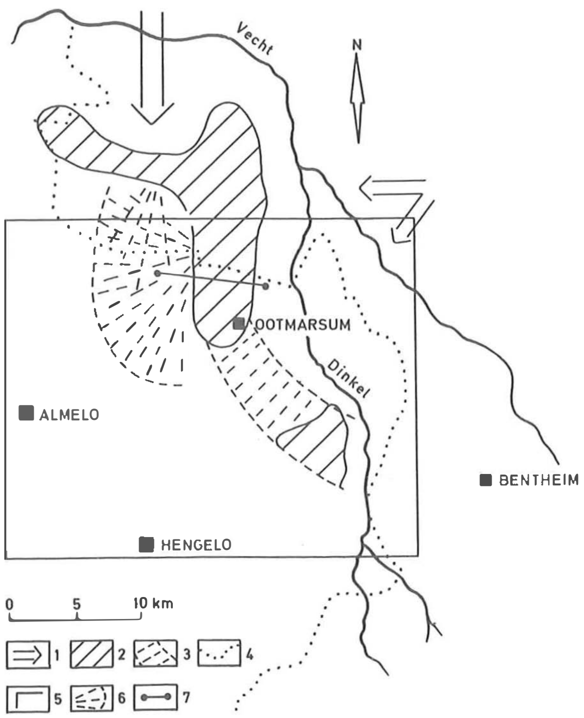

Fig. 1. Physiographic picture of sheet 28E–29W and the adjacent county of Bentheim. 1. push direction of the Saalian land ice lobes; 2. push moraine; 3. push moraine, eroded; 4. Dutch-German border; 5. mapsheet Almelo/Denekamp; 6. Saalian outwash fans, partly covered by younger deposits; 7. section shown in fig. 3.

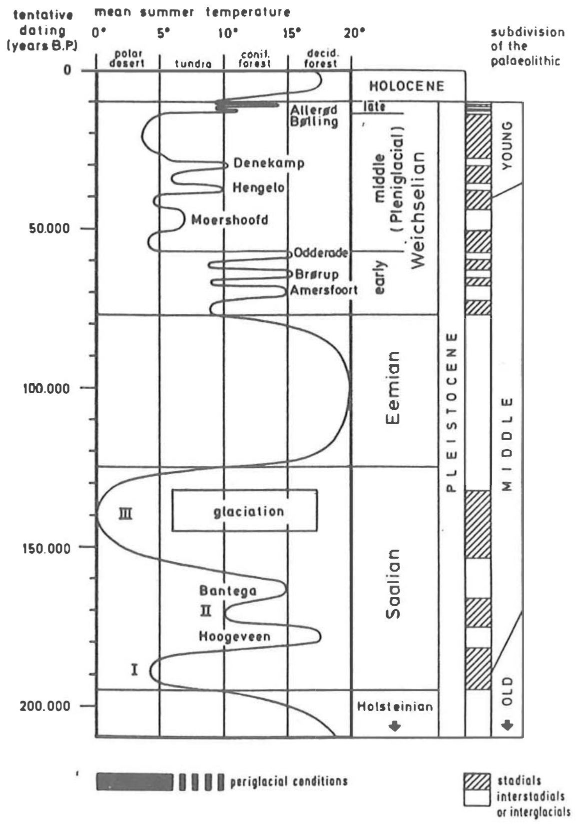

Fig. 2. Climatic curve for the Late Pleistocene in the Netherlands (based on Zagwijn, 1975).

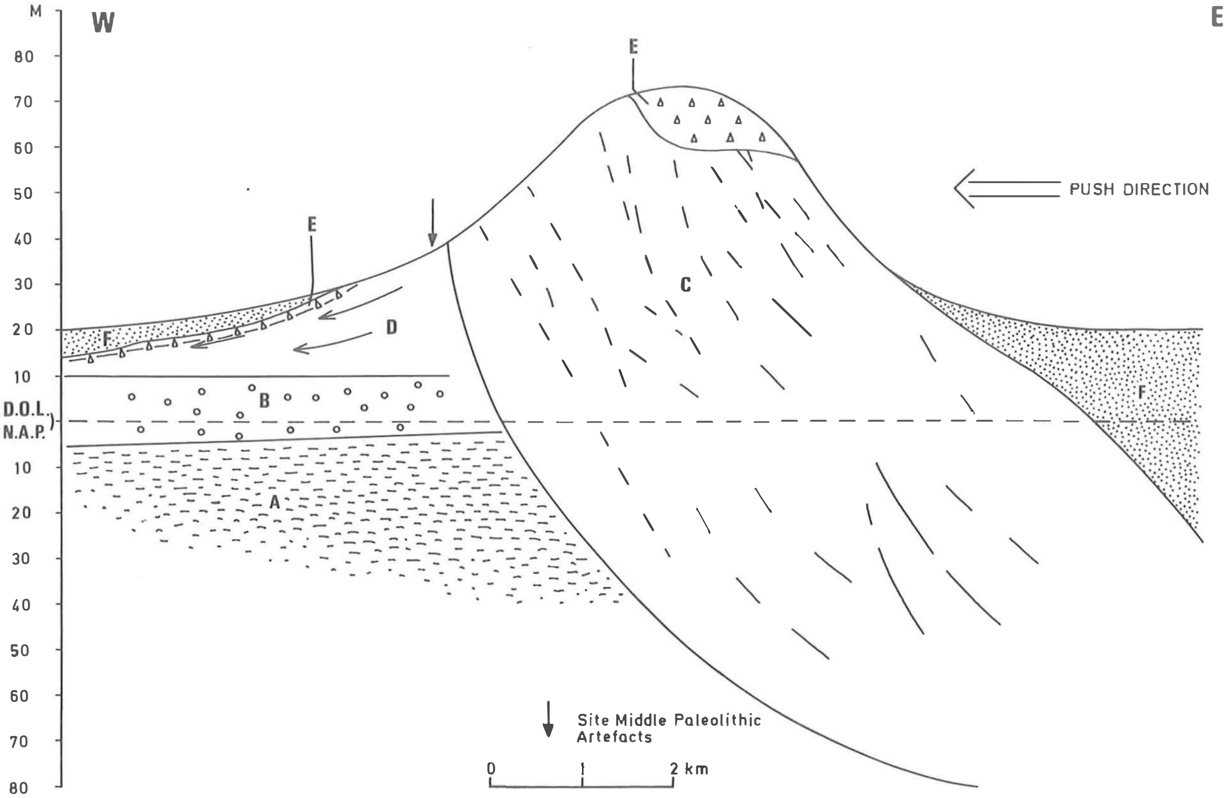

Fig. 3. Schematic cross section through the Ootmarsum push moraine ridge. A. fine-grained Tertiary deposits; B. coarse-grained Middle Pleistocene deposits; C. ice-pushed strata; D. Saalian outwash fan; E. basal till of the Saalian ice sheet; F. Weichselian solifluction fans.

(1975). The direction of push was, for the N-S section of the ridge, from the east; the E-W section in the county of Bentheim has been pushed up from the north (fig. 1).

During the formation of the ridge, glacial meltwater flowed over it, taking up local material from the ridges, and thus building up from this a major outwash fan on the western flank (figs. 1 and 3). After the formation of the ridge and the outwash fans, the ice sheet flowed further south, meanwhile overriding and strongly eroding the ridges; a basal till or the remains of it are found all over the ridges, and on the outwash fan.

b) Major erosion took place on the ridges when periglacial conditions prevailed during parts of the Weichselian (fig. 2). The sparse vegetation cover during the sub-arctic and arctic phases of this stage, together with the abundant snow meltwater and the strong terrain gradient on the slopes of the ridges, led to the formation of solifluction valleys (figs. 4 and 5). According to the geomorphological map a very regular pattern is found on the Ootmarsum ridge. This regular pattern is the response to the drumlinoid form of this part of the ice-pushed ridge. This form is caused by the overriding ice-sheet.

A detailed description of the periglacial processes and related forms is given by many authors (*e.g.* Van der Hammen *et al.*, 1967; Maarleveld, 1976). Aeolian accumulation forms are well known from this timespan, they occur mainly in the lower areas between the ice-pushed ridges, and are very scarce on the ridges themselves. Coversand accumulation is found on top of the solifluction fans that have been built up at the foot of the ridge (fig. 3), each fan matching a solifluction valley system (fig. 4). During part of the Late Pleniglacial very severe and dry climatic conditions prevailed, presumably a polar desert; these conditions are documented by a deflation level characterized by an aeolized pebble and stone layer. In the lower areas this band is covered by coversand. On the Ootmarsum ridge aeolized

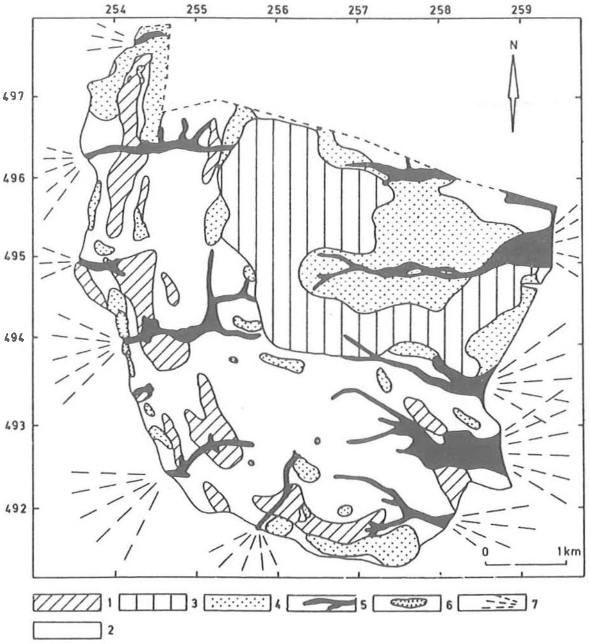

Fig. 4. Generalized distribution of different lithologies outcropping on part of the Ootmarsum push moraine ridge. 1. Tertiary strata: heavy clay; 2. Tertiary strata: other lithology; 3. basal till of the Saalian ice sheet; 4. Middle Pleistocene coarsegrained sands; 5. Weichselian valley bottom deposits; 6. quarry; 7. Weichselian solifluction fans.

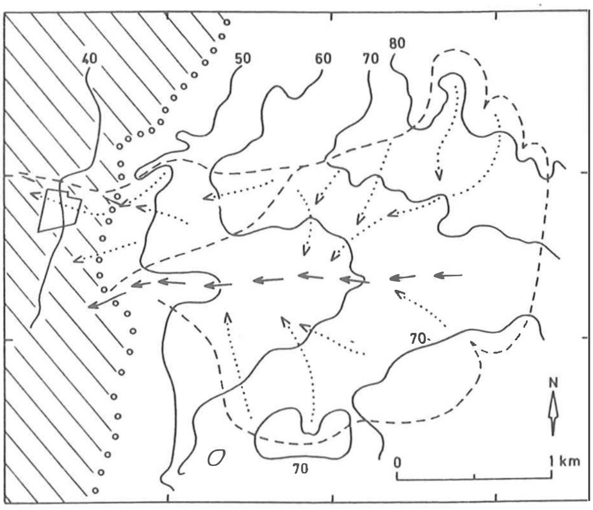

Fig. 5. Part of the Ootmarsum ice-pushed ridge showing the western flank with different drainage areas near Mander. 1. water divide; 2. direction of solifluction mass-movement; 3. contourline in metres above N.A.P. (D.O.L.); 4. archeological site with Middle Palaeolithic finds; 5. Mosbeek; 6. western boundary of outcropping ice-pushed strata; 7. outcropping Saalian outwash fan, partly covered by a Weichselian solifluction head.

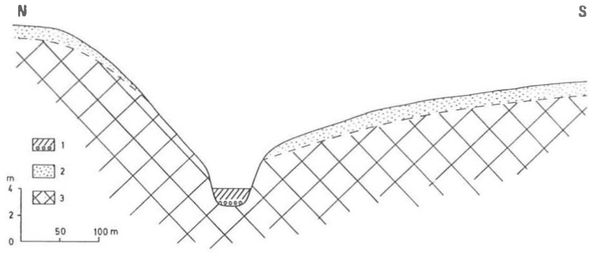

Fig. 6. Cross section through the Mosbeek valley near the watermill of Bels. 1. Holocene (anthropogenic) accumulation lying on top of the Weichselian basal gravel; 2. Weichselian solifluction head; 3. ice-pushed strata.

gravel and boulders, often reshaped into ventifacts, are found in the topsoil.

From the detailed facies analyses of the periglacial sediments carried out by Ruegg (1981, 1983), it appears that after the formation of the aeolized stone layer (called: Beuningen Gravel Bed) mainly wet-aeolian conditions prevailed together with permafrost (Maarleveld, 1976). Consequently on the flanks of the ice-pushed ridges sheet-like movement of the top layer could still take place till the end of the Pleniglacial.

During the Late Weichselian the vegetation became denser (fig. 2); permafrost conditions did not occur any more and the existing surface-relief became fossilized. The drainage of the water surplus concentrated into a channel-bound system of small brooks; the effective erosion caused by these brooks is very small, but it occurs.

c) This erosion is evident from the third group of processes: the human interference with this drainage system. Where man has built dams to create water reservoirs to keep water mills going, sediment accumulated in front of these dams (fig. 6) and the reservoirs became silted up. These ponds have frequently been dug out, to retain their water storage capacity. Any archeological finds within these spots are possibly strongly disturbed by human activity so geological data can hardly support the archeological interpretations.

3. INTERNAL STRUCTURE OF THE OOTMARSUM RIDGE

In eastern Twente only clay-rich Tertiary sediments are incorporated into the ice-pushed ridges. These Tertiary sediments are marine deposits which are characterized *inter alia* by the presence of glauconite, a green clay mineral that can turn brown when it becomes oxidized. It stains the sediments green, yellow or brown.

Before being pushed up by the land ice sheets, the Tertiary layers were covered in their undisturbed position by fluviatile sands of Middle Pleistocene age. The latter are medium fine to coarse sands rich in quartz and mineralogically very poor in contrast to the glauconitic sediments. Because of the low thickness of the fluviatile sands (less than 10 m) in comparison with the Tertiary sediments that are mixed up within the ice-pushed ridge (more than 70 m) (fig. 3), the sands form only a minor part of the internal structure of the ridge and of its surface. The ridge reveals its internal structure at the surface (De Jong, 1967), exposing strips of various types of lithology. In general these strips appear to be arranged according to the internal glaci-tectonical structure, parallel to the general strike of the ridge and perpendicular to the direction of pushing (figs. 1 and 4).

Together with the preglacial deposits, part of the fluvial-glacial fan has been partly pushed as well. Shortly after the formation of the ridge, a strong surface relief must have been present. This relief has been flattened out by till accumulations, formed at the base of the overriding land ice sheet and mainly eroded from the ridge itself. Very thick accumulations have been encountered during the survey (section in figs. 1, 3 and 4).

4. MORPHOLOGICAL EXPRESSION OF THE LITHOLOGY

The lithology of the outcropping strata appears to be related to some extent to the present-day morphological features visible on the Ootmarsum ridge. The effect of selective soil erosion can be explained primarily by the periglacial conditions during the Weichselian. Under a temperate climate, without man's interference, a dense vegetation will protect the soils against the eroding impact of rain. Overland flow caused by heavy rainstorms will only be effective on the steeper slopes, and those slopes tend to coincide with either the coarse gravelly sands of Middle Pleistocene age or the heavy clay of the Tertiary strata. The first have a high infiltration capacity, the latter are very difficult to erode by running water.

Richter *et al.* (1951) have drawn attention to the conspicuous ridges with slope angles up to 15° which are determined by outcrops of materials rich in gravelly sands, that belong to the Middle Pleistocene fluvial deposits.

The ice-pushed Tertiary deposits can be divided roughly into two lithological units: one group consists of heavy clays ($\pm 60\% < 2\mu m$); the other group contains all the other lithologies, mainly loamy green sands to loams. Under periglacial conditions, the first group is very sensitive to frost action when exposed, because they tend to break up under repeated freezing and thawing. They will be only slightly effected when the role of moisture increases and a solifluction head accumulates on top of the heavy clay. The vertical downward movement of the moisture is prevented and the contact zone between the solifluction head and the underlying heavy clays will act as a slipface. As the duration of the different climatic conditions during the periglacial intervals (fig. 2) of the Weichselian is not yet known in enough detail, one is only able to record the final result of all these different processes active during this long timespan. The areas in which fields with heavy clay dominate belong to the more resistant flat zones in the morphology (with step angles 1°–5°), while the second group in general is reflected by wide flat depressions (slope angles 1°–2°) as is demonstrated by fig. 5; here the Mosbeek drainage basin is widening in eastern direction. The relatively narrow deep valley section crosses a zone with predominantly heavy clays (fig. 4). This morphological expression of the lithology is only valid in very general terms. As appears from very detailed mapping (Van der Akker & Knibbe, 1963; Richter *et al.*, 1951) the main mapped units, as shown in fig. 3, are divided up into very small elongated sub-units, sometimes less than 20 m wide, caused by the internal glaci-tectonic structure. Fig. 6 shows a cross section through the narrow part of the Mosbeek where it crosses the field with predominantly heavy clays near the watermill of Bels. In this section the asymmetry of the valley is very striking. This asymmetry is typical for many valleys developed under periglacial conditions. The south-facing slope is always steeper because the moisture-dominated solifluction processes are less active here as a result of the more abundant sunheat received.

5. ABSTRACT

A general outline is given of the geology and morpho-genetic processes that concern the area near Mander on the ice-pushed ridge of Ootmarsum.

6. ACKNOWLEDGEMENTS

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