

# THE EVOLUTION OF THE FLUVIAL AREA IN THE WESTERN PART OF THE NETHERLANDS FROM 1000-1300 AD<sup>1</sup>

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## ABSTRACT

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The Dutch fluvial area changed drastically during the period 1000-1300 AD, mainly due to human influence. Four topics are discussed:

1. On the basis of new radiocarbon datings and calculations of the rate of sedimentation it is concluded that the River Lek came into existence about 2000 years ago;
2. The silting up of the Kromme Rijn near Wijk bij Duurstede did not occur before the second half of the eleventh century. A dam was constructed in the river in 1122 AD;
3. The present rivers have a steeper gradient than recently abandoned meander belts. Changes in gradient are shown to be complex and not necessarily related to changes that occurred between 1000 and 1300 AD.
4. During the period 1000-1300 AD the main rivers were embanked; smaller branches were dammed. The embankments made it possible to reclaim the low-lying peat areas.

## INTRODUCTION

The fluvial area in the western part of The Netherlands, roughly west of a line drawn from Rhenen to Oss, dramatically changed in appearance during the period 1000-1300 AD.<sup>3</sup>

The main cause for this change was human activity: after the main rivers had been embanked, the low-lying backswamps with a peaty subsoil were reclaimed. These "cope"-reclamations (see the APPENDIX in BERENDSEN & ZAGWIJN, 1984, this volume p. xxx) resulted in a conspicuous pattern of parcelling that still is a striking characteristic of the peat areas in the western Netherlands.

Unfortunately, no written accounts exist describing how, where, why and when exactly these reclamations were carried out. Yet, historians (e.g. VAN DER LINDEN, 1955; DEKKER, 1983) were able to unravel part of the mystery by studying charters and documents. Geologists, geographers and soil-scientists

have studied possible changes in the drainage system (DEBOER & PONS, 1960; BERENDSEN, 1982), changes in the discharge of the rivers (PONS, 1953; 1957; GOTTSCHALK, 1971), and changes in gradient (VINK, 1926; 1954; PONS, 1957; BERENDSEN, 1982), while archaeologists studied periods of inhabitation (MODDERMAN, 1955; LOUWE KOIJMANS, 1974).

During the time preceding the Middle Ages, when man was rather dependent on the whims of nature, there seems to be a strong relationship between climatic changes (e.g. resulting in a higher discharge of the rivers, more frequent inundations, transgressions), changes in the drainage pattern and inhabitation, and human activity. Many authors therefore have tried to show the relationship of the factors mentioned above also for the period 1000-1300 AD, and a number of changes generally has been attributed to a common cause. Still, many problems remained unsolved because accurate datings (especially of geological events) often could not be obtained, and historical evidence often is too incomplete to permit anything more than speculative conclusions.

In the article attention will be restricted to some new evidence on four topics, that aroused much debate in the literature:

1. The age of the River Lek;
2. The silting up of the Kromme Rijn near Wijk bij Duurstede;

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<sup>3</sup> For a comparison of ages expressed in years BP, AD and BC see the Appendix in Berendsen & Zagwijn, 1984; this volume page 228.

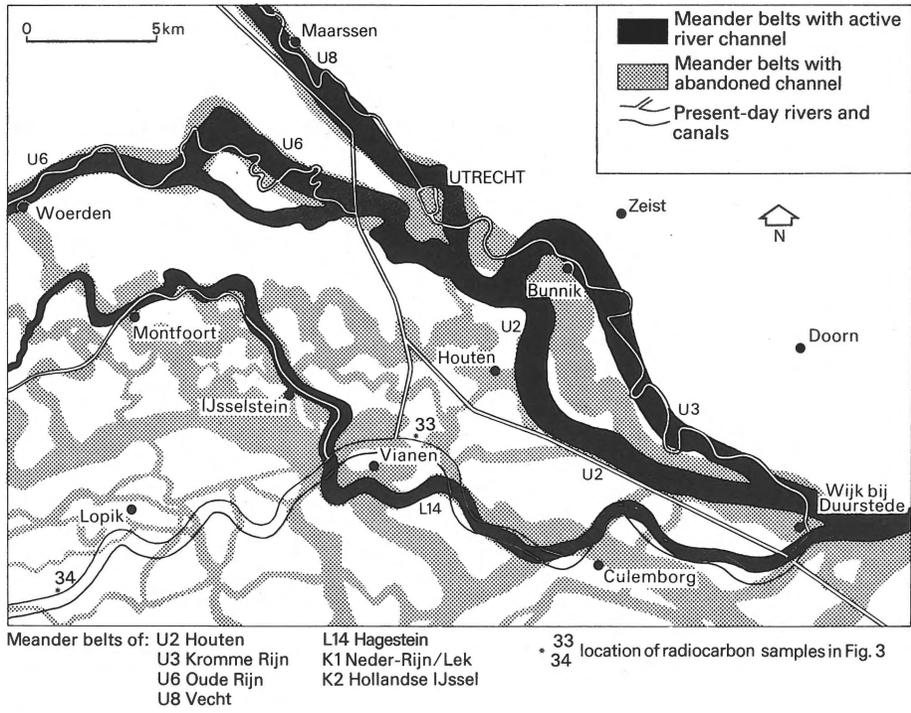


Fig. 1  
 Paleogeographic map of the drainage system, 2100 BP.

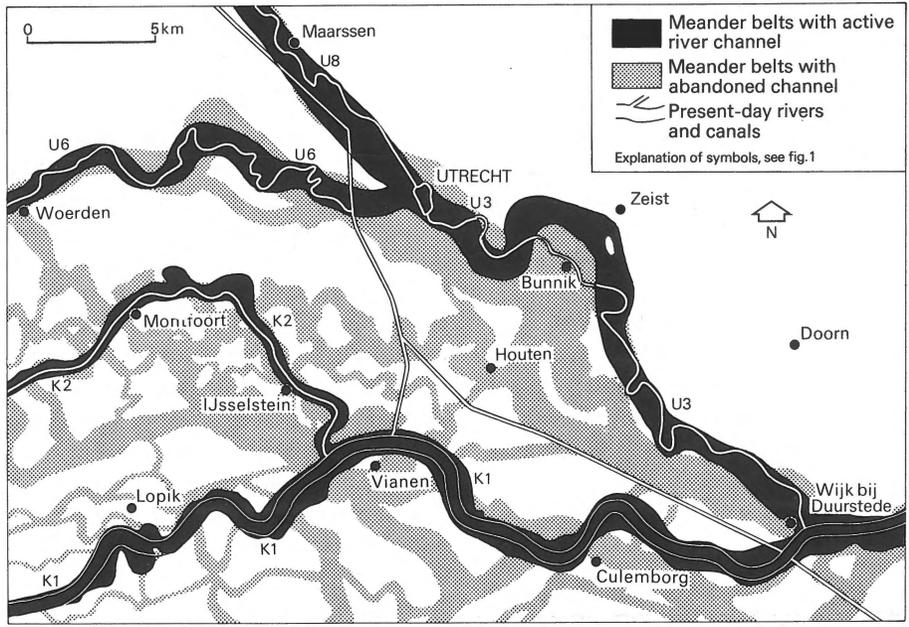


Fig. 2  
 Paleogeographic map of the drainage system, 1700 BP (250 AD).

3. Changes in gradient of the rivers;
4. Embankments, construction of dams in the lesser river branches, and the reclamation of the peat areas.

### THE AGE OF THE RIVER LEK

The question when the River Lek came into existence has been discussed by many authors.

VINK (1926, 1954) thought that the river existed since the Late-Weichselian but he was shown to be wrong; the geological map of The Netherlands scale 1:50.000, sheet 38 O and 39 W (VERBRAECK, 1970; 1984) clearly shows that the river cuts through a number of stream ridges of Atlantic and Subboreal age.

DE BOER & PONS (1960) thought that the Lek near Vianen came into existence as late as 800 AD, possibly even as late as the 10th century. This date has persisted for a long time. It was based on the following line of reasoning:

- a. The Lek cuts through the Hagestein stream ridge twice (L14 in Fig. 1). According to DE BOER & PONS (1960) the channel of the Hagestein stream ridge silted up around 900 AD; therefore the Lek must be younger.
- b. Archaeological finds of Roman times are not found along the river banks of the Lek.
- c. The origin of the Lek may be linked with the Carolingian-Ottonian period of transgression (800-1000 AD).
- d. Along the banks of the Lek crevasse-splays are found that are supposed to be synchronous with crevasse-splays near Nijmegen, dated by PONS (1953) to 1000-1200 AD, by PONS (1957) to 800-900 AD.

The arguments of DE BOER & PONS (1960) are not convincing, for the following reasons.

- a. The date of the silting up of the channel of the Hagestein stream ridge is highly inaccurate. It is based solely on the occurrence of archaeological finds along the former river channel. BERENDSEN (1982, p. 144) showed that residual channels may contain water for a long time after channels have been cut off; the occurrence of archaeological finds along such a residual channel therefore does not give an accurate dating of the final stage of the actual river channel.
- b. BERENDSEN (1982, p. 135) further showed that a lack of Roman artifacts does not necessarily mean that the River Lek did not exist during Roman times. It is feasible that artifacts have disappeared through later erosion, or that the river was still small during Roman times, and its natural levees were not yet high enough to attract inhabitation.
- c. GOTTSCHALK (1971, p. 18) showed that practically all literature on 9th century storm surges (e.g. VAN HENGST, 1898, p. 3) is based on an unreliable account written by John à Leydis (ca. 1490). GOTTSCHALK (1971) therefore denied the existence of the Carolingian-Ottonian period of transgression.
- d. The dating of the crevasse-splays has been carried out in an entirely different area; in addition the dating is not precise.

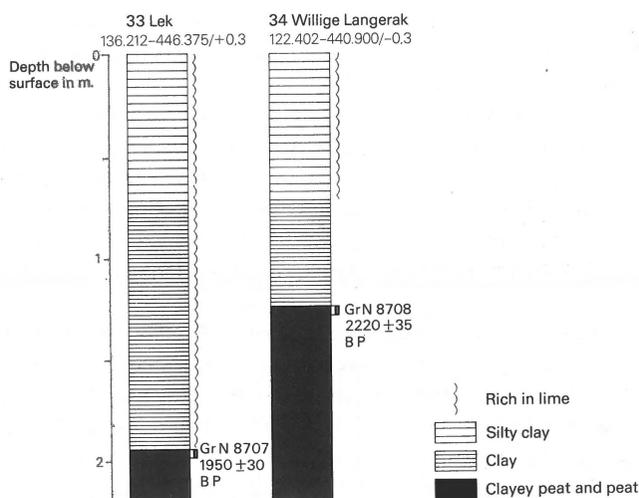


Fig. 3  
Radiocarbon datings of the River Lek.

Crevasse-splays generally do not occur in the early stage of the existence of a river (BERENDSEN 1982, p. 195).

In conclusion, it can be stated that the arguments used by DE BOER & PONS (1960) for dating the River Lek are not sound.

HENDERIKX (1980, p. 234) showed that the dividing of the River Rhine near "Dorestad" (Wijk bij Duurstede) into two branches is mentioned in a charter of Charlemagne in 777 AD. He concluded on historical grounds that the present course of the River Lek probably came into existence well before 750 AD.

BERENDSEN (1982) published paleogeographic maps (Figs. 1 and 2) which show that the present course of the River Lek existed as early as 250 AD (Roman Period). His dating of the River Lek is based upon two radiocarbon ages of peat samples that were taken 14 kilometres apart. Sample localities are indicated in Fig. 1. The two datings differ only slightly (Fig. 3).

The peat samples were taken underneath the top layers of heavy clay and silty clay that is rich in lime. The thickness of the top layers decreases laterally, while the clay content increases. The lime content also decreases laterally. This means, that the top layers must have been deposited by the River Lek.

Two possibilities should be considered:

1. Sedimentation of clay started immediately after peat growth stopped. Since the transition from peat to clay occurs gradually (but within 10 cm) it is likely that no erosion took place and thus that there is no hiatus. In this case it must be concluded that sedimentation by the River Lek started about 2000 BP.
2. Sedimentation of clay did not start immediately after peat growth stopped, in other words, there would be a hiatus. In that case the age of the River Lek can be estimated by

comparing its rate of sedimentation to the rate of sedimentation in other well-known and well-dated layers in comparable environments in the same area.

In Fig. 4 average rates of sedimentation for various environments in the central Netherlands (e.g. river-basins, crevasse-splays) have been plotted in a frequency histogram. In the river-basins the average rate of sedimentation varies from 0.4 to 1.5 mm/y, in the crevasse-splays from 1.6 to 3.8 mm/y, and in the bottomlands (Dutch: uiterwaarden) from about 3 to 5 mm/y.

The layers of clay in Fig. 3 are basin-clays, deposited near the natural levees; therefore a rate of sedimentation between 1 and 1.5 mm/y may be expected. The arrows at the top of Fig. 4 indicate the computed rate of sedimentation for the top layers of clay, with various assumed ages of the River Lek. It is clear that it should be concluded that sedimentation by the River Lek must have started only shortly after the beginning of the Christian Era, and that the date of DE BOER & PONS (1960) of about 800 AD cannot be correct, because it would imply a rate of sedimentation that is simply impossible.

The sections of Fig. 3 show that the top layers of clay are somewhat more silty. This suggests that discharge increased after some time. If we accept that sedimentation in the river basins was stopped in 1100 AD by the embankment of the river, then there are 1370 years available for the deposition of a 125 cm thick layer of clay in section "Willige Langerak" (Fig. 3). If the rate of sedimentation has been uniform, the age of the base of the silty clay is 330 AD; if the rate of sedimentation of the silty clay is twice that of the heavy clay,

the age of the base of the silty clay is 710 AD.

It may be concluded that the River Lek came into existence at the beginning of the Christian Era; discharge increased between 300 and 700 AD.

The radiocarbon datings of the River Lek virtually coincide with datings of the Hollandse IJssel downstream of Montfoort (GrN 7577, 1805 ± 50 BP) and the Gelderse IJssel (GrN 5491, 2000 ± BP). Apparently a major change in the drainage system occurred around the beginning of the Christian Era.

#### MIGRATION OF A MEANDER OF THE KROMME RIJN

Fig. 5 shows the meander belt of the Kromme Rijn near Wijk bij Duurstede, with some residual channels. The beginning of peat formation in channel 1 has been dated at 420 AD (BERENDSEN, 1982). During Carolingian times the Kromme Rijn followed the course of channel 2. Perpendicular to this channel landing-stages have been built into the river over a length of 200 m. Twenty-four poles of these landing-stages were dated by the radiocarbon method to the period 620-930 AD (MOOK, 1978; the radiocarbon dates were published by LANTING & MOOK, 1977, p. 197). After 930 AD the river shifted its course 500 m in a northeasterly direction, and reached its present position in 1122 AD, when the Kromme Rijn was dammed (DEKKER, 1980). In 1976 a trench was dug by the Rijksdienst voor het Oudheidkundig Bodemonderzoek (ROB) from the Carolingian channel to the present course

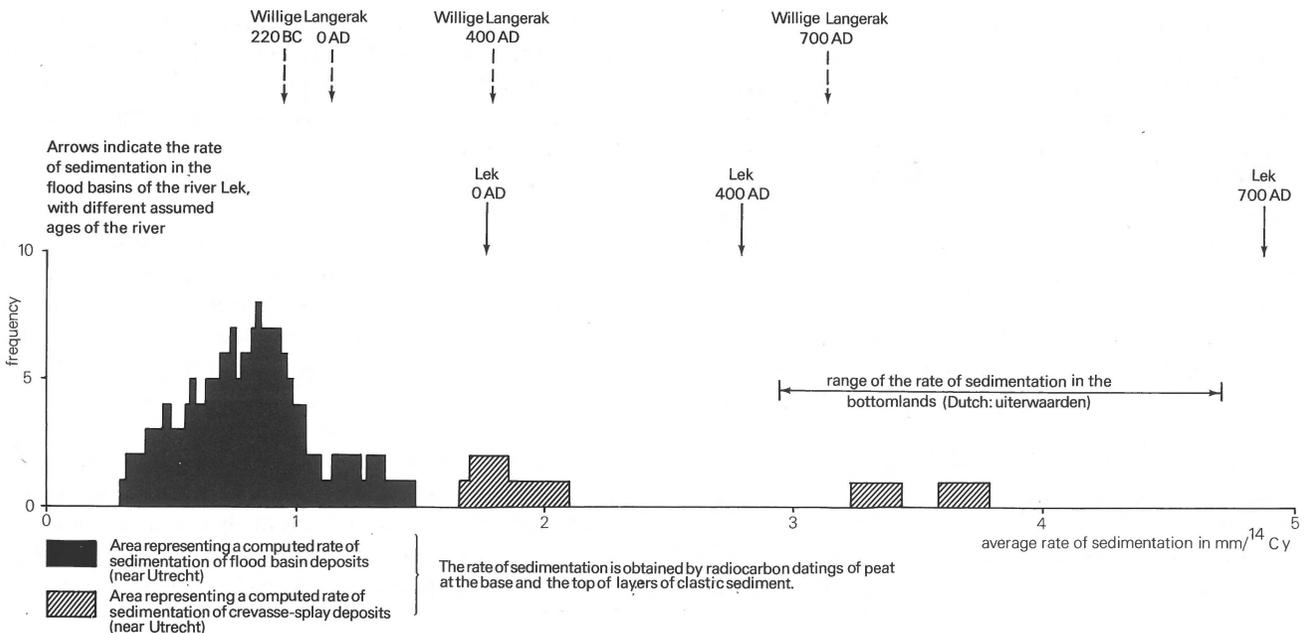


Fig. 4 Average rate of sedimentation in the river-clay area near Utrecht, The Netherlands, and calculated rates of sedimentation of the River Lek, for various ages of the river.

(Fig. 5). The trench cuts through a point bar, formed between 930 and 1122, consisting of coarse sand rich in gravel, that contains many sherds dating from the 10th and 11th century.

The gravel in the point bar is somewhat more rounded and the percentage of quartz grains is somewhat higher than the average of the deposits in the Betuwe Formation. Some gravel of Scandinavian origin was found. Therefore it is concluded that part of the gravel has been eroded from nearby ice-pushed ridges and sandur plains (BERENDSEN, 1982).

DEKKER (1980, p. 251) showed that toll was paid in "Dorestad" (Wijk bij Duurstede) as late as 1057 AD. Obviously silting up started in the second half of the 11th century. This natural process of silting up of the Kromme Rijn (VINK, 1954) was followed by the damming of the river in 1122 AD (DEKKER, 1980).

The construction of the dam practically coincided with the reclamation of the peat area of Langbroek (north of Wijk bij Duurstede). The silting up and damming of the Kromme Rijn finally caused the closing off of the estuary near Katwijk and not the other way around as suggested by some authors (e.g. VAN DER MEER, 1952).

#### CHANGES IN GRADIENT OF THE RIVERS

The gradient of the Nederrijn-Lek at average water level has a constant value of about 10.5 cm/km from the German border to Culemborg. West of Culemborg the gradient decreases as a result of the tidal influence.

The gradient varies with the water level: the higher the

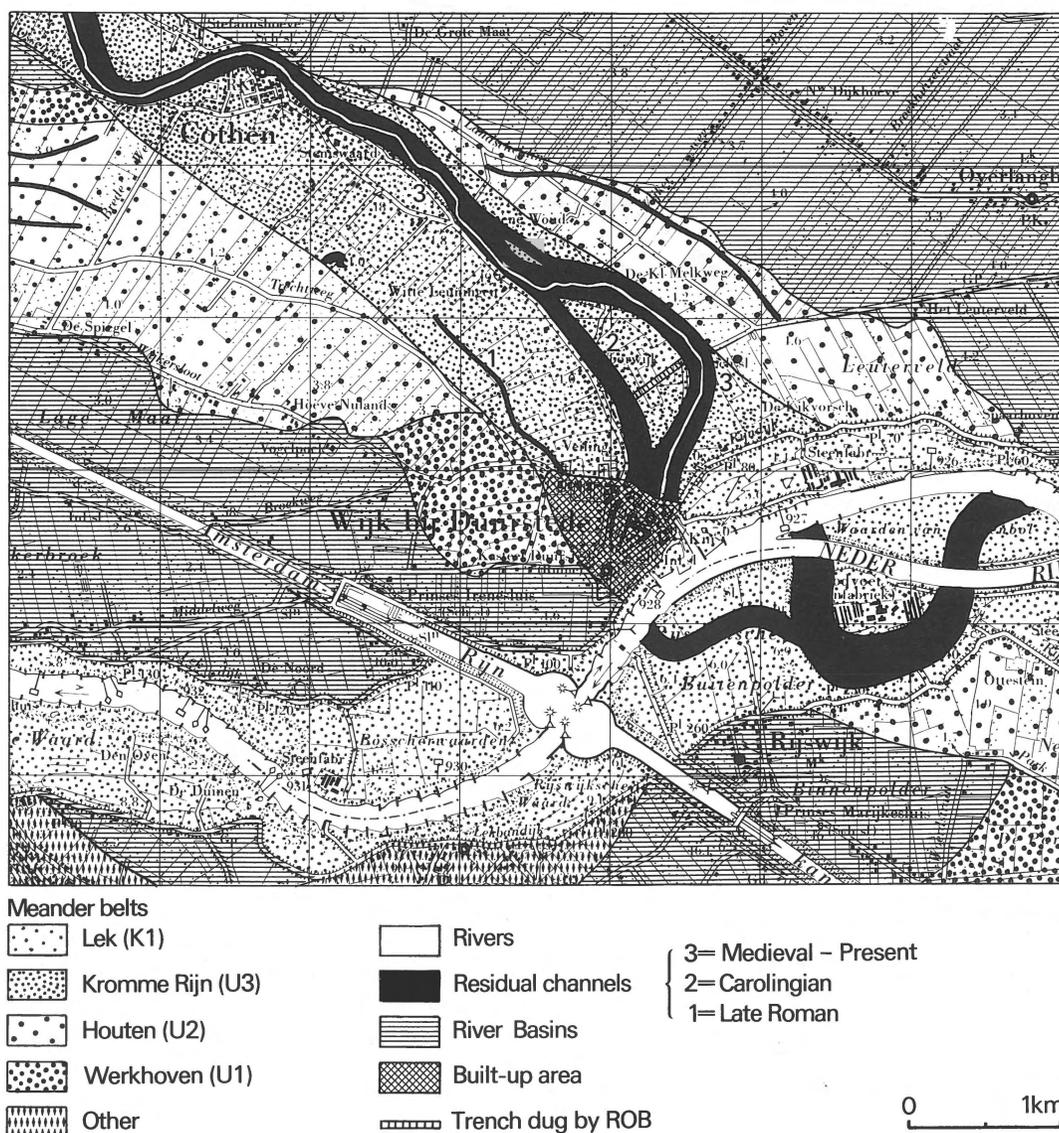


Fig. 5  
Meander belts and residual channels near Wijk bij Duurstede.

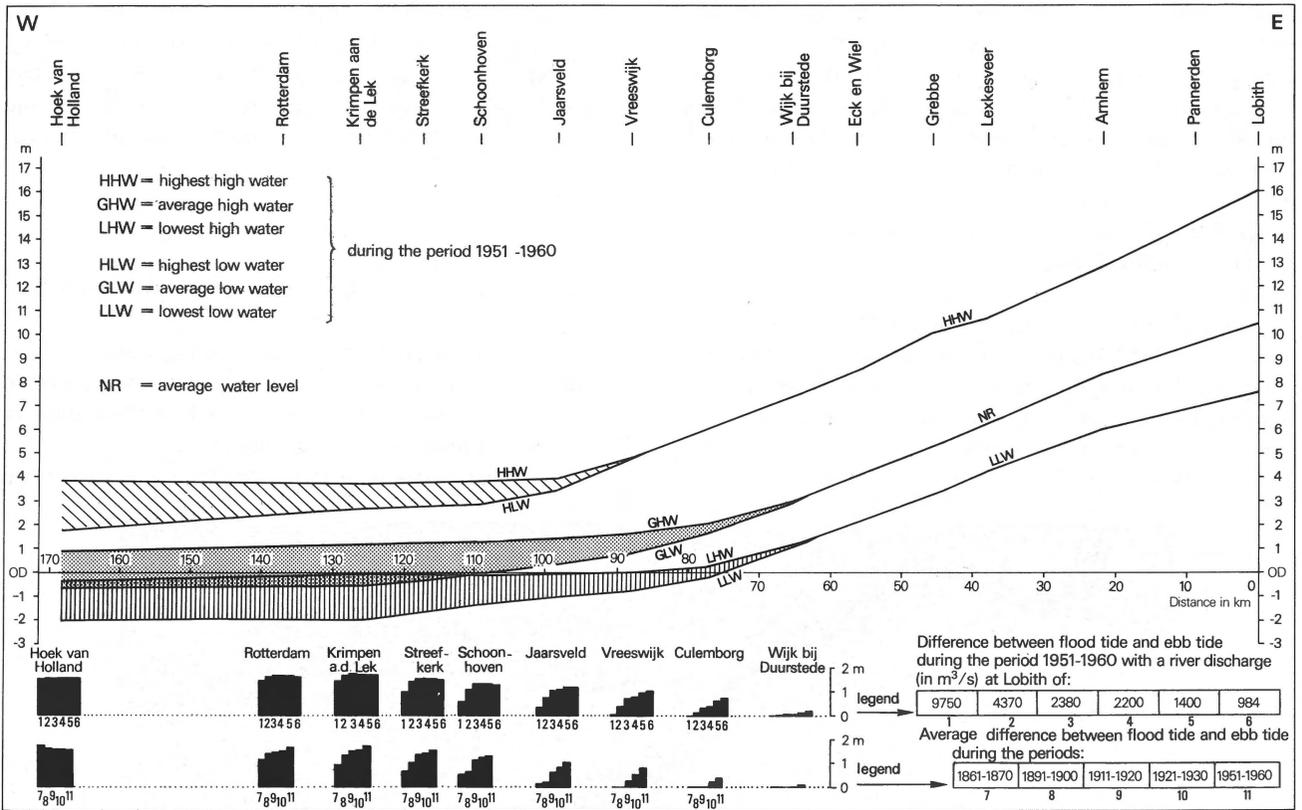


Fig. 6 Water level and tidewater on the Nederrijn-Lek. After measurements of Rijkswaterstaat (1964). OD = (Dutch) Ordnance Datum = NAP.

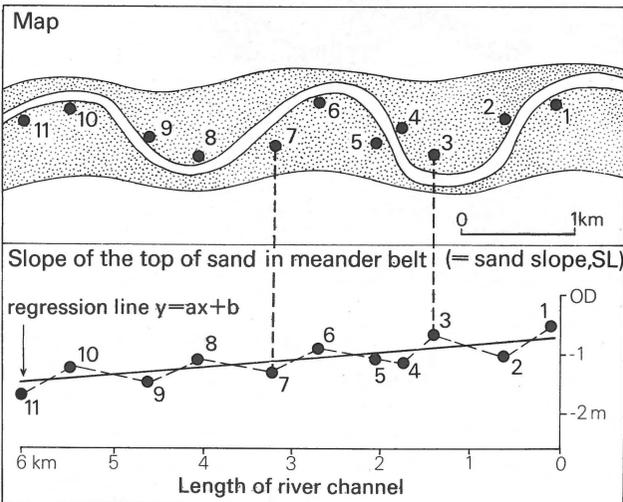
discharge, the steeper the gradient. In the lower reaches with tidal influence the gradient changes also with the tides: the gradient is steeper during ebb tide. This variation, however, is smaller than the variation in gradient caused by differences in discharge. The average water level of the river is now 1 m lower than a hundred years ago, as a result of the widening

and deepening of the Nieuwe Waterweg and dredging in the river (RIJKSWATERSTAAT, 1961; 1964). This causes tidal influence to reach farther upstream (Fig. 6).

To compare the gradient of recent rivers with fossil meander belts BERENDSEN (1982) introduced the term "Sand Slope", i.e. the slope of the top of the sand in a meander belt. To construct the "sand slope" of a meander belt, the highest level of sand in cross sections is plotted against distance, measured along the (fossil) river channel (Fig. 7). The "sand slope" (SL) is then obtained by line fitting (see BERENDSEN, 1982).

Points with the highest sand levels are located on point bars, where the river turns sharply. In straight stretches and in the reaches between two meanders the sand is found at a lower level, as a result of a weaker helical flow.

The sand slope shows the (former) direction of flow of a river in the meander belt. It was shown by BERENDSEN(1982) that if the sand slope of several meander belts in the perimarine area is plotted in a diagram, the lowest line in the diagram represents the oldest meander belt. Moreover, the oldest meander belt has the steepest gradient. Therefore, the sand slopes may be used to obtain relative datings of meander belts.



● Highest occurrence of sand in a cross section  
 Fig. 7 Construction of the "sand slope" of a meander belt.

Fig. 8 shows the sand slope (SL) of several meander belts near Utrecht. It may be concluded that:

- a. the gradient of the meander belts decreases westward;

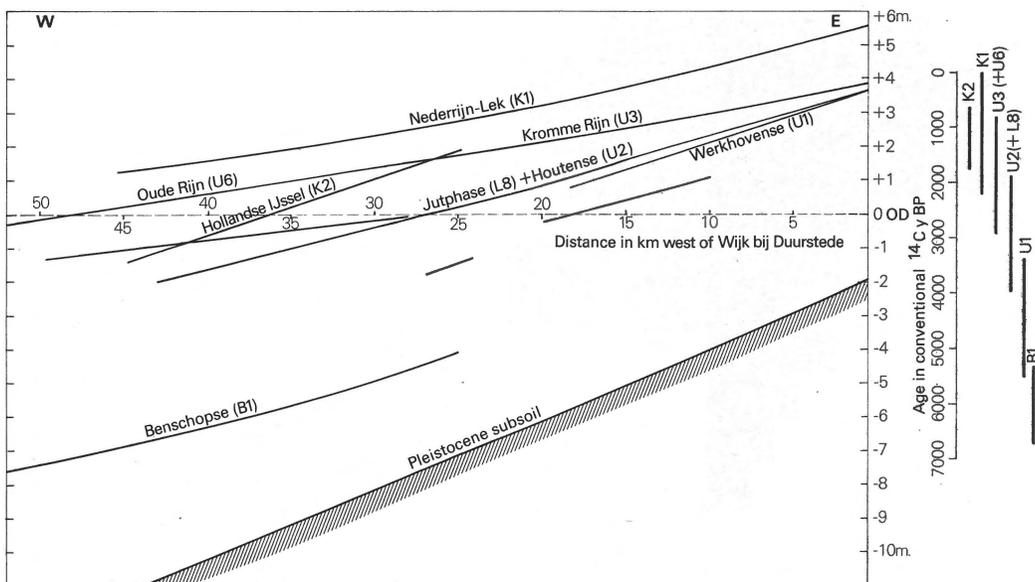


Fig. 8  
Slope of the top of the sand in various meander belts near Utrecht, The Netherlands.

- b. the SL of younger meander belts lies at a higher level, than the SL of older meander belts;
- c. the gradient of younger meander belts generally is less steep than the gradient of older meander belts
- d. the present rivers (Hollandse IJssel and Lek) have a steeper SL than the youngest abandoned meander belts.

The last conclusion is explained by a combination of the following factors:

1. The position of the SL is determined largely by high water level. In the tidal area flood tide diminishes the stream velocity, causing sedimentation of sand in the channel instead of on point bars. Therefore the gradient of the river (at high water level) and the SL diverge westward (downstream). Since the tidal influence presumably was also felt in now abandoned meander belts, a difference in sand slope between recent and abandoned meander belts might be the result of an increased tidal influence, as assumed by GOTTSCHALK (1975, p. 303) for the River Waal after 1421 AD. However, the increase of the tidal influence after 1860 AD (Fig. 6) probably did not affect the SL, because no new point bars were formed since then.
2. The channel deposits of the Hollandse IJssel and Lek are not founded in the sandy Pleistocene subsoil. Compaction of underlying layers of peat generally increases westward, and may be responsible for a steeper gradient of the SL.
3. Sinuosity decreased by about 15% by man-made meander cut-offs. In calculating the gradient of the SL the distance is measured along the present river channel, which is about 15% shorter. However, even after correction, the SL remains "too steep".
4. Embankments and dredging may have influenced the gradient, these influences, however, are hard to quantify.

5. In many places the top layers of the bottomlands (Dutch: uiterwaarden) have been removed for brick making, causing the sand depth to vary greatly. Still, the effect on the SL must be considered small, since the correlation coefficient of the regression line for the River Lek ( $r = 0,96$ ) is extremely good.

In conclusion, it appears that the Hollandse IJssel and Lek rivers have a SL that is too steep, in comparison with recently abandoned meander belts. This may be explained by an increase in tidal influence in the southwestern part of The Netherlands after 1000 AD when the rivers were embanked. However, many other factors may be involved that are not necessarily related to the period 1000-1300 AD.

#### EMBANKMENTS, CONSTRUCTION OF DAMS AND RECLAMATIONS

A large part of the low-lying peat areas in the western Netherlands has been reclaimed during the period 1000-1300 AD, by a very conspicuous pattern of parcelling called "cope-reclamations". The 10th century was a period with relatively few river floodings (GOTTSCHALK, 1971). Dendrochronological research (HOLLSTEIN, 1965) showed that during this period tree-rings of oaks in northern Germany are relatively narrow, probably indicating dry spring and summer seasons. It can be concluded, that even if political and economic circumstances constituted the main reasons for the reclamation of the peat areas, climatic conditions appear to have been favourable also.

The earliest cope-reclamations were carried out around 1000 AD, in the relatively high Sphagnum-peat areas in the western part of Holland. These peat areas most likely were reclaimed before dikes were constructed (VAN DER LINDEN,

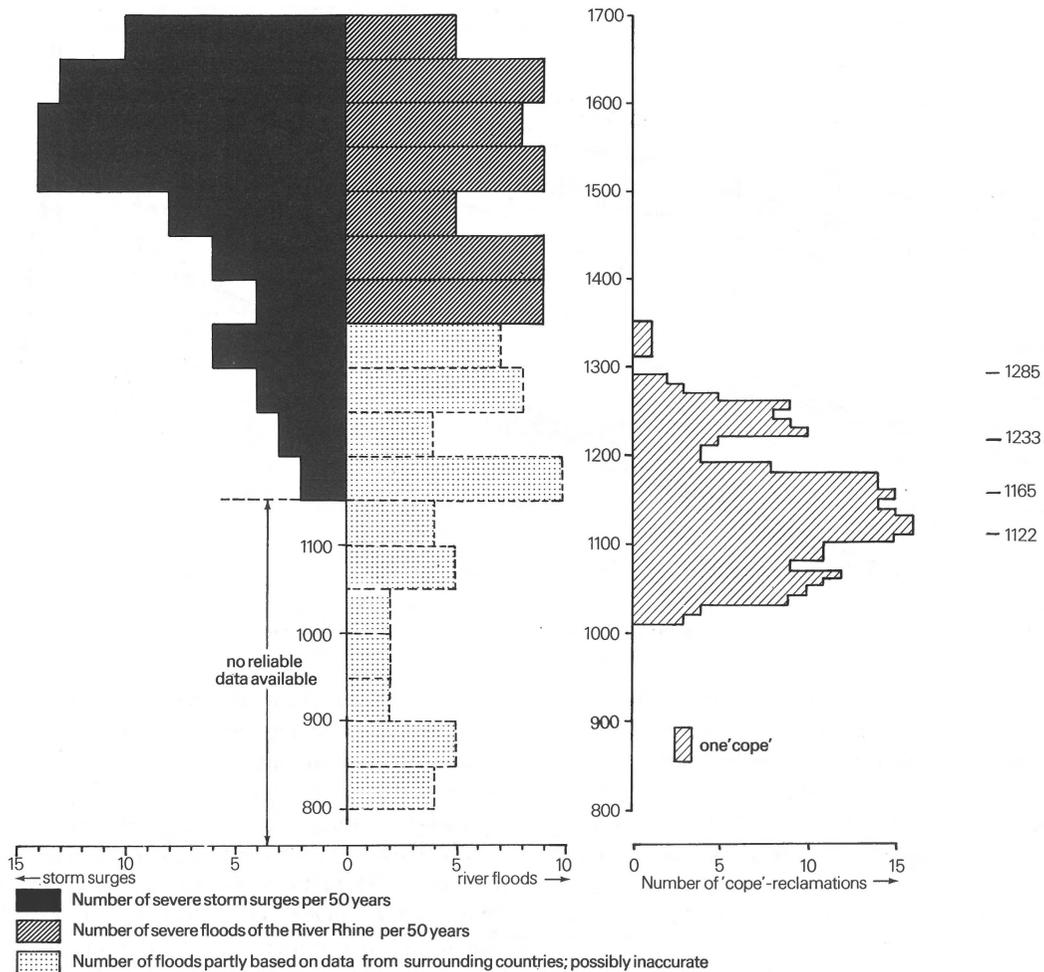


Fig. 9  
Frequency histograms of storm surges, river floods and "cope"-reclamations in The Netherlands. Based on Gottschalk (1971, 1975, 1977) and Van der Linden (1955).

1955). The reclamation activities gradually shifted from west to east. In the 12th century the low-lying wood- and reed/sedge peat areas near Utrecht were reclaimed. To make these reclamations a success, dikes had to be built first. Around 1150 AD all the main rivers in the area were embanked; at this time the number of reclamations carried out reached a maximum (Fig. 9).

The end of the 12th century shows a minimum in the reclamation activities in the western Netherlands (Fig. 9). The minimum may well be due to political or economic factors, but it is a striking fact that river flooding increased significantly during the second half of the 12th century (Fig. 9), especially around 1160 AD (GOTTSCHALK, 1971; LAMB, 1982). It seems likely that further reclamation was stopped, awaiting the construction of heavier dikes. After several serious floodings a heavy dike was built along the River Lek in 1233 AD (GOTTSCHALK, 1971). After the dike was completed reclamation-activities increased again (Fig. 9 and Fig. 10).

It seems that there is also a relation between the construction of a dam in the Kromme Rijn near Wijk bij Duurstede in

1122 AD (DEKKER, 1980) and the cope-reclamations in the Kromme Rijn area and the area north of the Oude Rijn (Fig. 10), since these activities were carried out simultaneously.

An increasing number of river floods in the period 1265-1281 finally led to the construction of a dam in the Hollandse IJssel (GOTTSCHALK, 1971).

The number of storm surges (Fig. 9) seems to have increased after 1200 AD. Until 1400 AD this increase can be apparent and may be explained by an increase in the number and quality of historical documents; the 16th century maximum, however, is real (GOTTSCHALK, 1975 p. 822). Fig. 9 does not suggest any relation between storm surges and river floods. Also, during the last century no such relation can be detected (RIJWSWATERSTAAT 1964). BERENDSEN (in press) showed that at present no relation can be proven between marine sedimentation and fluvial sedimentation for the last 5000 years, although such a relation has been presumed to exist by many authors (e.g. PONS, 1957; DE BOER & PONS, 1960 HAGEMAN, 1963; 1969; ZAGWIJN & VAN STAALDUINEN, 1975).

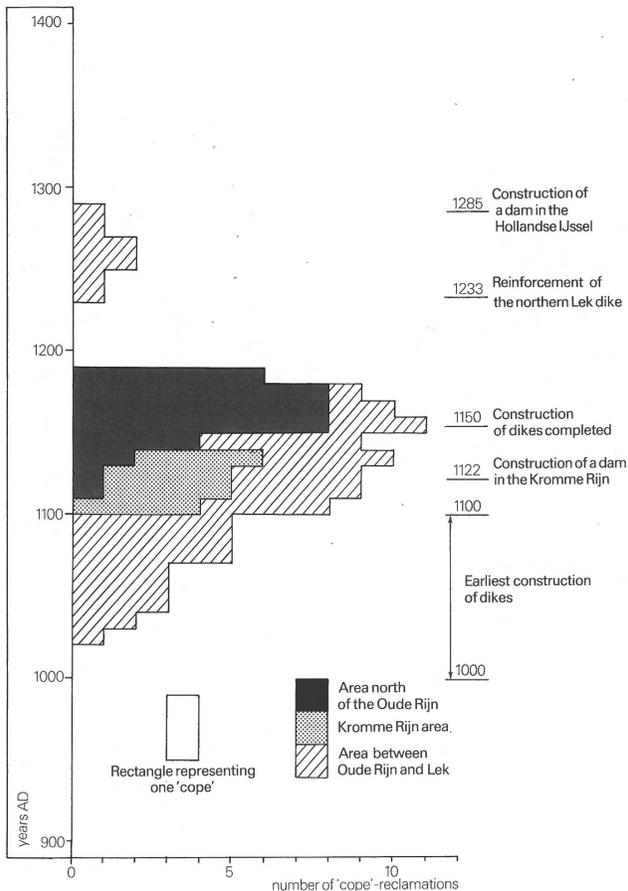


Fig. 10  
Frequency histogram of "cope"-reclamations near Utrecht (The Netherlands).

### CONCLUSIONS

1. In the central Netherlands no avulsion took place during the period 1000-1300 AD. The River Lek and the Hollandse IJssel downstream of Montfort came into existence in the beginning of the Christian Era.

2. The Kromme Rijn near Wijk bij Duurstede shifted its course considerably between 930 and 1122 AD. The silting up of the river near Wijk bij Duurstede did not occur before the second half of the 11th century.

3. The Rivers Lek and Hollandse IJssel seem to have a steeper "sand slope" than recently abandoned meander belts. This may be the result of an increase in tidal influence in the southwestern part of The Netherlands, but other factors that are not necessarily related to the period 1000-1300 AD may also be involved.

4. The cope-reclamations in the low-lying peat areas near Utrecht could be carried out only in combination with the construction of dikes. The reclamation-activity took place between 1000 and 1300 AD, and reached a minimum in the second half of the 12th century. At the same time river flooding increased, which necessitated the construction of heavier dikes.

5. On the basis of available data a relation between the occurrence of storm surges and river floods cannot be proven, neither for the present nor for the past.

### REFERENCES

- Berendsen, H. J. A. 1982 De genese van het landschap in het zuiden van de provincie Utrecht - Thesis, Utrecht. Utrechtse Geograf. Stud. 25: 256 pp.
- (in press) Quantitative analysis of radiocarbon dates of the perimarine area in the Netherlands - Geol. Mijnbouw
- Berendsen, H. J. A. & W. H. Zagwijn 1984 Some conclusions reached at the symposium on geological changes in the western Netherlands during the period 1000-1300 AD. In: Berendsen, H. J. A. & W. H. Zagwijn (eds): Geological changes in the western Netherlands during the period 1000-1300 AD - Geol. Mijnbouw 63: 225-229 (this issue).
- De Boer, T. A. & L. J. Pons 1960 Bodem en grasland in de Vijfheerenlanden - Versl. Landbouwk. Onderz. 66.6. Wageningen: xxx pp.
- Dekker, C. 1980 De dam bij Wijk. *Scrinium et scriptura* - Opstellen betreffende de Nederlandse geschiedenis aangeboden aan Prof. Dr. J. L. van der Gouw, bij zijn afscheid als buitengewoon hoogleraar in de archiefwetenschap en in de paleografie van de veertiende tot de zeventiende eeuw aan de Universiteit van Amsterdam. Erven van der Kamp (Groningen): 248-266.
- 1983 Het Kromme Rijngebied in de Middeleeuwen - *Stichtse Histor. Rks* 9, De Walburg Pers (Zutphen): 672 pp.
- Gottschalk, M. K. E. 1971 Stormvloed en rivieroverstromingen in Nederland, 1: de periode vóór 1400 - Van Gorcum (Assen): 581 pp.
- 1975 Stormvloed en rivieroverstromingen in Nederland, 2: de periode 1400-1600 - Van Gorcum (Assen): 896 pp.
- 1977 Stormvloed en rivieroverstromingen in Nederland, 3: de periode 1600-1700 - Van Gorcum (Assen, Amsterdam): 474 pp.
- Hageman, B. P. 1963 De profieltype-legenda van de geologische kaart voor het zeelei- en rivierengebied - *Tijdsch. Kon. Ned. Aardrijksk. Gen.* 80: 217-229.
- 1969 Development of the Western Part of The Netherlands During the Holocene - *Geol. Mijnbouw* 48: 373-388.
- Henderikx, P. A. 1980 De Lek en de Hollandse IJssel in de vroege Middeleeuwen. *Scrinium et scriptura* - Opstellen betreffende de Nederlandse geschiedenis aangeboden aan Prof. Dr. J. L. van der Gouw, bij zijn afscheid als buitengewoon hoogleraar in de archiefwetenschap en in de paleografie van de veertiende tot de zeventiende eeuw aan de Universiteit van Amsterdam. Erven van der Kamp (Groningen): 229-247.
- Hollstein, E. 1965 Jahrringchronologische Datierung von Eichenhölzern ohne Waldkante - *Bonner Jahrb.* 165: 12-27.
- Lanting, J. N. & W. G. Mook 1977 The Pre- and Protohistory of The Netherlands in Terms of Radiocarbon Dates - Groningen: 230 pp.
- Lamb, H. H. 1982 Climate history and the modern world - Methuen, (London): 387 pp.
- Louwe Kooijmans 1974 The Rhine/Meuse Delta. Four studies on its Prehistoric Occupation and Holocene Geology - Thesis, Leiden: 421 pp.
- Modderman, P. J. R. 1955 De bewoonbaarheid van het rivierkleigebied in de loop der eeuwen - *Tijdschr. Kon. Ned. Aardrijksk. Gen.*, II 72: 30-38.
- Mook, W. G. 1978 Het verband tussen C-14 en werkelijke ouderdommen - *Spiegel Historiae* 13, (Dorestadnummer): 305-308.
- Pons, L. J. 1953 Oevergronden als Middeleeuwse afzettingen en overslaggronden als dijkdoorbraakafzettingen in het rivierkleigebied - *Boor Spade* 6: 126-134.

- 1957 De geologie, de bodemvorming en de waterstaatkundige ontwikkeling van het Land van Maas en Waal en een gedeelte van het Rijk van Nijmegen - 's-Gravenhage; Versl. Landbouwk. Onderz. 63.11, Thesis, Wageningen: Bodemkundige Studies 3: 156 pp.
- Rijkswaterstaat 1961 Onderzoekingen betreffende de opzet van het deltaplan en de gevolgen van de werken - Rapt Deltacomm. 5. Staatsdrukkerij ('s-Gravenhage): 425 pp.
- 1964 Tienjarig overzicht der waterhoogten en afvoeren - Staatsdrukkerij ('s-Gravenhage).
- Van der Linden, H. 1955 De Cope. Bijdrage tot de rechtsgeschiedenis van de openlegging der Hollands-Utrechtse laagvlakte - Thesis, Utrecht. Bijdr. Inst. Rechtsgesch. Rijksuniversiteit Utrecht (1956): 400 pp.
- Van der Meer, K. 1952 De bloembollenstreek - Versl. Landbouwk. Onderz. 58.2, Serie: De Bodemkartering van Nederland 11, ('s-Gravenhage): 155 pp.
- Van Hengst, J. A. 1898 De Lekdijk Benedendams en de IJsseldam. Geschiedenis van dit Hoogheemraadschap vanaf de vroegste tijden tot in de tweede helft der negentiende eeuw. 1: 860-1648 - Swart ('s-Gravenhage): 336 pp.
- Verbraeck, A. 1970 Toelichtingen bij de geologische kaart van Nederland, schaal 1:50.000, blad Gorinchem Oost (38 O) - Rijks Geologische Dienst (Haarlem): 140 pp.
- 1984 Toelichtingen bij de geologische kaart van Nederland, schaal 1:50.000, blad Rhenen (39 W en 39 O) - Rijks Geologische Dienst (Haarlem): 300 pp.
- Vink, T. 1926 De Lekstreek, een aardrijkskundige verkenning van een bewoond deltagebied - Thesis, Amsterdam: 432 pp.
- 1954 De Rivierstreek - Bosch en Keuning (Baarn): 840 pp.
- Zagwijn, W. H. & C. J. Van Staaldin 1975 Geologische overzichtskaarten van Nederland - Rijks Geologische Dienst (Haarlem): 134 pp.