A STUDY OF THE VEGETATION OF THE "TURFKOELE" AND OF THE PALYNOLOGICAL CHARACTER OF THE PEAT DEPOSITED IN THIS SWAMP

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On the frontier of the municipalities "Melick en Herkenbosch" and "Vlodrop" near the road from Herkenbosch to boundery-mark 376, in the site named "Koezoep", in the province of Limburg, Netherlands, is a peat swamp, known as the "Turfkoele".

From the geological map (no. 58, fourth part sheet 4) it appears that the peat under the swamp has been formed on a deposit of river sand. This deposit has come from the Roer and lays on the middle terrace of this river and of the Meuse.

The swamp lies in a bend of the Roer valley. This bend, worn out in the low terrace of this river, consists of fine sand. So we may say that the peat has been formed in a deserted bend of the river Roer.

On three sides the surrounding soil lies about 5 meters above the surface of the swamp (+ 28 m N.A.P.). The edge, which I will call the "Hoge Wal" is on the north and east side of the swamp partly demolished, while on the south side the "Hoge Wal" has been planted with *Pinus sylvestris*.

The swamp is divided into a northern and a southern part by a regulated brook, the "Lange Graft", running from north-east to south-west and emptying into the Roer. The southern part of the "Turfkoele" receives water from the "Lange Graft" via a culvert. From this part rises a little brook, also emptying into the Roer.

In the northern part of the "Turfkoele" and on the edge nearby, borings have been made (boring C and A respectively), while boring B was made in the southern part.

First I will describe the present-day vegetation in a few words; after that the results of my palynological study of the peat. The latter will be compared with those of some peat studies carried out in other places, most of them in the neighbourhood.

Vegetation of the southern part of the "turfkoele"

There is not much open water in this part. In the centre there is some, about 4 m deep, but for the greater part grown over with *Equisetum fluviatile*.

The water level changes after rainfall, especially in the *Alnetum* on the west side. In a dry period, it is possible to walk through this

part in all directions, but after some days of rain, there may be more than 50 cm water. Undoubtedly this will influence the vegetation.

On the surface of it it looks as if this is the kind of vegetation typical for an oligotrophic soil, especially because of the abundance of *Myrica gale* and *Sphagnum* species. On closer examination this impression appears to be wrong. The part adjoining the "Lange Graft" has a vegetation characteristic for a eutrophic soil and consists of an *Alnetum-glutinosae* (with *Alnus glutinosa. Dryopteris austriaca, Humulus lupulus, Lysimachia vulgaris, Stachys palustris*, and other species), and a *Scirpeto-phragmitetum medio-europaeum* (with *Sparganium erectum, Typha latifolia, Scirpus sylvaticus, Stachys palustris* and others).

Along the "Hoge Wal" (on the south side) there is a narrow border consisting of a eutrophic vegetation, about 1.5 m broad, with a.o. *Alnus glutinosa, Solanum dulcamara, Calamagrostis canescens* and *Salix cinerea*. Probably the rain water sinks from the "Hoge Wal" as far as this border, which may explain its eutrophic character.

Going from this side to the middle of the swamp, first we see a *Caricion-fuscae* vegetation with much *Betula, Sphagnum* and some *Myrica*, an oligotrophic vegetation therefore. More to the centre this passes at various places into a *Scirpeto-phragmitetum medio-europaeum*. Only at one place we find a true peat moor with a vegetation belonging to the group of the *Ericeto-Sphagnetalia*, with *Sphagnum, Polytrichum, Eriophorum, Oxycoccus* and other species.

As mentioned before, on the west side of the swamp, there is an area with an eutrophic vegetation, first a *Querceto-carpinetum-filipenduletosum* (with a.o. *Alnus glutinosa, Filipendula ulmaria, Angelica sylvestris, Lysimachia vulgaris, Humulus lupulus*), passing into an *Alnetum-glutinosae*.

So we pass in the southern part of the swamp from a vegetation of *Equisetum fluviatile* (in the centre), via a trembling bog overgrown by *Typha latifolia* with *Cicuta virosa* and *Menyanthes trifoliata*, to *Sphagnum* societies of the *Caricion-fuscae* type, which in their turn pass into associations belonging to the group of the *Ericeto-Sphagnetalia*. The whole is surrounded by an oligotrophic vegetation consisting of *Myrica, Betula* and *Sphagnum* species except on the south side (narrow border of an eutrophic vegetation) and on the west side (*Alnetum-glutinosae*).

Vegetation of the northern part of the "Turfkoele"

This part is not so large as the southern one. The vegetation is of a meso- to eutrophic character. Along the southern border, the vegetation consists of an *Alnetum-glutinosae* with some transitions into a *Valerianeto-filipenduletum* (a.o. *Alnus glutinosa, Humulus lupulus, Stachys palustris, Cicuta virosa, Scirpus sylvaticus, Solanum dulcamara*). Towards the centre are transitions into a *Caricion-fuscae* too (a.o. *Sphagnum contortum, Sphagnum subsecundum*).

Going from the north side to the centre, first we find a *Phragmition-eurosibiricum* with a *Valerianeto-filipenduletum* (a.o. *Typha latifolia, Sphagnum molle, Equisetum fluviatile, Lysimachia vulgaris* and *Stachys*

palustris), passing into a *Valerianeto-filipenduletum* with an *Alnion-glutinosae* and a *Caricion-fuscae* vegetation.

From the north side a narrow "ridge" runs into the swamp. On this ridge we find an *Alnetum-glutinosae*, passing at the border into a *Valerianeto-filipenduletum*.

Open water is found only in the western part. Round it grows *Equisetum fluviatile*, and this vegetation passes into a *Valerianeto-filipenduletum*, *Scirpeto-phragmitetum medio-europaeum* and, locally, into a *Caricion-fuscae* and an *Alnetum-glutinosae* vegetation.

The surface is not so densely covered with *Sphagnum* as in the southern part of the swamp. Furthermore, there are more trees in this part, especially *Alnus glutinosa* and some *Betula pubescens*; relatively little *Myrica gale*.

So we find in the northern part a vegetation with *Equisetum fluviatile* (only in deeper water) passing into a *Scirpeto-phragmitetum medio-europaeum*, *Caricion-fuscae* and a *Valerianeto-filipenduletum*; locally also into an *Alnetum-glutinosae*, especially on the northern and southern border of this part of the swamp.

Palynological Analysis of the Peat

Boring A

Palynological Aspect

From the Fig. 1 it appears that the lowermost layer contains many pollen grains of *Pinus*, less of *Betula* and *Salix*. The herb-pollen percentage too is rather low. So the first peat must have been formed during the Praeboreal. First, the pollen percentage of *Pinus* fluctuates round 60 %, but after the appearance of *Corylus*, and then of *Alnus*, this percentage decreases rapidly. At 1.80 m thermophilous trees appear. The pollen percentage of these trees increases very fast, so at 1.80 we may locate the boundary line between Praeboreal and Boreal. In the Boreal we see a slight indication of a *Corylus* top (23 %). *Alnus* appears at a depth of 1.70 m. At first the percentage remains under 10 %, but higher on it increases (from 1.10 m).

At 1.50 we meet the Quercetum mixtum, at first *Ulmus* only, after that *Tilia* and *Quercus* too. The *Alnus*-pollen percentage increases fast and at 0.90 m the *Alnus* and *Pinus* lines cross each other. This is the beginning of the Atlanticum.

In the Atlanticum the *Corylus*, *Alnus* and Quercetum-mixtum lines rise further. At 0.70 m the Quercetum mixtum has a top in the Atlanticum (29 %), caused by *Quercus* (15 %), *Tilia* (7 %) and *Ulmus* (7 %). After this the Quercetum-mixtum percentage decreases. This decrease, together with a maximum of Corylus (32,5 %), indicates the boundary line between Atlanticum and Subboreal (0.60 m). The low percentage of Ericaceous pollen increases slightly too. The Quercetum mixtum has been partly pushed aside by *Corylus*, which reaches a maximum in the Subboreal. After this the *Corylus* percentage also decreases.

At 0.30 m *Fagus* and pollen grains of cultivated *Gramineae* appear.

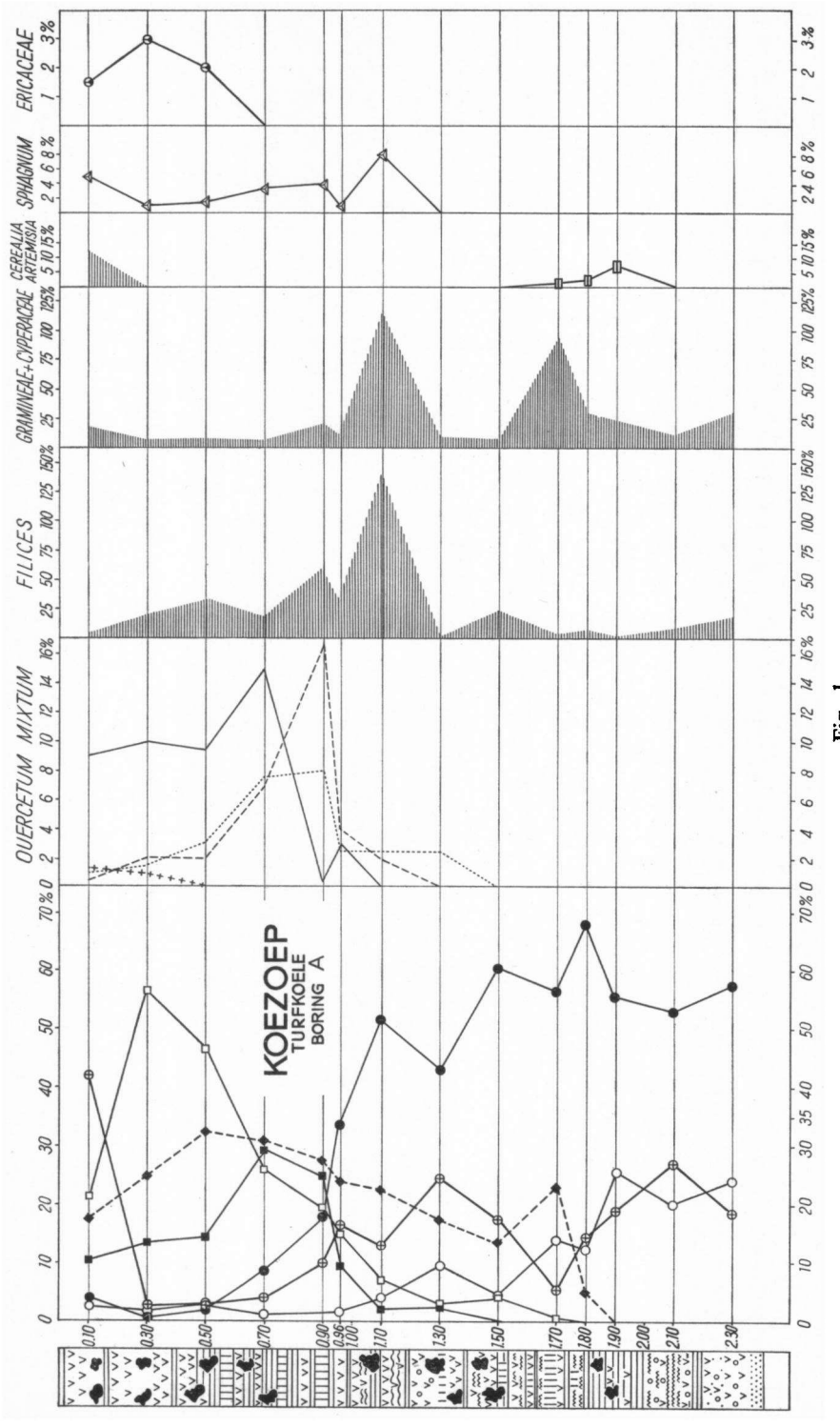
KOEZOEP
TURFKOELE
BORING A
QUERCETUM MIXTUM
FILICES
GRAMINEAE+CYPERACEAE
CEREALIA
ARTEMISIA
SPHAGNUM
ERICACEAE
0.10
0.30
0.50
0.70
0.90
0.96
1.00
1.10
1.30
1.50
1.70
1.80
1.90
2.00
2.10
2.30

Fig. 1

Alnus reaches a maximum (56 %); the *Salix* percentage increases suddenly to 42 %, pointing to a *Salicetum* in accordance with the present day vegetation.

The *Fagus*-pollen percentage remains very low which suggests that the Subatlantical peat has been removed and eventually has been replaced in the upper layers of the deposit by recent peat.

Stratigraphical Aspect

It appears that the peat rests on river sand mixed with fine gravel. The lowest peat layers contain much wood and fruits of *Betula*. Probably there was a *Betula-Salix* marsh here, with *Pinus* in the surrounding country. The undergrowth consisted of *Filices* and *Gramineae* with some *Musci*. After this the water level rose a little, for besides the *Gramineae* at the lower level, *Carex*, *Eriophorum*, *Phragmites* and *Sphagnum* appear. In the surroundings the conifers (*Pinus*) were replaced by deciduous trees (*Quercus*, *Tilia* and *Corylus*).

The upper peat layers consist of a woody peat, with *Carex* and some *Ericaceae*. The vegetation of these peat layers will have resembled the present-day vegetation to a large extent.

So, the whole gives the impression of a marsh, at one time drier than at other times.

Boring B

Palynological Aspect

As in boring A, *Pinus* (50 %), *Betula* (28 %) and *Salix* (16 %) appear first in Fig. 2. The herb-pollen percentage is low, so the peat had been formed first in the Praeboreal.

At 1.70 m *Pinus* reaches a maximum (76 %) but decreases rapidly. *Betula* and *Salix* fluctuate round 23 %, resp. 10 %.

In the diagram we see *Corylus* and *Alnus* appear at 1.50 m. The pollen percentages of these trees rise fast and at 1.50 m the boundary line between Praeboreal and Boreal is reached. At the same time the Quercetum mixtum, with *Quercus* and *Tilia*, makes its appearance.

Here, too, *Corylus* reaches a just perceptible top in the Boreal (22,5 %).

The crossing of the *Pinus* and *Alnus* lines takes place at about 1.20 m, this being the beginning of the Atlanticum. At the same time the Quercetum mixtum reaches a maximum (19.5 %) caused by *Quercus* and *Tilia*.

Here, either the growth of the peat must have stopped for a time; or a peat layer has been washed away. This seems the more plausible as a deposit of river sand is found here. Hence, this part of the diagram is not wholly reliable.

After the crossing of the *Pinus* and *Alnus* line, the *Corylus* percentage increases and then declines. At this moment there is an *Ericaceae* maximum too, though of less significance. The Quercetum-mixtum percentage drops too. Conclusion: this part belongs to the Subboreal (from 1.10 m).

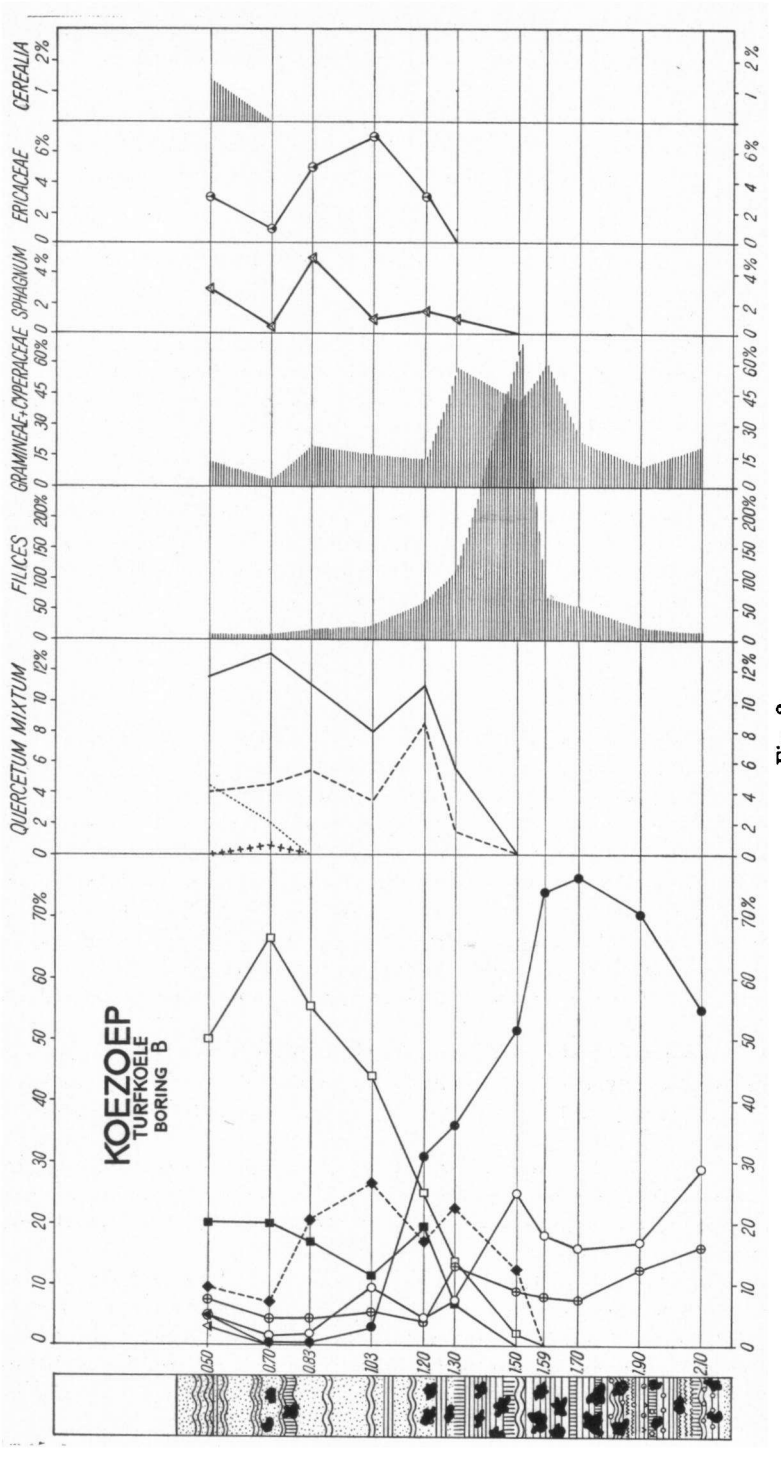
KOEZOEP
TURFKOELE
BORING B
QUERCETUM MIXTUM
FILICES
GRAMINEAE-CYPERACEAE
SPHAGNUM
ERICACEAE
CEREALIA
0 10 20 30 40 50 60 70%
0 2 4 6 8 10 12%
0 50 100 150 200%
0 15 30 45 60%
0 2 4%
0 2 4 6%
1 2%
0.50
0.70
0.83
1.03
1.20
1.30
1.50
1.59
1.70
1.90
2.10

Fig. 2

Above 0.70 m we see *Fagus* and *Carpinus*, together with cultivated *Gramineae*, and an *Alnus* top (66 %) as in boring A.

Stratigraphical Aspect

Here again, the peat appears to rest on a deposit of river sand. The undermost layers are built up in a *Betula-Salix* marsh, with *Carex*, *Sphagnum*, *Eriophorum* and *Phragmites*, with *Pinus* in the immediate surroundings.

As far as about 1.20 m the structure of the peat does not change much. Then we find river sand again, brought probably by the Roer, with a little *Sphagnum* and *Carex*, higher up with *Phragmites*. Up to the upper layers the peat remains very sandy. On the peat we find circ. 50 cm water with *Sphagnum* growing in it.

Boring C

Palynological Aspect

At first, the spectra (Fig. 3) show a high percentage of *Pinus* pollen (78.5 %) and some of *Betula*, *Salix* and various herbs (at first some *Gramineae* and *Cyperaceae*, but these disappear soon). Here too, peat must have been formed from the Praeboreal. At 2.15 m we see thermophilous trees, all appearing at the same time and their pollen percentages increase fast. Therefore, it is impossible to give a good classification.

At about 1.80 m there are pollen grains of *Fagus* and *Carpinus*. As in boring A, cultivated *Gramineae* are found together with *Fagus* in the top layers. It looks as if the peat has partly been removed by dredging. The lowermost layers have not been disturbed. The upper peat may have been formed in recent times; the intermediate layers would have been removed. The *Alnus* maximum, at the top of the deposit, points to a vegetation corresponding to that of the present day.

Stratigraphical Aspect

Here again, the peat rests on a deposit of river sand. The undermost layers are built up in a *Betula-Salix* marsh, with *Sphagnum*, *Eriophorum* and some *Carex*, with *Pinus* in the immediate surroundings. The uppermost layers are mixed with river sand and are built up with *Carex*, *Eriophorum* and *Phragmites*.

Comparison of the borings

Palynological Aspects

In the "Turfkoele" the first peat was formed in the Praeboreal; it contains many pollen grains of *Pinus* and some of *Betula* and *Salix*. From the thermophilous trees we see first *Corylus*, followed by, or appearing at the same time with *Alnus*. Then the Quercetum mixtum appears, with *Quercus* and *Tilia* chiefly. In the Boreal there is an indication of a *Corylus* top. After the crossing of the *Pinus* and *Alnus* lines in the diagram, the Quercetum mixtum reaches a maximum,

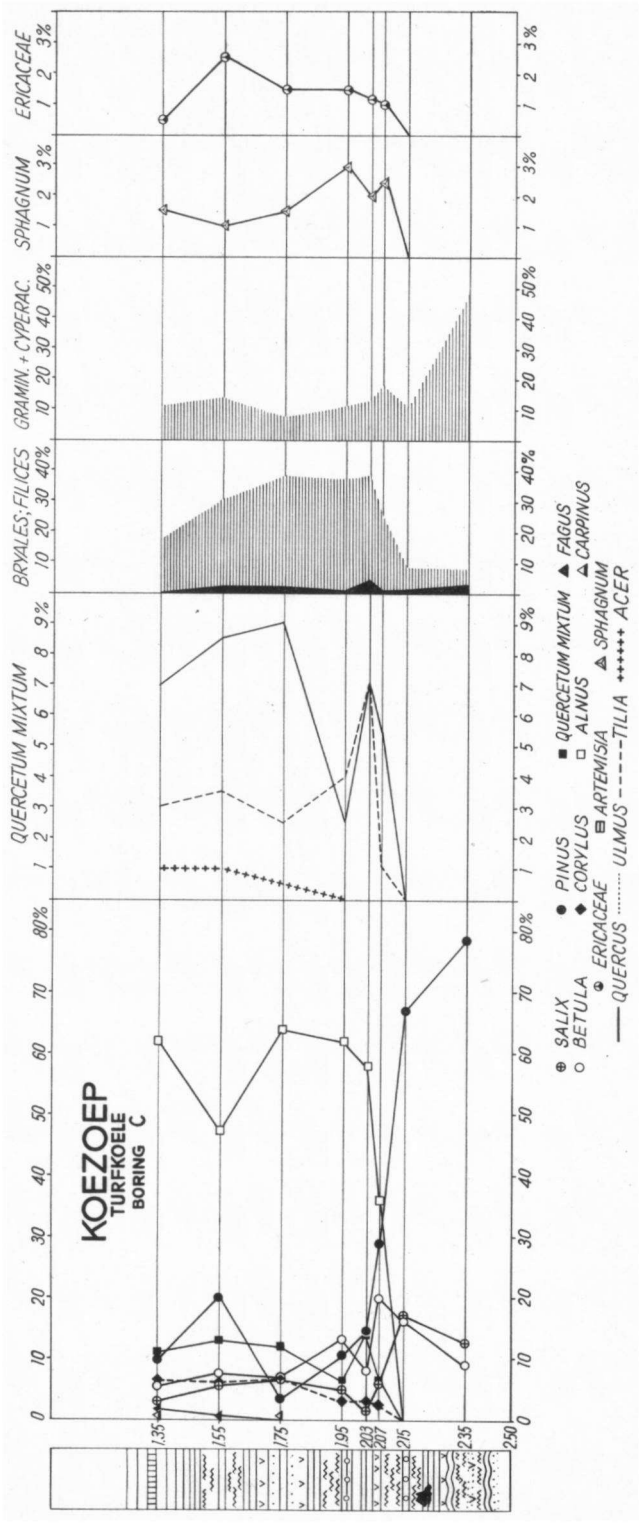
KOEZOEP
TURFKOELE
BORING C
QUERCETUM MIXTUM
BRYALES; FILICES
GRAMIN. + CYPERAC.
SPHAGNUM
ERICACEAE
SALIX
BETULA
PINUS
CORYLUS
ERICACEAE
QUERCETUM MIXTUM
ALNUS
ARTEMISIA
FAGUS
CARPINUS
SPHAGNUM
QUERCUS
ULMUS
TILIA
ACER

Fig. 3

which in diagram B is probably secondary. In the subboreal the Quercetum mixtum was pushed aside by *Corylus;* the latter reaches a maximum here.

Stratigraphical Aspects

From the three borings we may conclude that the peat was formed upon river sand deposited by the Roer. The undermost layers were built up in a *Betula-Salix* marsh with an undergrowth, and with *Pinus* in the immediate surroundings. Afterwards *Pinus* was pushed aside by deciduous trees.

From the borings B and C it becomes clear that at the end of the Subboreal the Roer again deposited river sand. To do so, the Roer had to change its course. After another diversion of the river bed the peat bog remained very wet (borings B and C).

In boring B we find first a wet marshy peat, above it a peat built up with *Carex* and *Sphagnum.* In boring C we find the same, with *Carex, Phragmites* and *Eriophorum;* in boring A we have to deal with a marshy peat becoming gradually dry.

In comparing the diagrams with those of H. J. ESHUIS (1946): the southern Peel (profile 5 of Eshuis), we find a marked difference in the age of the peat; that in the "Turfkoele" being older, namely Praeboreal, in opposition to the Boreal or Atlantic age of the peat in the southern Peel. After the crossing of the *Pinus* and *Alnus* lines the percentage of the *Pinus* pollen-grains remains low in both diagrams. In the diagram of Eshuis, *Corylus* has a top in the Atlanticum-Subboreal, so somewhat earlier than in the "Turfkoele". The same applies to *Alnus,* this reaching a top in the Subboreal in the Peel. In both peat formations we find a Quercetum-mixtum top in the Atlanticum caused by *Quercus* chiefly. In the diagram of the southern Peel we see *Fagus* in the beginning of the Atlanticum. In the "Turfkoele" only the upper layers contain a few *Fagus* pollen-grains.

It is impossible to compare the palynological character of the peat near Susteren (L.), studied by FLORSCHÜTZ (1941), with that of the "Turfkoele". There the peat is chiefly of late-glacial age and it was apparently dug off above the crossing of the *Pinus* and *Alnus* lines.

Nearer to the "Turfkoele" is the peat bog near Broeksittard (L.) studied by BELDEROK and HENDRIKS (1951). In comparing their diagram with those of the "Turfkoele" we see in both diagrams a *Corylus* maximum in the Boreal and a Quercetum-mixtum top in the Atlanticum, caused by *Quercus* and some *Tilia* and *Ulmus.* At the transition of the Subboreal into the Subatlanticum there is an *Alnus* top. Remarkable is the fact of thermophilous trees appearing already in the Late-glacial and early Praeboreal. Belderok en Hendriks do not mention this fact.

The diagrams of the "Turfkoele" as well as those of the "Hautes Fagnes" (VAN DER HAMMEN, 1951: "Belle Croix"; FLORSCHÜTZ and VAN OYE, 1939: "Vivier Fagnoul") and of the border of the Eiffel (PERSCH, 1950), so the pollen diagrams of peat bogs of the southern

Netherlands and the adjoining parts of Belgium and Germany, are characterized by an, on the whole, intensive development during the Praeboreal. There is no regularity in the arrival of thermophilous trees. In the northern Netherlands and Denmark, *Corylus* appears first, mostly in the young Praeboreal; after that come *Ulmus* and *Quercus;* and *Alnus* and *Tilia* only in the second part of the Boreal. In the south this is not common. Here the thermophilous trees often appear all at the same time. Among the components of the Quercetum mixtum, the large percentage of *Tilia* is striking. At the same time with, or preceding the maximum extension of the Quercetum mixtum (Atlantic Quercetum-mixtum top) we find an, often rather high, maximum of *Tilia.*

In the diagrams of the "Turfkoele" the relative low percentages of *Corylus* during the Boreal are striking.

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