Extract of "Symposium on River Morphology"
General Assembly of Bern, Sept.-Oct. 1967

THE RIVERLANDSCAPES IN THE NETHERLANDS

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SUMMARY

A considerable part of the Netherlands consists of a delta area, mainly formed by the rivers Rhine and Meuse. During soil survey investigations many connections between the origin of the riverlandscape and soil conditions were found.

Several of these features are of general interest in deltaic areas in other parts of the world.

In the Netherlands several riverlandscapes are recognized:

1. The landscape of the riverterraces;
2. The landscape of the braiding river;
3. The landscape of the meandering river;
4. The landscape of the tidal river;
5. The landscape of the artificially embanked river.

Of each landscape the main features are discussed e.g. sedimentation processes, period of sedimentation, soil forming processes etc.

In recent years new facts were discovered concerning the history of the land occupation by man.

The agricultural development shows a fair connection with soil conditions in the area.

RÉSUMÉ

Les sols fluviatiles des Pays-Bas

Les grands fleuves le Rhin et la Meuse ont construit une partie considérable des Pays-Bas en forme d'un delta. Pendant les investigations pour la carte des sols, plusieurs relations entre l'origine des paysages fluviaux et les conditions des sols se manifestaient.

Quelques-unes de ces relations sont d'une importance mondiale pour les terrains de delta.

Aux Pays-Bas on distingue plusieurs paysages fluviaux, c'est-à-dire :

1. Le paysage des terrasses;
2. Le paysage réticulé;
3. Le paysage de méandres;
4. Le paysage des fleuves à marées;
5. Le paysage d'endiguement.

Les caractères principaux de chaque paysage sont discutés, par exemple : le mécanisme de la sédimentation, les périodes de sédimentation, la formation des sols.

Des faits nouveaux sur l'occupation des terrains fluviaux ont été découvertes récemment.

Le développement agricole est étroitement lié aux conditions des sols.

1. INTRODUCTION

Since 1945 the Soil Survey Institute of the Netherlands prepares soil maps of different parts of the country. The first maps were made in a riverclay landscape (Edelman c.s. 1950). It became soon apparent that in fluviatile areas soil conditions are closely related to geology and geomorphology.

Discharge, sediment load, slope etc. of the river have changed over and over in the course of time influencing erosion, transport and sedimentation.

Due to changing conditions in the hinterland and backward erosion the nature of the sediments changed with them.

One same location did not always have the same position in relation to the rivers. Upper-, middle- and lower reaches have changed their positions as a consequence of the movement of the sea level and tectonic movements; the profile of equilibrium was often not a very stable one. Typical differences in the landscape forms are found above and below the transition zone of the lower- and middle reaches of the rivers. In the higher- and middle reaches, terraces have been formed of which the older ones occur in the higher places of the landscape, the youngest forms the bottom of the valley.

In the lower reaches sedimentation is dominant. In such regions the younger deposits lie on top of older ones. The landscape there is almost flat except for some slight differences in height that are inherent to the sedimentation pattern.

A great part of the Netherlands is a delta area, formed mainly by the rivers Rhine and Meuse.

Some characteristic features of the various landscapes in relation to the nature of the sediments and the soils will be discussed by means of the results of the soil survey work that was done for the Soilmap of the Netherlands, scale 1:200.000 (1965).

Starting at the points where the rivers Rhine and Meuse enter the country, following them downstream to the sea, we will discuss:

1. The landscape of the riverterraces;
2. The landscape of the braided river;
3. The landscape of the meandering river;
4. The landscape of the tidal river;
5. The landscape of the artificially embanked rivers.

2. The landscape of the riverterraces

During a great part of the Pleistocene, the course of the rivers Rhine and Meuse was approximately from south to north running generally parallel. Presumably the rivers were partly forced to follow this course by the tectonic movement of the Peelhorst. This rising area formed a real barrier to a more westward course.

The sediments of the rivers were mainly coarse sand and gravel, sometimes clay.

In several parts of the country these deposits occur near the surface, especially in the central, southern and eastern parts.

There is no doubt that in most of them a considerable soil formation took place. Later geological events however have removed most of the traces of this.

During the Risz-ice-age the inland-ice covered a considerable part of the Netherlands. The rivers were compelled to flow in another direction, as the glaciers prevented them to follow their normal course. In the vicinity of the ice the direction changed abruptly to the west. In the meantime the inland-ice overrode the old riverterraces, covering them with glacial till. Especially in the central part of the Netherlands the fluviatile deposits were in some places pushed up by the inland-ice to considerable heights, say one hundred meters. As a consequence of the presence of masses of ice and snow on the continents, the level of the sea had dropped considerably, with consequences for the erosion base of the rivers. This drop in the sealevel was repeated during the Würm-ice-age.

In the southern part of the country tectonic movements raised the land. The rivers cut their beds periodically deeper into the existing sediments. Terrace after terrace was developed. The soilmap shows quite clear that young holocene riverclay-soils accompany the river everywhere except between Venlo and Roermond. Here, the rising of the Peelhorst prevented the sedimentation of such deposits. In this area v.d. Broek

and Maarleveld (1964) recognized five terraces of which terrace I is the oldest, dating back before the Alleród-time but for the greater part younger than the Early Würm-time. The characteristic soils of the Allerød-time are found in the top of coversand deposits, overlying this terrace.

The terraces II, II*a* and II*b* were formed during Allerød-time. The Allerød-soils are found at the base of the coversand deposits. The terraces II*a* and II*b* are the result of tectonic movements of the Peelhorst during the Allerød-time.

Terras III was formed during or after the Younger Dryas-time. It is covered with old riverclay deposits that have been dated elsewhere.

Where the terraces are not covered by younger deposits there is a striking difference in soilformation. On the oldest terraces, soils occur that could be named Brown Podzolic Soils, in many places with bands enriched in clay. On the younger terraces mainly Gray Brown Podzolic-soils occur with a well developed textural *B*-horizon.

3 The landscape of the braided river

After leaving the area where the rivers have cut deep into older sediments, forming terraces, they continue their course onward to the sea in a broad valley.

There have been three main courses, one to the east and north of Montferland, one between Montferland and the hills of Nijmegen and one through the Valley of the river Niers, to the south of Nijmegen and the Reichswald. There, Rhine and Meuse meet and flow on together. The sediments at and near the surface were deposited during the Würm-ice-age. The climate was cold, with much snow and ice. The soil was permanently frozen to a considerable depth, so that it was almost impermeable to water and behaved in many places like solid rock.

When in spring snow and ice melted, enormous masses of water had to find their way in a short time over this frozen subsoil.

The near absence of vegetation and the spasmodic occurrence of great quantities of water with a high running speed, favoured the transport of much coarse material. This resulted in a landscape of many small riverbeds with many islands of gravel and sand between them (Pons en Schelling 1951), the braided riverlandscape.

The braiding of a river is mainly the result of sudden increases in discharge during fairly short periods (Doeglas 1951). During the Würm-ice-age such circumstances were found in the river area. Presumably during the Late-Glacial-time the activity of the river reduced. Gradually the sediments became less coarse and finally a thin cover of clay was deposited over the braided landscape. It is often referred to as "Old Riverclay". It differs from most of the younger riverclay in several ways. It is found especially in the landscape of the braided river with its typical sedimentation pattern.

The material is more sticky and heavier to till for the farmers. The colours are different, often with more contrast between the different soil horizons. The well-drained parts of the landscape have reddish-brown soils, often with a textural *B*-horizon.

In the lower parts heavy gley-soils are found often developed in a gray clay. The soil formation is in accordance with the considerable age of these soils, in many cases approximately 10.000 years.

The upper part of all these soils is limeless. A great part of the area is under grass, some tracts, especially the well-drained light textured ones, are arable land.

Special skill is needed to farm these soils succesfully, as they are sensitive to the right kind and the right time of working, sowing and planting.

4). The landscape of the meandering river

The transition from Pleistocene to Holocene is marked by a change in climate and owing to this, the rivers changed their character. The permanently frozen subsoil

vanished. The vegetation changed from a tundra-vegetation to a forest-vegetation. The spasmodic character of the discharges changed into a gradual one, distributed over the year.

It is generally accepted that during that period the braiding river changed into the meandering river. The sediment load diminished considerably and as a consequence erosion proceeded in the direction of the lower reaches, where the river cut down into its own sediments.

Especially in the eastern part of the central riverclay area, deep and steep valleys were eroded. A great part of the originally broad and flat riverbottom was drained, so that the southwest to westerly winds could easily blow out considerable quantities of sand. This sand was not carried far, but came soon to a halt in the nearby vegetation where it formed riverdunes. These dunes are situated on top of the sediments of the braided river-system and diverge in direction from the braided river-pattern. The dunes form in the eastern part of the riverclay-area an important part of the landscape. The heights are considerable, differences of 10 meters over short distances occur. The lowest places are sometimes parts of the old riverbeds, filled up with blown sand or blown-out hollows, that reach till the top of the old riverclay. Many of these places have no outlets, they are filled with water, the so-called "vennen". The broad valley of the braiding river extended originally as far north as the area north of the river Lek (Rhine) (Verbraeck 1967 i.p.). Lateron the main activity was centered in the area between the rivers Lek and Linge. In that area remarkable sand-knolls are found, arranged in a westerly direction, the so-called "donken". They form tops of the riverdunes piercing through a cover of young riverclay inwhich they are embedded.

In the beginning of the Holocene the main activity of the rivers was restricted to the areas of the Tielerwaard and the southern part of the Alblasserwaard.

Lateron several other important branches developed during the Old Holocene (Old Holocene rivers).

The holocene meandering river flowed originally in a relatively narrow bed. Any appreciable increase in discharge caused it to flood the neighbouring land. Outside the riverbed the velocity of the water dropped quickly, so that near the bed the coarse material was deposited. The river built its own natural levees, enclosing itself between them. After some time these levees were built up so high, that only high riverlevels caused inundations of the bordering area. The natural levees have a relatively light texture, growing heavier at the top.

Outside the riverbed, between the levees of the several branches of the river, the velocity of the water was very slight. There backswamp-areas were formed that were filled with water at high levels of the riverwater during winter and spring.

In these backswamps very heavy material was deposited.

The riverbed is gradually raised bij coarse material. In the inner curves sandbars develop, the outer curves show deep scouring. The thus developing meanders move gradually downstream in the meanderbelt, that is narrow along a small river and broad when it accompanies a big natural river. The area enclosed by a meander consists generally of a series of sandbars, the so-called pointbar. In such an area the textural composition of the soil changes over short distances, the light textured soils occurring on the sandbars, the heavier in the gullies between them.

High natural levees are sometimes not resistant against a swiftly oncoming flood. In the top, narrow breaches are scoured, the crevasses, and the material is deposited in the backswamp. Fanlike this coarse material is deposited on the heavy backswampclay. In the longer run, accumulation in the riverbed may give the river so a high position in the area, that the bed is abandonned and the river takes a new course in a nearby lower place, most often the backswamp.

The soil conditions in this area show clearly much of the life history of the river. In the meanderbelt many soils belong to the natural levees. In the regime of the Rhine

these soils are mostly rich in lime. The same soils near the Meuse are often limeless. The levee-soils are relatively light textured, well-drained, topographically high. They have a brown colour and have a good permeability. These soils are mostly well suited for agricultural use. On these soils most of the habitation, the villages and the farms and roads are found. In the backswamps the situation is quite different. The soils are heavy textured with a low permeability for water. The soils are gray with a poor aeration. They form desolate trackts of land scatered through the area and originally without habitation or roads. Only recently the aspect is gradually changing as a result of reallocation.

5. The landscape of the tidal rivers

When the rivers approach the sea, the riverbottom becomes more and more horizontal, it looses slope. As a result the velocity of the water diminishes and in order to be able to contain all the water available, the rivers broaden and divide into branches. The river is no longer able to carry the coarser particles of the sediment load. So, farther downstream, the rivers only deposit finer material.

The typical aspect of the landscapes of the meandering rivers, the pronounced relief due to the alternation of backswamps and natural levees, gets lost. Gradually the landscape becomes very flat where the rivers enter into an extensive peat area. Clayey borders fringe the river where it flows through this area. Peatgrowth started early, in low places already in Preboreal times (Pons en Bennema 1958).

Especially in Mid-Atlantic times peatgrowth was very strong during a period of decreased activity of the rivers (Verbraeck 1967 i.p.). Shortly afterwards it was interrupted, but started anew at the transition of Atlantic to Sub-Boreal times.

On the clayey banks bordering the rivers there was a lush forest vegetation with alder, willow, oak and several other trees. At some distance away from the rivers the eutrophic vegetation changed into a mesotrophic one, where still riverfloodwater could influence the vegetation. There extensive Carex marshes developed. At a still greater distance from the river vegetation was not influenced by flood water, but it grew almost exclusively on rainwater. There sphagnum peat developed in oligotrophic conditions. Growing sphagnum peat forms slight mounds that keep themselves wet like sponges. As a result the central parts of the areas surrounded by river branches, consist of sphagnum peat surrounded by a belt of Carex peat, that is bordered by a strip of forest peat along the rivers. Peatgrowth proceeded until well into Sub-Atlantic times. In the western part of the Netherlands the layer of peat may have a depth of say 10 meters, quickly decreasing to the east. The enormous peatgrowth is generally attributed to the fact that at the coast an affshore bar developed, thus hindering natural drainage to a considerable extend and to the fact the sea-level during the Holocene rose considerably. The soilmap shows how the riverbranches run through the extensive peat-area, accompanied by natural levees that grow more and more narrow, going from east to west.

Some smaller branches start in the east with a wide funnel-shaped mouth, but seem to loose themselves in the peatlandscape.

Presumably their main function was the drainage of the peatlandscape but they had also a regulating function at high rivertides. At high tides riverwater pushed up into the branches, where the water soon lost its velocity and the sand was deposited in the funnel-shaped mouth (Poelman 1966).

Human activity has strongly influenced the appearence of the landscape. In earlier times vast areas of the peatlandscape have been dug off for the preparation of fuel. As it is undesiderable to have much ashes in the fuel, people selected preferably the area with sphagnum-peat. There lakes came into being that were gradually enlarged by wind and water.

In the western part of the area the subsoil of the lakes is formed by seaclay that was deposit during a succession of inroads of the sea into the peat-landscape. In the eastern part the subsoil is pleistocene sand. During the last century many of the lakes with a seaclay bottom have been drained and reclaimed.

Especially in the west, fertile land has been gained in that way. More to the east, where the seawater smothered in the peatlandscape, heavy limeless clays rich in organic matter, were deposited. Those soils, deposited under anäerobic, reducing, brackish conditions often obtain a considerable quantity of pyrite FeS2. When this is oxydized extremely acid soils may develope the so-called acid sulphate soils with a pH of sometimes as low as 2.

The reclamation of the peat-area on a large scale started in the 11th century. It was strictly regulated due to the fact that the Count of Holland and the Bishop of Utrecht had strong administrative and executive power. The peat-area to be reclaimed was divided in parcels and sufficiently drained. This resulted in a considerable shrinkage as drainage was kept adequate for agricultural purposes, and as a result the watertable had to be lowered again and again. Where in the peat-subsoil clay-or sanddeposits occurred, shrinkage was less than in places with pure peat in the subsoil. So after some time the course of the former rivers showed at the surface. The originally lowest places in the peat-area, the rivers, became after shrinkage the highest places. This inversion of the landscape is a quite common phenomenon in the peat-area.

Where drainage was or is too intense, the peat can dry out very strongly during dry periods. This causes the peat to dry in irreversible. After drying out the material will not take up water again for a very long period. For agricultural purposes, in this case the growing of grass, this is a considerable drawback.

6. The landscape of the artificially embanked rivers

Artificial embankment of the rivers has had some typical effects. After the embankment, starting approximately in the 11th century, the riverwater no longer deposited its sediments in the whole riverclay-area, but could only loose its sediments between the embankments. There, outside the actual riverbed, very homogeneous material was deposited. It is often rich in lime and in it, deep brown friable soils have developed. These fertile soils are almost exclusively grassland, as from time to time they are floaded and as a consequence less suited to the use as arable land.

At exceptional high rivertides it is possible that in some places the artificial embankments break through. There the water is thrust violently through the breach, scouring out a deep hollow behind the embankment, the sand out of this pit is deposited fanlike around it. In principle this material is quite infertile but by digging off the thickest layers and remodelling the land generally, farmers have been able to turn these dikeburst soils sometimes into good horticultural soils.

Some places in the embankments are particularly sensitive to dike-burst. They are almost predestinated to break through. This is the case where seepage under the embankment occurs.

In such cases sometimes an auxiliary dam has been constructed around the place with seepage. The pressure of the water that collects between the embankment and the auxiliary dam then slows down the seepage.

A characteristic feature of the area between the artificial embankments is formed by the many brickfactories. The light clays are well suited for manufacturing bricks, especially along the river Rhine. As the need for bricks is ever increasing the quantities of clay available will soon be insufficient to meet the needs of the factories. Many of them will have to be closed, unless means are found to use other clays as well e.g. backswampclays.

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