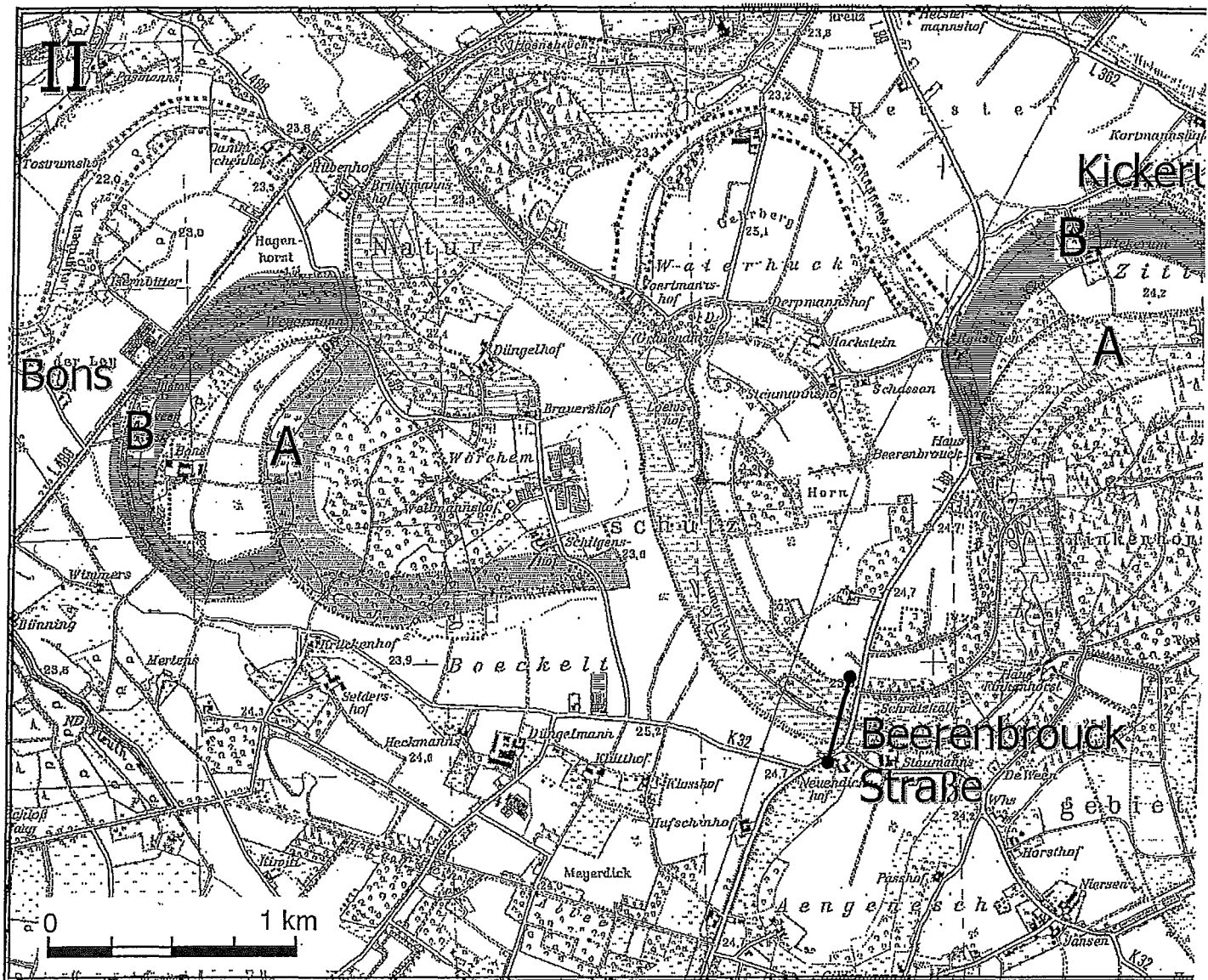


# 43ste Nederlands-Belgische Palynologendagen, Groesbeek



De Fluviatiele ontwikkeling in het Niersdal op de overgang van  
het Weichsel Laat Glaciaal naar het Holoceen

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## CLIMATE AND VEGETATION CHANGE AND LATE GLACIAL FLUVIAL RESPONSE OF THE NIERS-RHINE (WESTERN GERMANY)

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### Summary

The Niers valley was part of the Rhine system that came into existence during the maximum Saalian glaciation and was abandoned at the end of the Weichselian. The aim of the study was to explain the Late Pleniglacial and Late Glacial fluvial dynamics and to explore the external forcing factors climate change, tectonics and sea level.

The sedimentary units have been investigated by large-scale coring transects and detailed cross-sections over abandoned channels. The temporal fluvial development has been reconstructed by means of geomorphological relationships, pollen analysis and  $^{14}\text{C}$  dating.

The Niers-Rhine experienced a channel pattern change from braided, via a transformational phase to meandering at the Late Pleniglacial to Late Glacial transition. This change in fluvial style is explained by the early Late Glacial climate amelioration (at c. 12,5 ka  $^{14}\text{C}$  BP) and climate-related hydrological, lithological and vegetation changes. A delayed fluvial response of c. 400 years (transitional phase) was established. The channel transformations are not related to neotectonic effects and sea-level changes. Successive river systems have similar gradients of c. 35-40 cm/km.

A meandering river system dominated the Allerød and Younger Dryas periods. The threshold towards braiding was not crossed during the Younger Dryas. The final abandonment of the Niers-Rhine was dated at the Younger Dryas to Holocene transition. The first traces of Laacher See pumice have been found in the Niers valley indicating that the Niers-Rhine still existed in the Younger Dryas period.

### Fig. 1 Geological setting of the Niers Valley

The Niers valley is situated in the southeastern Netherlands and adjacent Germany. The valley was formed during the maximum Saalian glaciation. Then, the Rhine flow was diverted to the west by the southward migration of the Scandinavian ice sheet. During (parts of) the Weichselian the Niers valley was the westernmost Rhine course. At the end of the Weichselian the Niers-Rhine was finally abandoned.

### Fig. 2 Late Pleniglacial to Holocene floodplain levels in the Niers valley

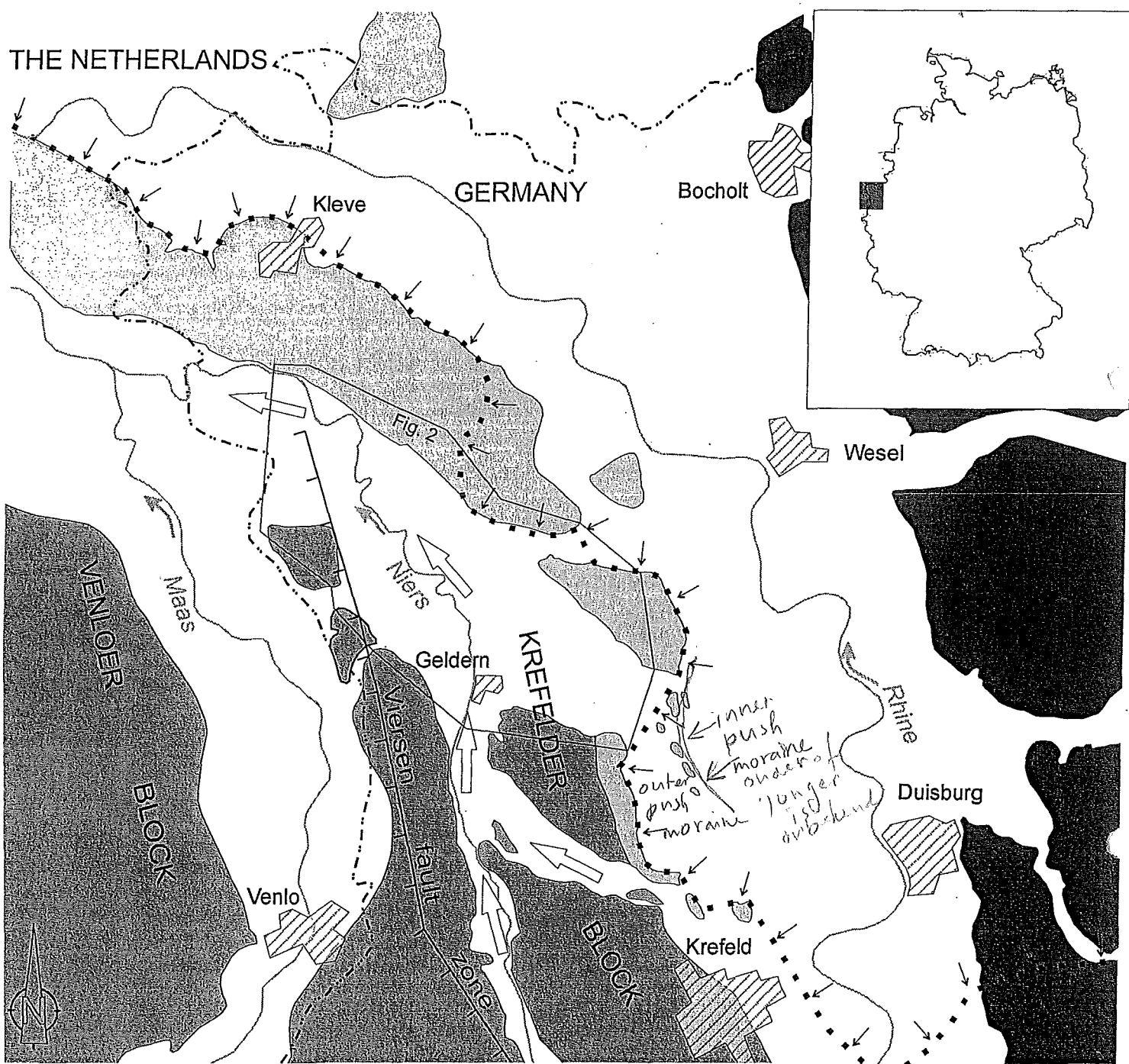


Fig. 1.

# Bijlage 1: Riviersystemenkaart Niersdal

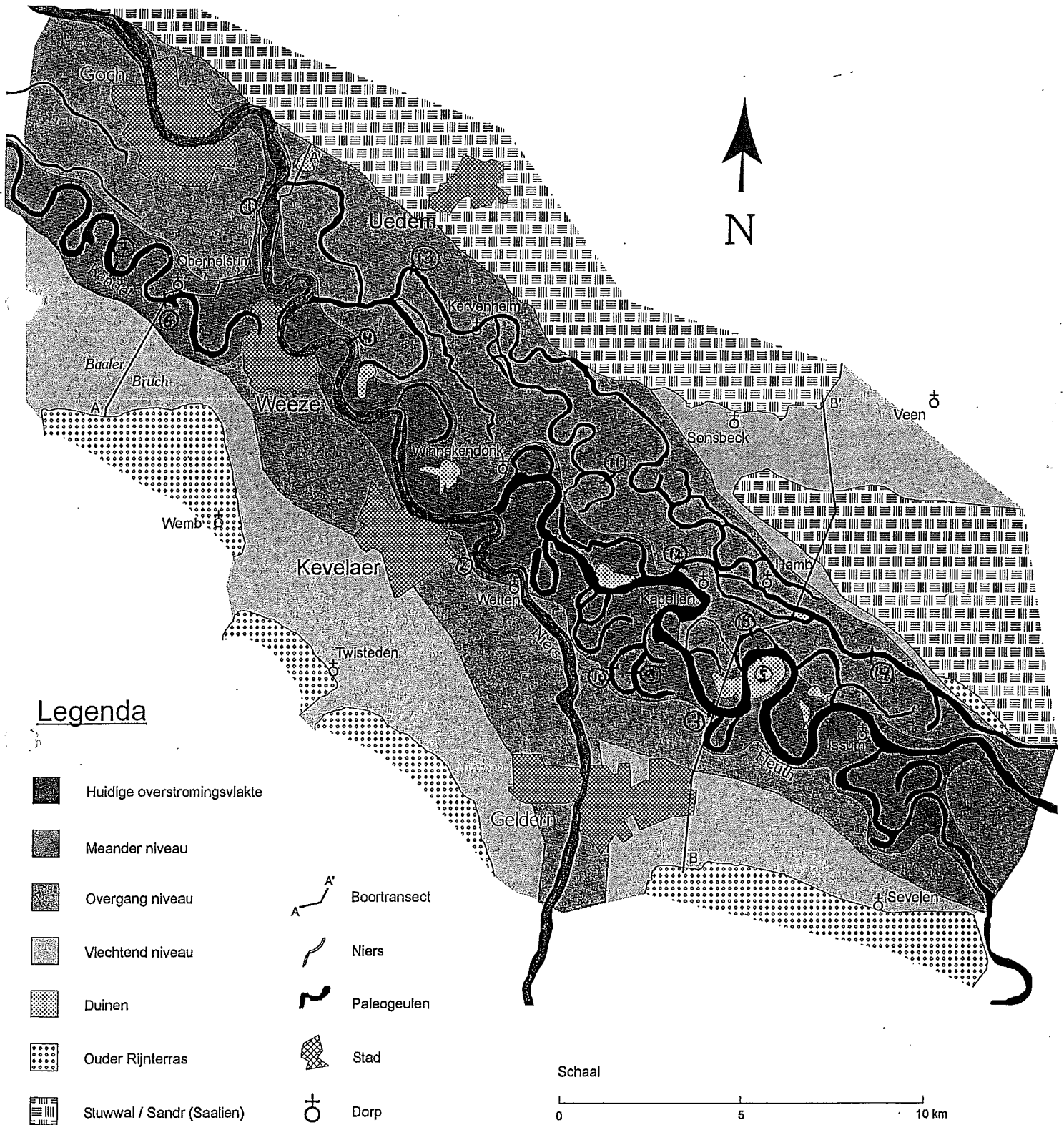
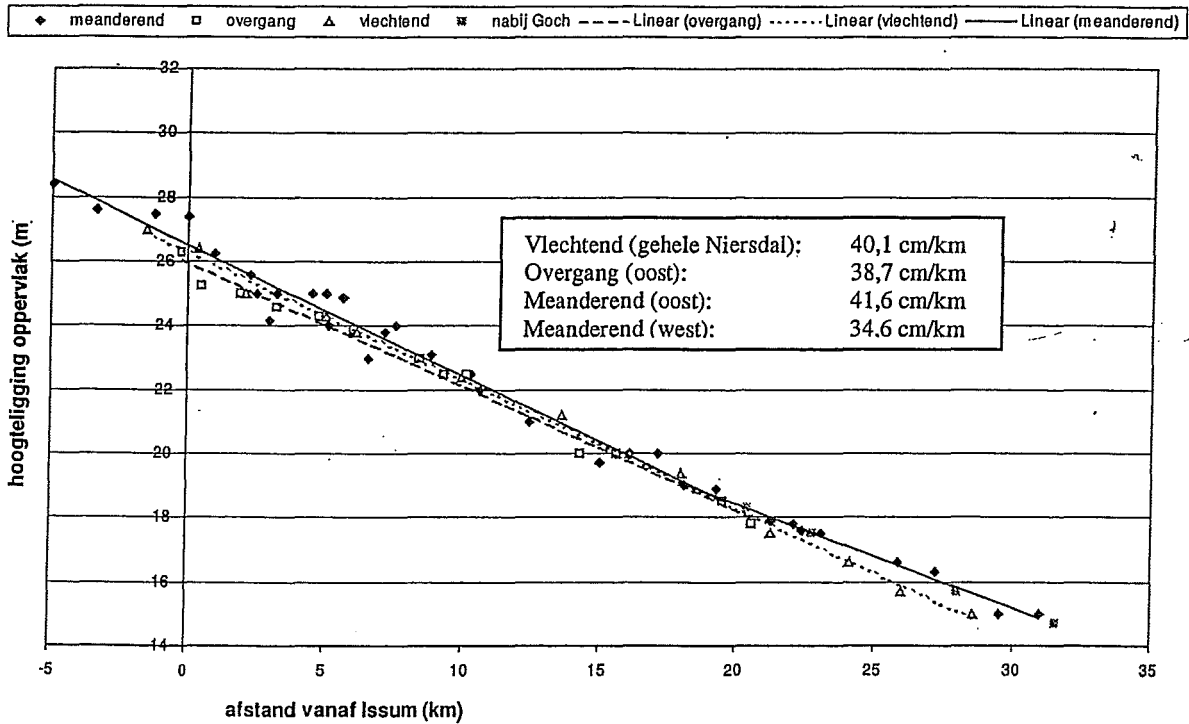


Fig. 2.

### gradientlijnen Niersdal (oppervlakte)



Figuur 3.: datapunten en gefitte regressie (gradiënt)lijnen voor het vlechtend riviersysteem, overgangssysteem en het meanderend systeem. De datapunten westelijk van Goch, waarvan het nog onduidelijk is tot welk systeem ze behoren, zijn apart weergegeven zonder regressielijn. Bovenin de figuur zijn de hellingen van de systemen weergegeven. Bij meanderend is onderscheid gemaakt tussen oost en west.

Fig. 4a

SSW

NNE

Baaler Bruch

Oberhelsum - Kalbeck

Kalbeck - Sternberg

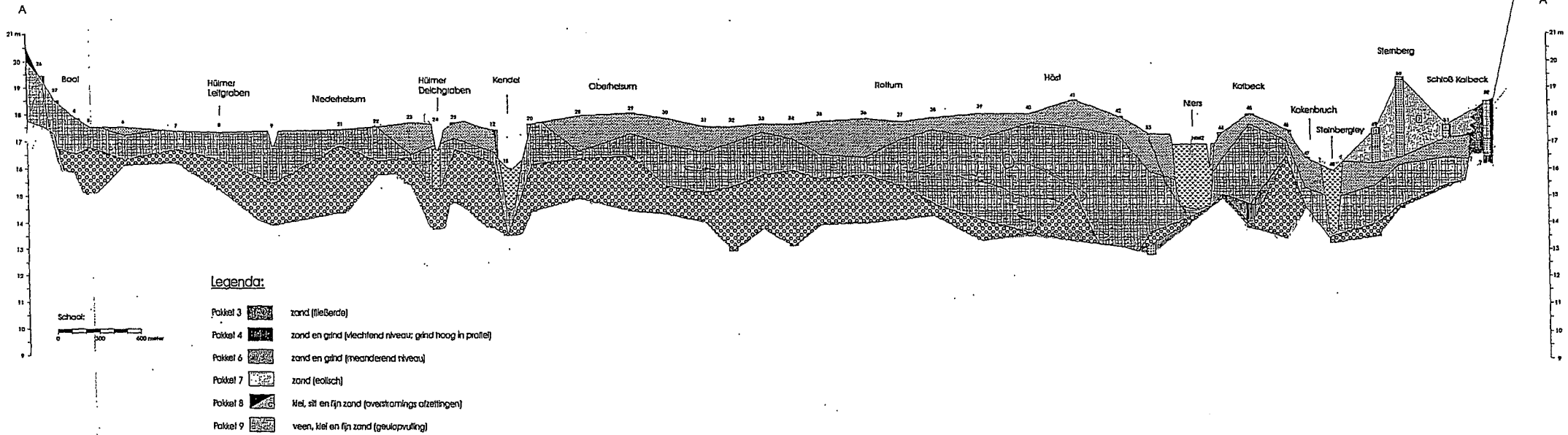
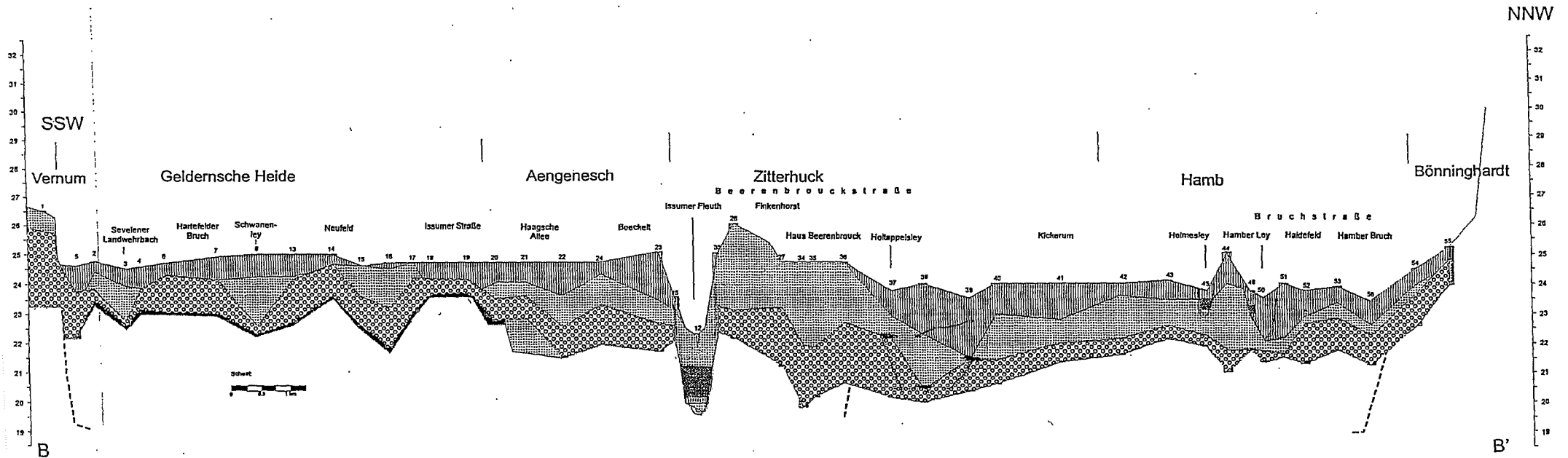


Fig. 4b : overzichtsprofiel Geldern - Bönninghardt

| Legenda |  |
|---------|--|
|         | Pakket 1 Miocene (Zand / grind)                          |
|         | Pakket 2 Top laag Miocene (SN)                           |
|         | Pakket 3 Flakwade (SN / zand)                            |
|         | Pakket 4 Vloedland sediment (Zand / grind)               |
|         | Pakket 5 Overgangsediment (Zand / grind)                 |
|         | Pakket 6 Strandwal sediment (Zand / grind)               |
|         | Pakket 7 Eolisch (Zand / overland zand)                  |
|         | Pakket 8 Overstromingsaantropen (Ool / silt / fijn zand) |
|         | Pakket 9 Geolopruif (Ool, dyfje, veen)                   |
|         | Pakket 10 Bodem (Druwe)                                  |

| Legenda (volommen) |                         |
|--------------------|-------------------------|
|                    | veen / humus            |
|                    | ool / klei              |
|                    | silt / siltig           |
|                    | fijn zand / fijn zandig |
|                    | grof zand / grof zandig |
|                    | grind / grindig         |



Three Late Pleniglacial and Late Glacial palaeofloodplain levels have been distinguished above the Holocene floodplain (fig. 2): an oldest level with braiding characteristics at the outer limits of the Niers valley, a transformation level formed during a phase of channel transformation and a level with meandering channel characteristics. It is emphasized that floodplain levels have been distinguished, not terraces, since the different units occur more or less at the same level.

The oldest level has a very subdued morphology and differences in elevation are generally no more than 1 m. The geological maps of the area show slightly elevated gravel bars and connecting and disconnecting channels, suggesting a braided channel pattern during the formation of this level

The transformation level is well expressed along the northern margin of the valley (fig. 2). It is characterized by straight channels and well-developed small meanders. The channels are not wider than 100 m and the thickness of the fine-grained infill is no more than 1.5 m. Infill of the channels is mostly clastic with an alternation of loam and organic loam beds. These palaeochannels seem to represent the transformation from the multi-channel, braided system, when the full valley width of 5 to 10 km was occupied by the river system, to the younger, single-channel meandering system.

The next younger level is characterized by high-sinuosity meandering channels of several generations. The clear cross-cutting relationships enable to establish a relative chronology of the meander scars, especially east of Kevelaer. The palaeomeanders are generally c. 200 m wide and the fine-grained infill is c. 2 to 3 m thick. Bankfull depth may have been more than 5 m. The infill of the older large palaeomeanders consists mostly of loam or peaty loam and peat. The youngest palaeomeander system of the Issumer Fleuth, however, is organic with lacustrine gyttja and peat. Small dune fields occur in association with this last meander belt (presently occupied by the Issumer Fleuth and Niers, see fig. 2).

Fig. 3 Floodplain gradient lines of the successive river systems

It is clear from figure 3 that the successive palaeofloodplain surfaces (braiding-transformational-meandering) have similar elevations and gradients of c. 35-40 cm/km. The transformational and meandering systems show a (normal) downstream decrease in gradient. The reconstructed gradients reveal some important elements:

First, the change in channel pattern of the successive floodplain levels is not related to differences in gradient.

Secondly, neotectonic effects on the river gradients could not be established.

Thirdly, the impact of sea-level changes was negligible during the formation of the floodplain levels.

Fourthly, based on the considerations above, it is postulated that climate change and climate-related changes in water and sediment supply, were the main factors that determined the changes in channel pattern from braiding to meandering.



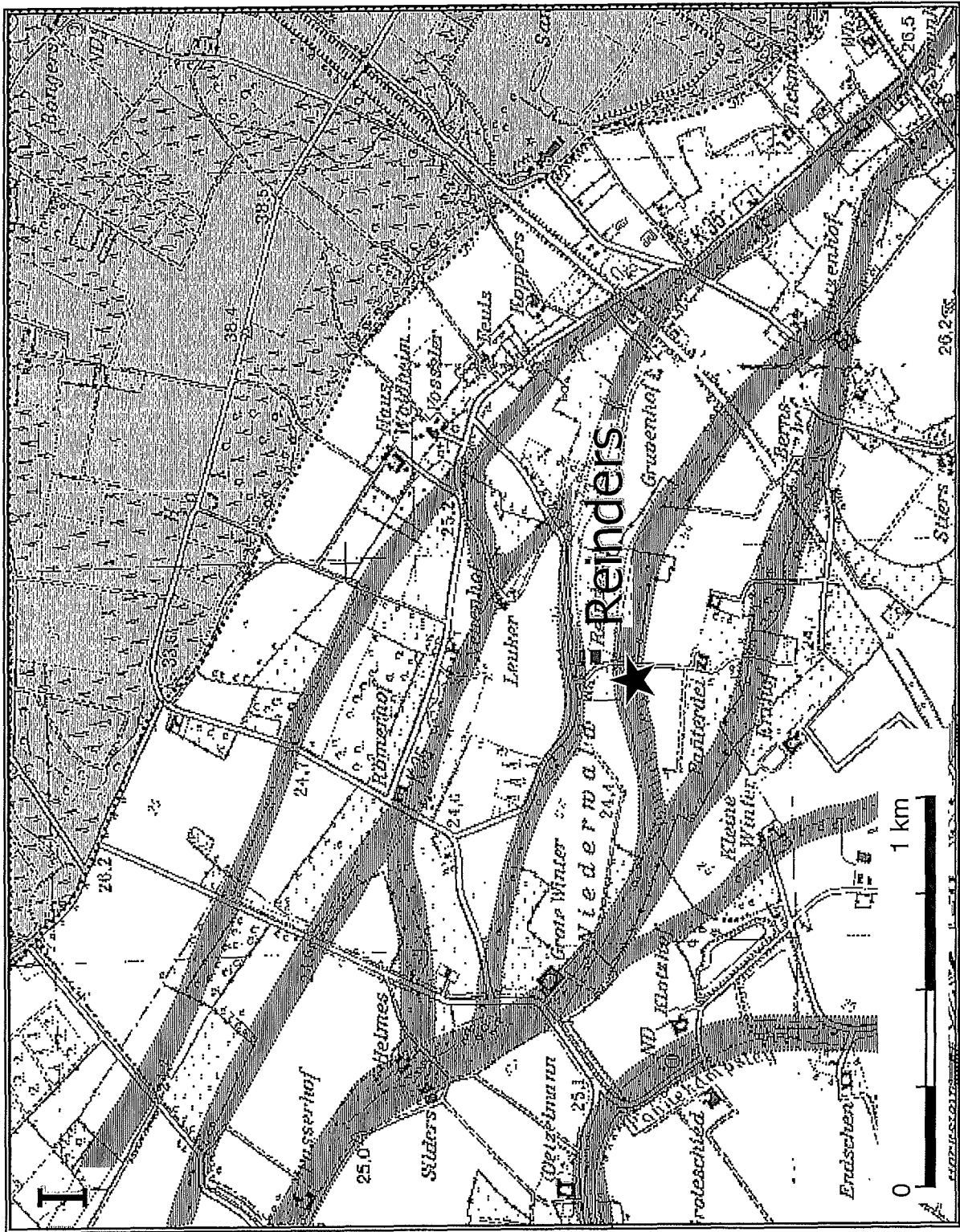


Fig. 4 Lithological cross sections over the Niers valley

Two large-scale coring transects perpendicular to the main valley axis (fig. 4) and many detailed cross-sections over abandoned channels have been made (see fig. 2 for location). It is clear that on a large scale the top of the gravel in the cross sections shows a general dip towards the northeast (fig. 4). In addition to this, in the central part of the profiles the gravel is generally found at a greater depth than at the margins. At the southern margin of the Niers valley, where a braided surface morphology has been found, gravel and gravelly sand is normally found at a shallow depth (average c. 1 m). A loam layer is present at the top of the sequence (Hochflutlehm).

In the area with the transformational river system near Hamb and Oberhelsum (fig. 4a, b) gravelly sediment occurs at a larger depth (c. 1-2 m) and the overlying sand and loam units are more important. In the central part of the valley, with clear large-scale meandering surface patterns, gravel occurs at a depth of 2-4 m. The overlying sandy unit (c. 1-3 m thick) often reveals a clear fining upwards tendency formed by lateral migration of the meandering channels.

Locally, small dune fields are found in association with the last meander generation of the meandering system (fig. 4a: Sternberg; fig. 4b: Finkenhorst).

Fig. 5a Cross section Reinders

This cross section is from the transformation level. Channels are straight to sinuous, small (50 m wide) and shallow (1.5 m). They represent the transformation from the multi-channel, braided system, when the full valley width of 5 to 10 km was occupied by the river system, to the younger, single-channel meandering system. River water flow became more and more concentrated in fewer channels. The fill of the channel is mostly clayey because of clastic influxes from younger channel generations.

Fig. 5b Pollen diagram Reinders

The frequent occurrence of *Picea*, *Abies*, *Corylus*, *Alnus* and high values of *Pinus* throughout the diagram indicate an allochthonous component in the whole pollen diagram. This hampers the interpretation of the pollen diagram.

The lower part of the diagram, from 155 to 117 cm, shows a gradual *Pinus* decrease and increase of the Gramineae values. The high *Pinus* values at the base coincide with a sandy clay lithology and can probably be attributed to reworking. The continuous presence of *Hippophaë* is a strong indication for the Early Dryas biozone (c. 12,1-11,9 ka <sup>14</sup>C BP). The upper part from 117 to 80 cm is strongly dominated by high *Pinus* values. Theoretically, these high Pine values could be part of the Preboreal *Pinus* phase, however, typical elements for the early Holocene like *Monolete* psilate spores and *Typha latifolia* are missing and therefore this part of the diagram predates the Holocene. Most likely, the interval from c. 95 to 117 cm represents the *Pinus* phase of the late Allerød (c.

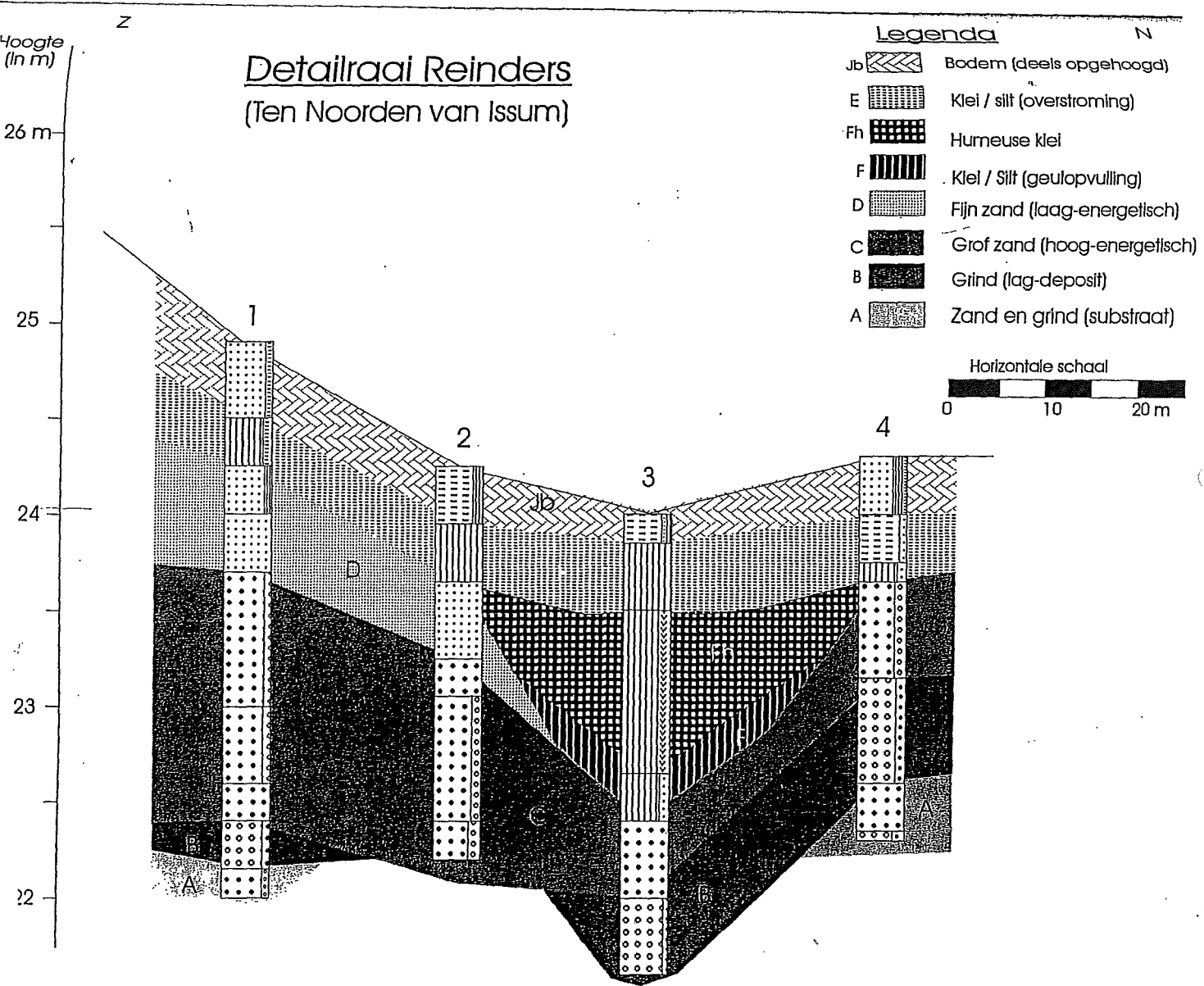


Fig. 5a

Fig. 5b

NIERSDAL  
Reinders

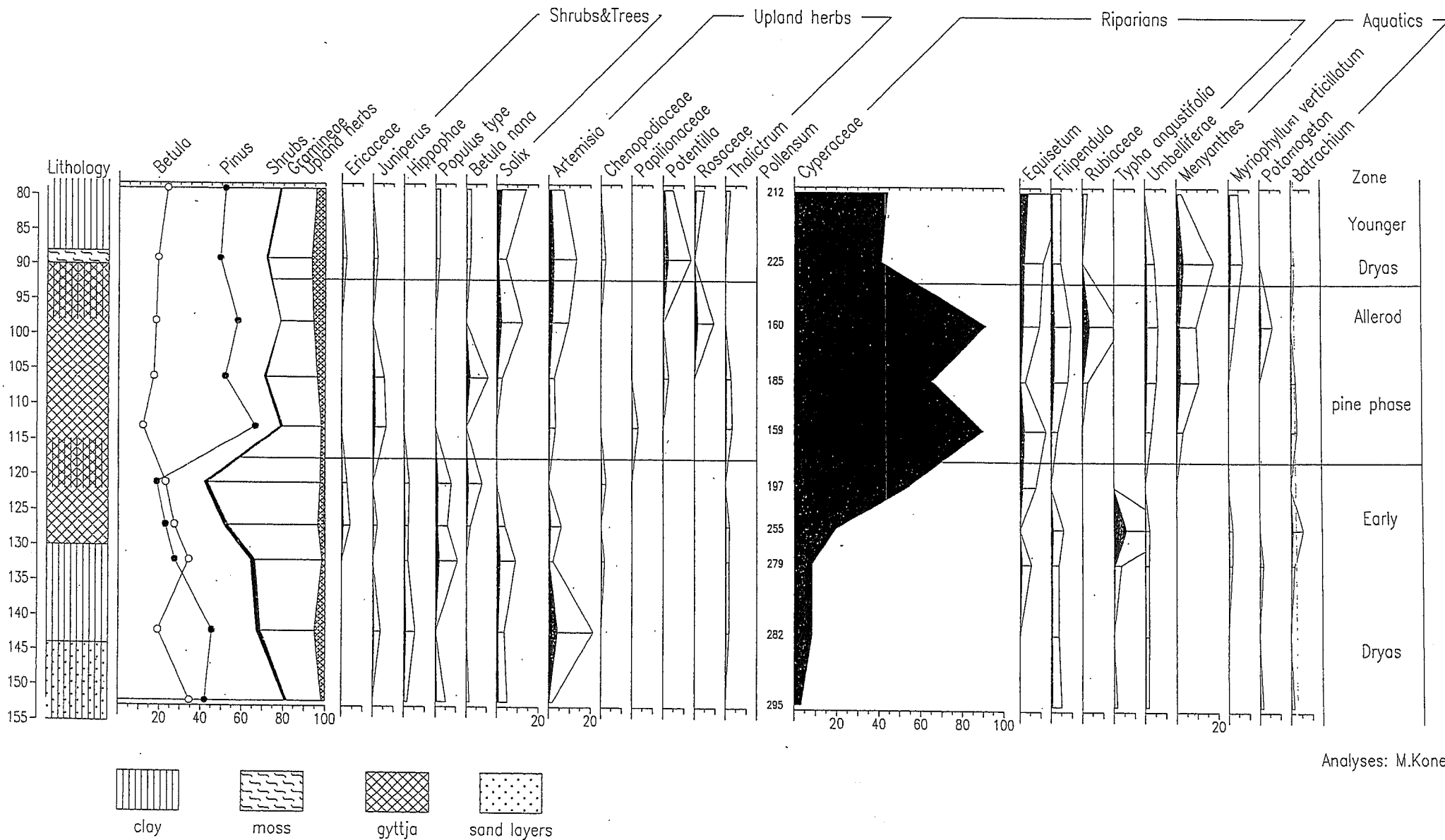
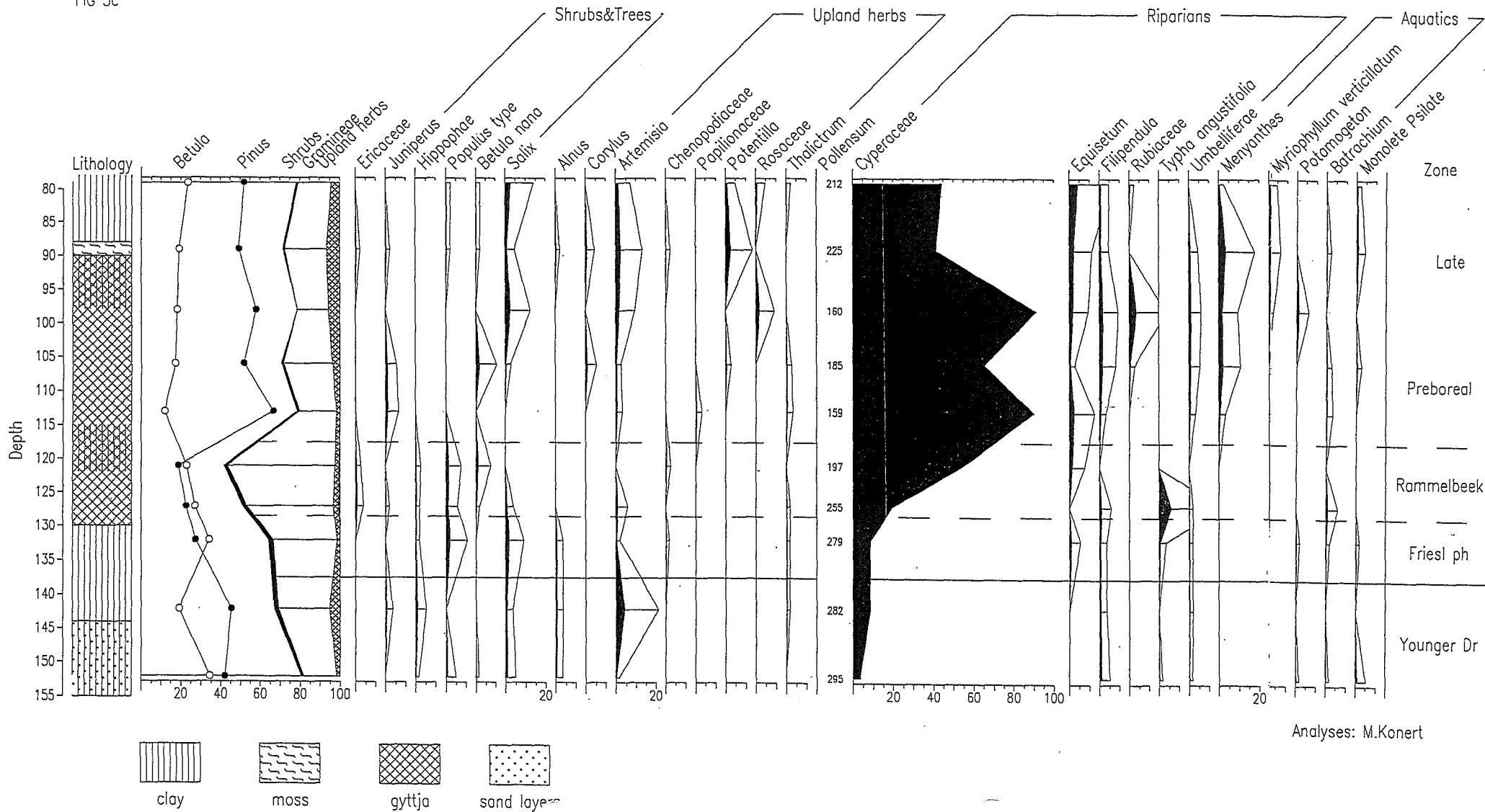


Fig. 5c

NIERSDAL  
 Reinders alternative interpretation  
 FIG 5c



11,2-10,9 ka  $^{14}\text{C}$  BP). This interpretation implies a hiatus at 117 cm covering the *Betula* phase of the Allerød.

From c. 95 cm upwards there is a gradual increase in *Artemisia*, *Pediastrum* and *Salix*, probably reflecting the climatic cooling of the Younger Dryas period.

The age of the basal part of the fill indicates that the transformation from a braided to a meandering system occurred during or shortly before the Early Dryas period (c. 12,1 ka  $^{14}\text{C}$  BP). After abandonment the channel scar was frequently inundated and filled with clastic suspension material from younger meandering channel generations during the Allerød and Younger Dryas.

The dates indicate that the change in fluvial style does not coincide with the early Late Glacial climate amelioration (at c. 12,5 ka  $^{14}\text{C}$  BP) and climate-related hydrological changes. The fluvial response seems to be delayed by c. 400 years (transitional phase) which can be related to the gradual Late Glacial development of the vegetation cover and related changes in water discharge (more regular) and sediment supply (decreasing input).

Three levels of the boring Reinders were analyzed for macro botanical remains in order to collect material for AMS C-14 dates. These levels are 128-130 cm, 111-113 cm and 88-90 cm. We are still waiting for the results. Although a Lateglacial age was anticipated, the macro botanical assemblage did not seem to agree with this. The 128-130 cm level contained fruits of *Betula verrucosa* (15) besides fruits of *Betula pendula* (2). *Betula verrucosa* is a species, which is not normally found in deposits of Late Glacial age. The species intermingles in the vegetation only from the Preboreal onwards. Another species that argues against a Late Glacial age of the infill is the occurrence of *Alisma plantago aquatica*. Its present day NW European distribution is limited to south Sweden and south Finland and it doesn't seem to occur more north. An alternative interpretation and zonation of pollenrecord Reinders is depicted in fig.5c

Fig. 6a Cross section Bons A

This cross section is from the high-sinuosity meandering system. The palaeomeander is circa 200 m wide. The cross section is clearly asymmetric with the stoss side at the left. The fill is 2 to 2.5 m thick and consists of clay at the base overlain by organic material. Palaeodischarge calculations reveal that the palaeoNiers-Rhine discharge was c. 10 to 20 % of the present-day Rhine discharge, indicating that during the Late Glacial probably a more northerly course co-existed with the Niers-Rhine.

Fig. 6b: Pollen diagram Bons A

The lower part of the fill below 162 cm is clastic in nature and characterized by high *Pinus* values. In addition, some *Alnus* and *Carpinus* pollen is present and therefore it is likely that part of the *Pinus* pollen has been reworked. The presence of *Empetrum*, *Artemisia*, *Helianthemum* and *Pediastrum* indicates the (final phase of the) Younger Dryas period (c. 10,9-10,1 ka  $^{14}\text{C}$  BP). *Juniperus* attains maximum values towards the end of this zone and marks the transition to the Holocene. It is succeeded by an increase

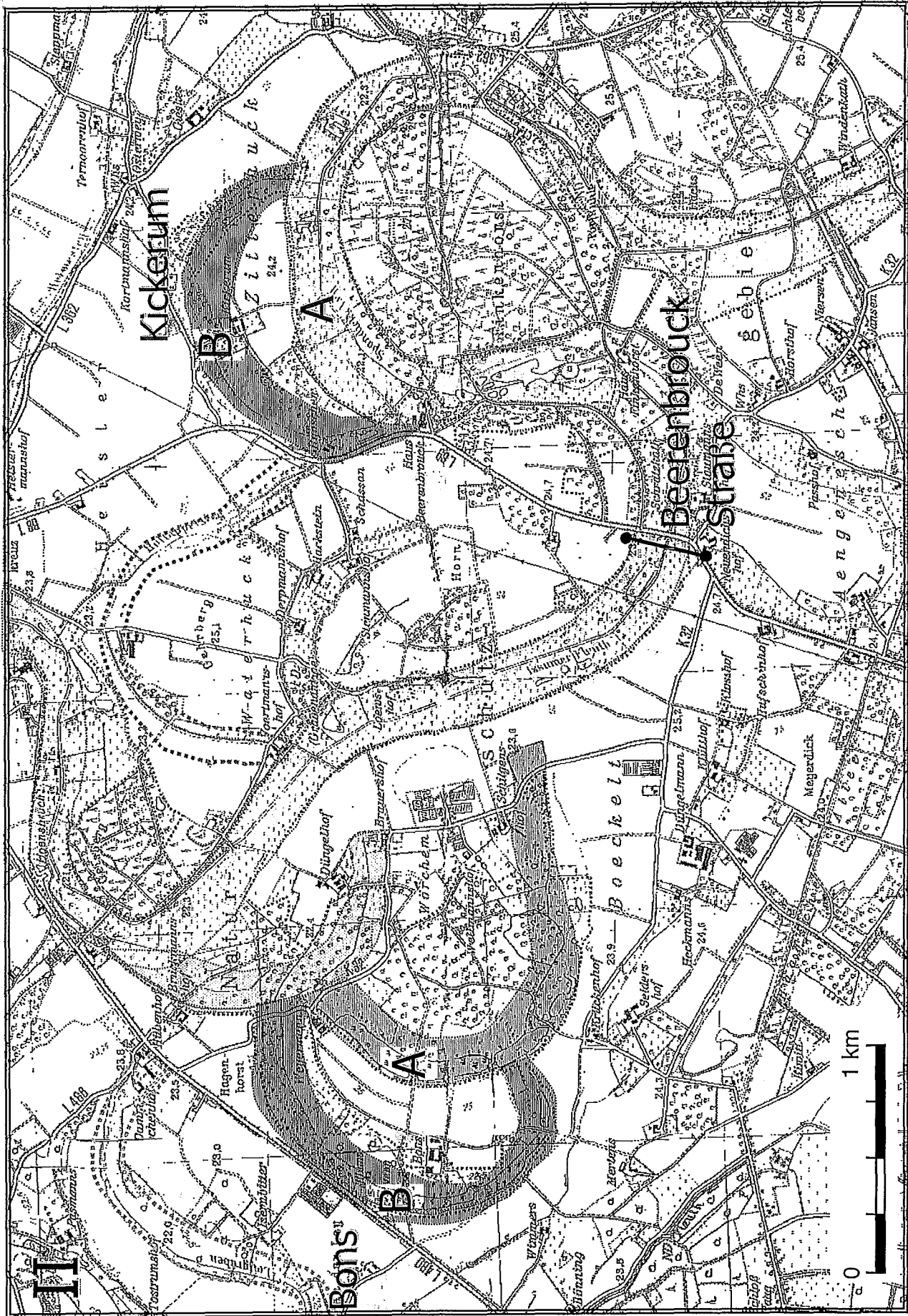


Fig. 6a

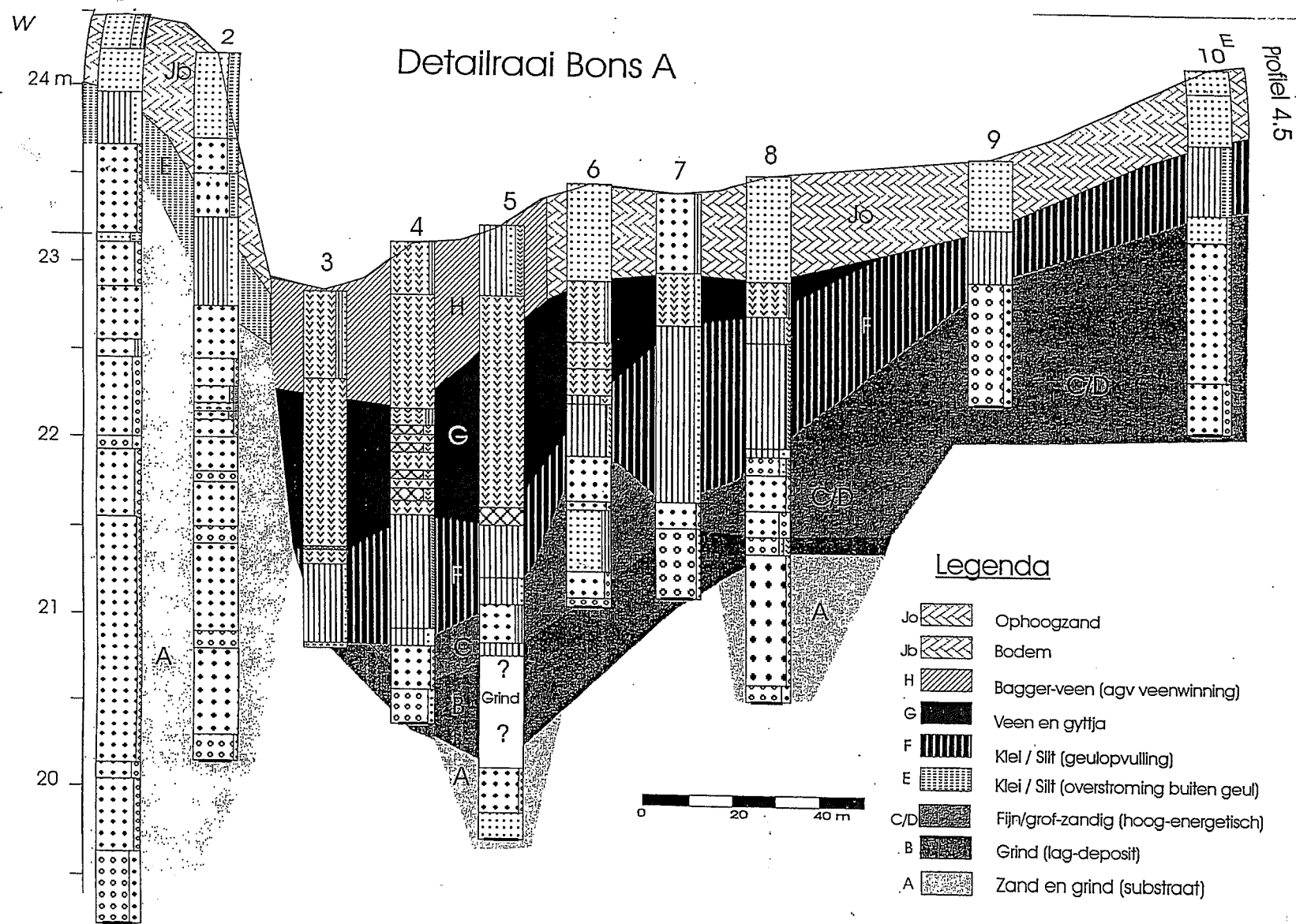
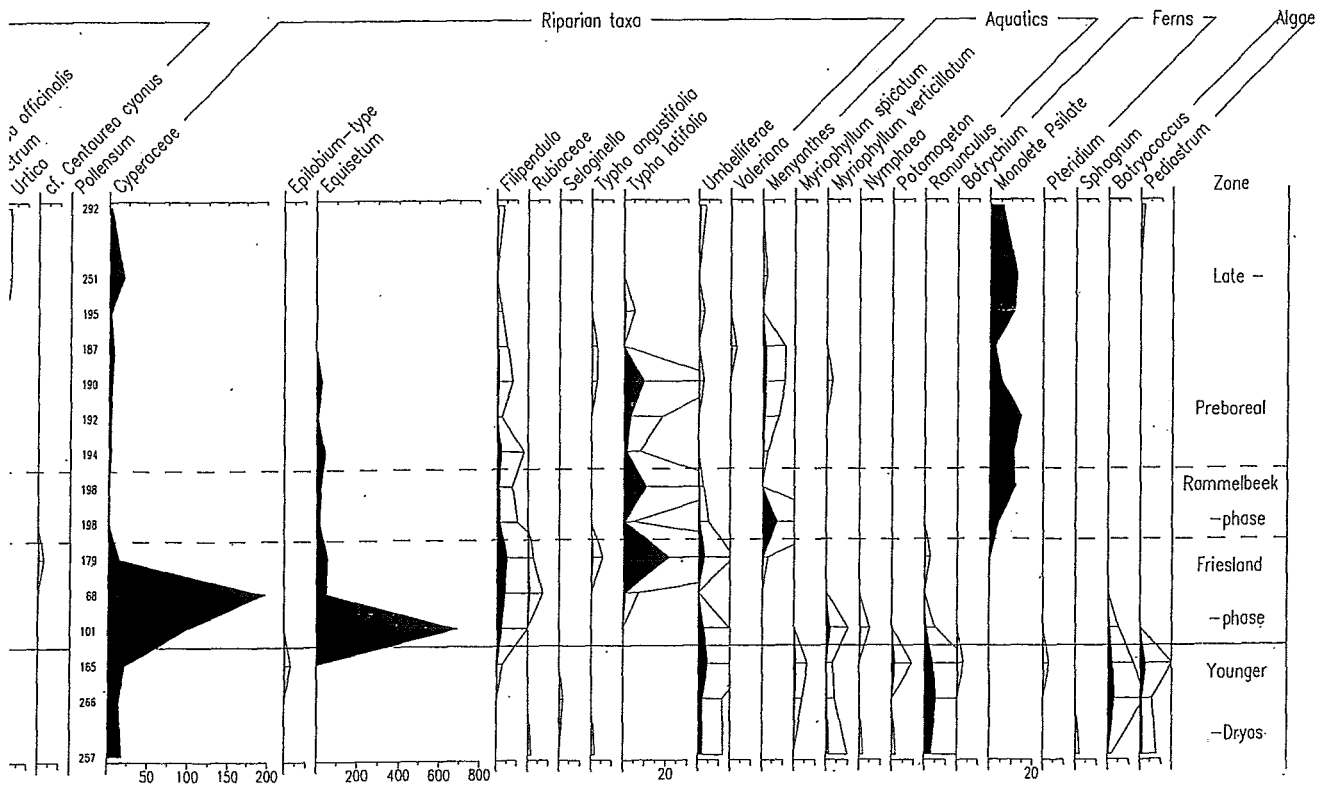
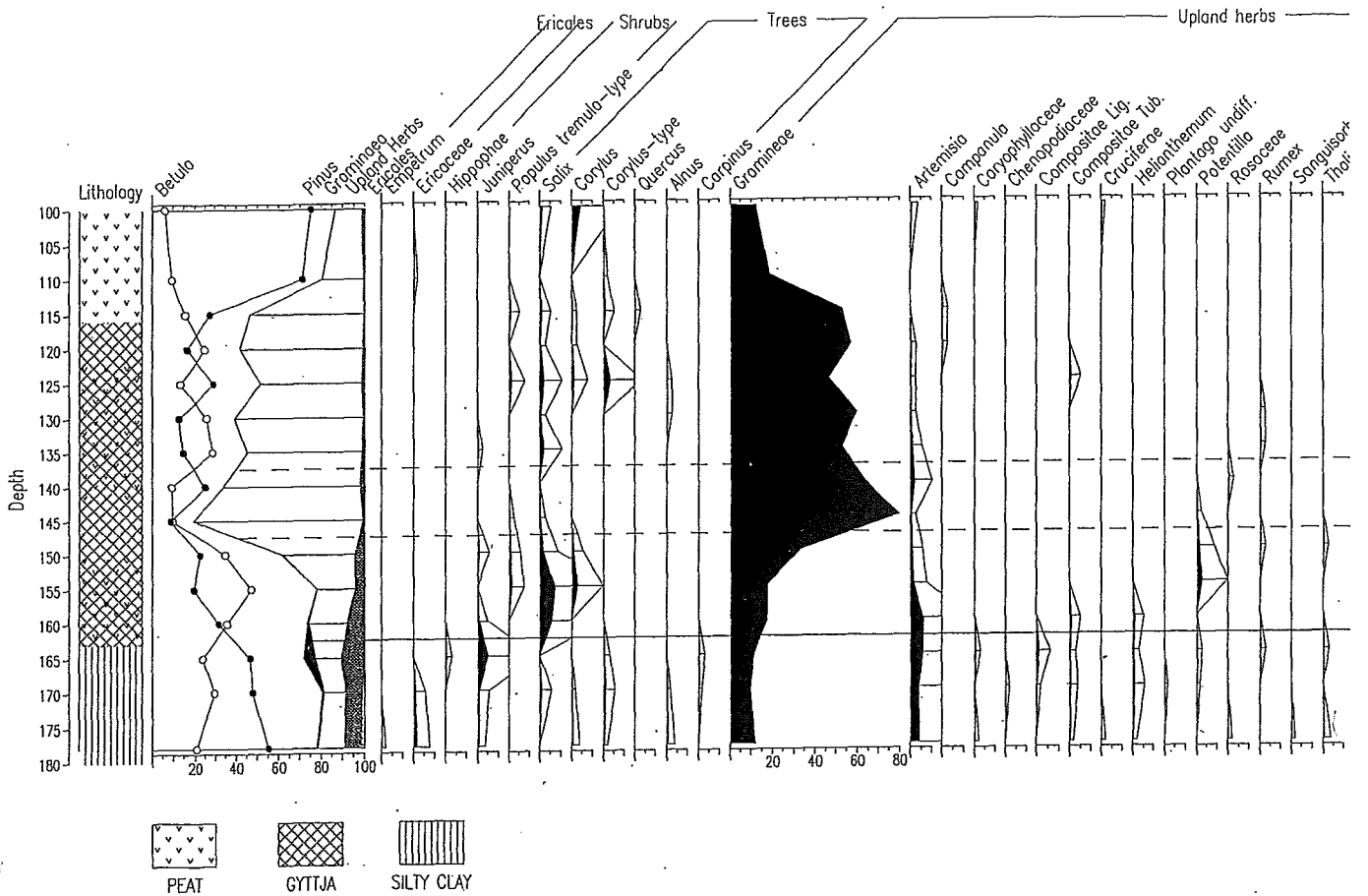




Fig. 6b



Analyses: M. Konert

of *Betula* that represents the Preboreal *Betula* phase (147-162 cm). The increase of *Filipendula* and *Typha latifolia* is also characteristic for the start of the Holocene. The Younger Dryas to Holocene boundary fully coincides with a change in lithology from clay to peat at 162 cm, indicating a change in the fluvial regime (see discussion). From 137-147 cm *Betula* has declined and Gramineae values reach a maximum. This zone is equivalent with the Rammelbeek phase (c. 9,9-9,7 ka  $^{14}\text{C}$  BP). Although the Gramineae values remain high, *Betula* shows an increase again at 137 cm, which is interpreted as the start of the late Preboreal *Betula* phase. The strong increase of *Pinus* at 112 cm is the start of the late late Preboreal *Pinus* phase (100-112 cm).

The lowermost spectra of the infill are from the Younger Dryas period. This biostratigraphical interpretation indicates that the Bons infill is older than the Beerenbrouck/Kickerum A infill which is also supported by the geomorphological evidence (fig. 2). This finding indicates that the Bons meander was abandoned during the Younger Dryas and that a meandering system was active in the Niers valley during or before the Younger Dryas stadial (Allerød).

Fig. 7a Cross section Beerenbrouckstrasse

The cross section is from the last generation of high-sinuosity meanders, formed just before the final abandonment of the Niers-Rhine valley (fig. 2). The fine-grained infill shows an asymmetric channel form with the stoss side at the left (south). The palaeomeander is circa 250 m wide and the fine-grained fill is c. 2.5 m thick. In contrast to older meander channels clay is only present at the flanks of the channel. In the deepest part of the channel the fill consists of calcareous gyttja changing upward into peat. Small dune fields occur in association with this last meander belt (see fig. 2), indicating deflation of temporarily dry channels or pointbar slopes, possibly related to increased discharge fluctuations.

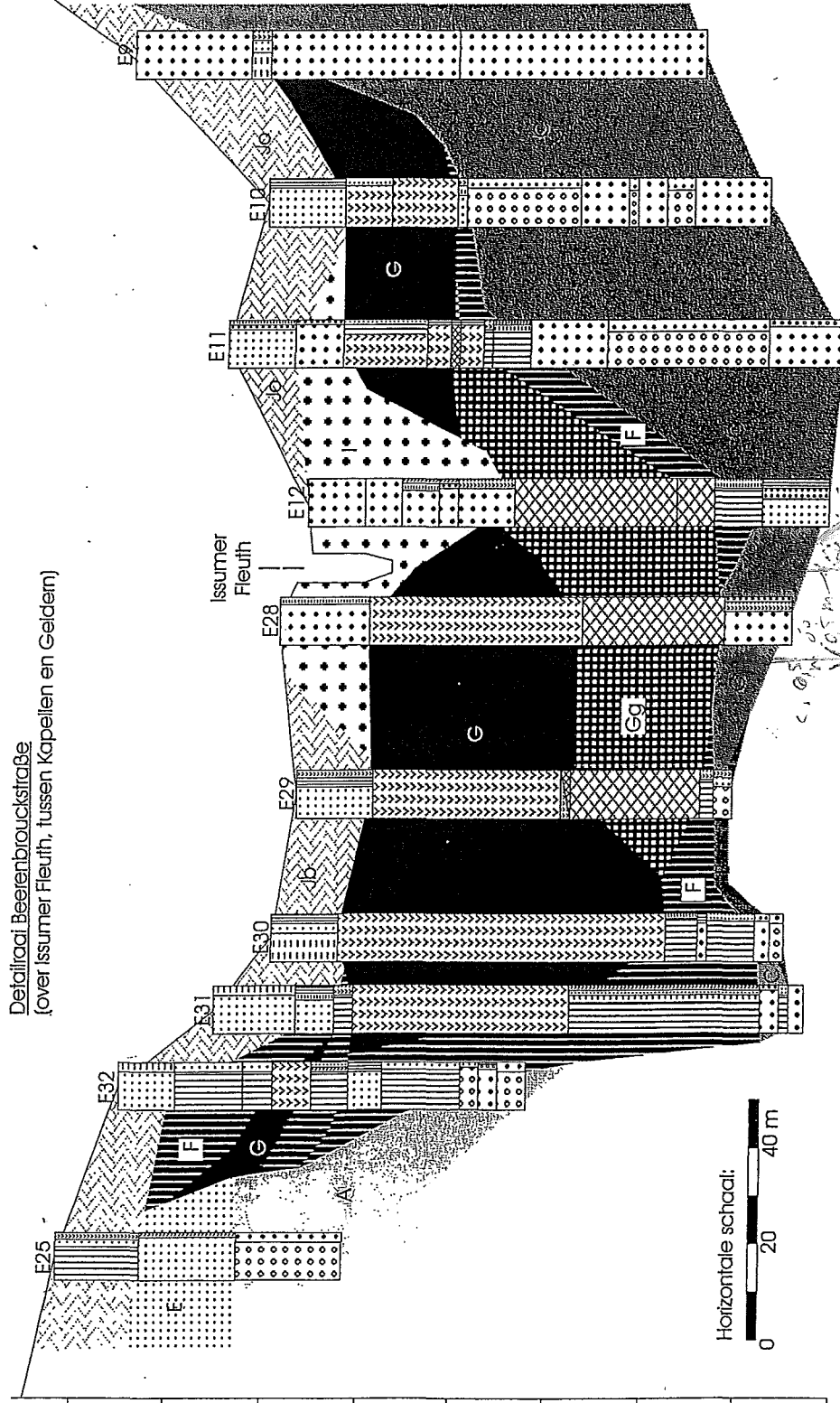
Fig. 7b Pollen diagram Kickerum A

Cross section Beerenbrouckstrasse has not been sampled for pollen analysis. Instead, cross section Kickerum A, located in the same meander channel, was analysed. The lower part, below 172 cm, of the diagram is characterized by *Pinus* and *Betula* and shows a strong dominance of the Gramineae. This zone is indicative for the early Preboreal Rammelbeek phase (c. 9,9-9,7 ka  $^{14}\text{C}$  BP). It could be argued, because of the low arboreal pollen values, that this zone is part of the Younger Dryas biozone. However, the absence of *Empetrum* and low value of *Juniperus* exclude a Younger Dryas age. The overlying zones are dominated by *Betula* (142-172 cm) and *Pinus* (117-142 cm) and are correlated with the late Preboreal *Betula* and *Pinus* phases. The upper part of the diagram, with increasing *Corylus*, and low *Quercus* and *Ulmus* values, is indicative for the start of the Boreal (c. 9,1 ka  $^{14}\text{C}$  BP).

The age of the basal fine-grained fill shows that the large-scale meandering Niers-Rhine system was abandoned at the Weichselian to Holocene boundary or in the very early Holocene. Therefore, the Niers-Rhine was still active during the Younger Dryas period. This contrasts with previous findings in which the final abandonment of the Niers-Rhine

Detailaal Beerenbrauckstraße  
 (over Issumer Fleuth, tussen Kapellen en Geldern)

NNE



Legenda

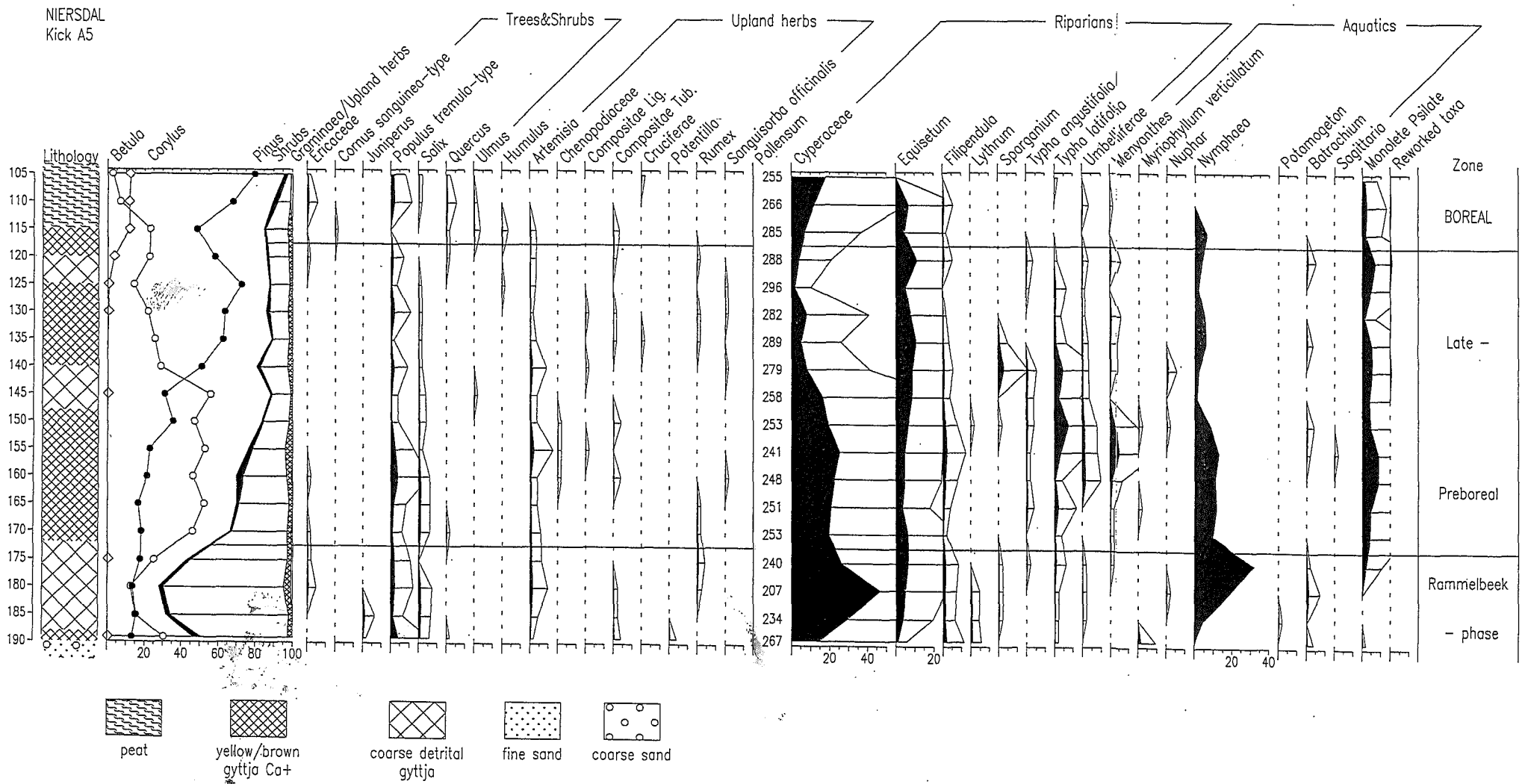
- |    |                              |
|----|------------------------------|
| Jo | Ophoogmatetaal/bouwvoor      |
| Jb | Bodem                        |
| I  | Zand (geulopvulling)         |
| G  | Veen                         |
| Gg | Gytifa                       |
| F  | Fijntastische geulopvulling  |
| E  | Zand (overstromingssediment) |
| C  | Grofkastische geulopvulling  |
| B  | Lag-deposit                  |
| A  | Substraat                    |

Horizontale schaal:



Fig. 7a

Fig. 7b



course was placed before the end of the Allerød (Verbraeck, 1984). Furthermore, it shows that the Niers-Rhine was a meandering system during the Younger Dryas, in contrast to the nearby Maas river (Kasse et al., 1995).

Stop Ottersum: underfit Niers

The present day brooks of the Issumer Fleuth in the east, the Niers (draining the older terrace surfaces) from the south and Kendel in the west follow the former meandering courses of the Late Glacial Niers-Rhine. They can be described as underfit streams with smaller meander wavelength and amplitude in comparison to the Late Glacial system.

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Tabel 1:

Comparison between the biostratigraphical sub-division of the Lateglacial and Early Holocene in The Netherlands and parts of north-western Germany.

| age<br>BP    | Biostratigraphy<br>Netherlands (Hoek, 1997) | Biostratigraphy north-western Germany<br>(Menke, 1985; Behre, 1996) |
|--------------|---|---|
| 9,150 -----  | 5   | Late Preboreal  |
|              |   | Boreal  |
| 9,500 -----  | 4c  |   |
|              |   | Präboreal c   |
| 9,750 -----  | 4b  | Early Preboreal   |
|              |   | Präboreal b   |
| 9,950 -----  | 4a  |   |
|              |   | Präboreal a   |
| 10,150 ----- | 3b  |   |
| 10,550 ----- |   | Late Dryas  |
|              | 3a  | Jüngere Dryas   |
| 10,950 ----- | 2b  |   |
|              |   | Alleröd   |
| 11,250 ----- | 2a2   | Allerød   |
|              |   | Mitteler Dryas  |
| 11,500 ----- | 2a1   |   |
|              |   | Bölling   |
| 11,900 ----- | 1c  | Earlier Dryas   |
|              |   | Älteste Dryas   |
| 12,100 ----- | 1b  | Bølling   |
| 12,450 ----- | 1a  | Earliest Dryas  |
|              |   | Meiendorf   |
| 12,900 ----- | LP  | Late Pleniglacial   |
|              |   | Pleniglazial  |
|              |   | Artemisia rise  |

Fig. 8

