ORGANIC B IN HIGH MOOR PEAT AND HIGH MOOR PEAT RECLAMATION SOILS

ORGANISCHE B IN HOOGVEEN EN HOOGVEENONTGINNINGSGRONDEN

by/*door*

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1. INTRODUCTION

Until some centuries ago a vast expanse of high moor peat[2]) was situated in the north-east of the Netherlands. It adjoined the Bourtanger Moor of north-west Germany. Fig. 1 shows a very common profile in this high moor peat according to Tousijn (1945). Most of it was gradually excavated in order to obtain fuel. It was early appreciated that together with the waste from the large towns these residual peats could be converted into high-grade agricultural soils.

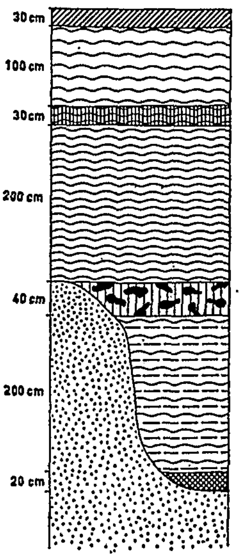
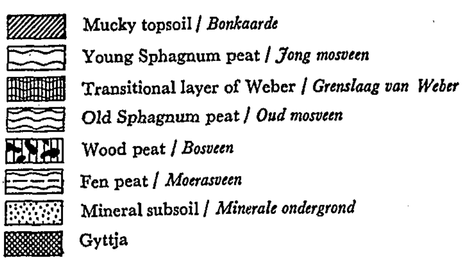


Fig. 1
High moor profile / *Hoogveenprofiel*



Intensive drainage was required both for peat excavation and agriculture, so that the entire high moor peat area is intersected by canals not more than 250 m apart and usually extending into the mineral subsoil. The latter consists predominantly of sand with less than 75% $<$ 50 mu and an M 50 of 150 mu.

As shown diagrammatically in fig. 2 in peat excavation on the top layer of some 50 cm of the recent moss peat is tipped in the open work pit of the past season. When the peat has been dug out the recent moss peat tipped back into the pit is covered with a good 10 cm of sand. This sand comes from the peat excavation canals.

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[2]) High moor peat mainly has to be considered as „rain peat" (anaerobic conditions are maintained by rain-water). Fen peat is „ground-water peat" (anaerobic conditions maintained by ground-water).

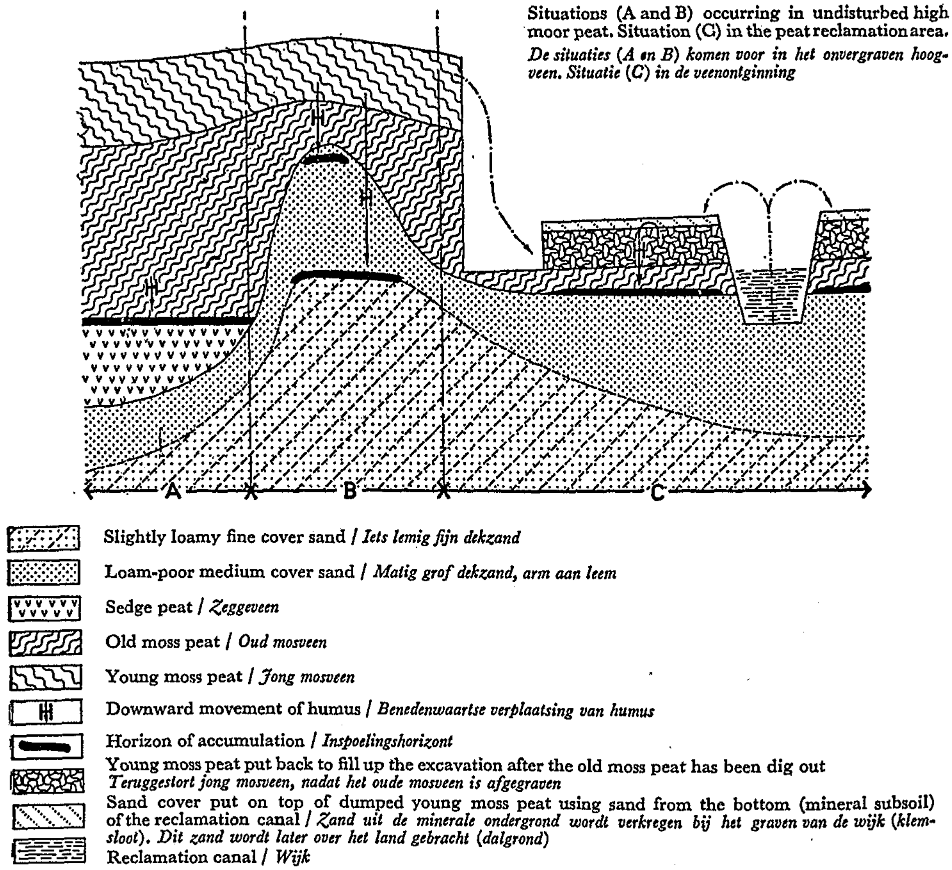


Fig. 2
Accumulations of black amorphous humus. Peat excavation in progress.
Ophopingen van zwarte amorfe humus. Veenafgraving.

The peat excavation process is still in progress, so that well-drained high moor peats occur side-by-side with high moor peat reclamation soils.

While surveying the reclamation soils and studying the profiles through the high moor peat it was noticed that horizons and accumulations of black amorphous organic matter occurred in and below the peat. The horizons are shown in fig. 2.

It was also observed that in summers after periods of heavy precipitation black amorphous organic matter was also deposited in the peat pits. This was formed after evaporation of the drainage water from the peat walls. The same phenomenon was observed in humous bands in the sandy subsoil underlying unexcavated peat. Here a black sludge of a jelly-like consistency leaked out of the pores of the humous layers.

These phenomena may be compared with the observations of Stobbe and Wright (1959) in Canadian humic podzols. They are of the opinion that in an environment deficient in sesquioxides a high percentage of the organic matter moves fairly rapidly from the Ao to the B in solution and/or colloidal suspension.

We attempted to demonstrate the illuviation of mobile organic matter by means of ^{14}C dating. This was rendered possible by the fact that relatively recent peat lies at the surface in both the unexcavated low moor peats and in the high moor peat reclamation soils, whereas the peat in which the shifted organic matter accumulates is much older.

The occurrence of this illuviated organic matter is described in three situations, viz. in the peat, in the mineral subsoil underlying the peat, and at the transition from the peat to the mineral subsoil. These situations are shown in fig. 2.

2. DATING OF MOBILE ORGANIC MATTER IN PEAT

The ^{14}C dating of carbonaceous matter is based on two principles. The first is that the half-life of ^{14}C is 5570 years, viz. after 5570 years the percentage of ^{14}C is halved compared to that of a zero time.

The second principle is that it is assumed that the percentage of ^{14}C now present in the atmosphere and taken up by flora and fauna together with the ^{14}C is the same as at any given time in the past. Disregarding fluctuations in the percentage of ^{14}C caused by slow protracted changes in the constellation of the earth and atmosphere, De Vries (1959) pointed out some very recent changes. As a result of the use of coal and petroleum since the second half of the 19th century and recent nuclear explosions, changes have taken place in the percentage of ^{14}C which make it necessary for the comparative material to be selected with great care.

Waterbolk (1959) quotes an example of a sample of grain taken from a Roman castellum burnt in 69/70 A.D.

The uncorrected result of the ^{14}C dating was 230 $\pm$ 25 A.D. (GRO 1415), showing that owing to the choice of comparative material the dating proved to be some 200 years too late.

We can date an illuvial layer of mobile organic matter in a layer of peat by means of ^{14}C. This dating does not, however, provide us with an absolute age, but a mixed dating of the illuviated organic matter together with the recipient medium (the peat). Provided we know the age of the peat, it is possible via the ^{14}C activity to specify combinations of amounts of illuviated organic matter and their age. The possible combinations are plotted in fig. 3 in the form of a graph.

The age in years is plotted linearly on the y axis and the ^{14}C activity on the x axis. By this we mean the percentage of ^{14}C of the amount of ^{14}C contained by recent carbonaceous material.

Thus at an age of zero years there is 100% ^{14}C, at an age of 5570 years (on half-life) the activity is only 50%, and so on.

We can write the following equations for graph:

(1) $y = a x 5570$
(2) $x = 2^{-a} \times 100$

Solving a from (2)
$\log^{2-a} + \log 100 = \log x$
$a \log 2 = \log x — z$

(3) $a = \frac{2 — \log x}{\log 2}$

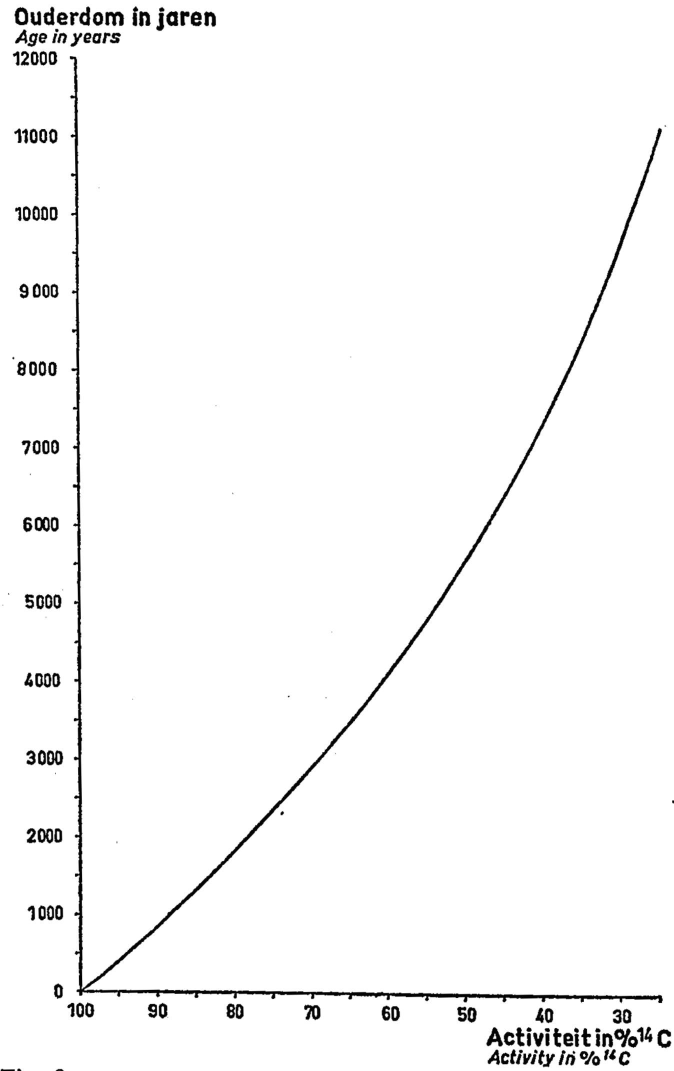


Fig. 3
Combinations of amounts of illuviated organic matter and their age.
Combinaties van hoeveelheden ingespoelde humus en de ouderdom daarvan.

and supplying a in equation (1) from equation (3), we obtain

$$y = \frac{2 - \log x}{\log 2} \cdot 5570$$

$$y = \frac{-5570}{\log 2} \log x + 2 . \frac{5570}{\log 2.}$$

Designating the constant $\frac{5570}{\log 2}$ as b, then the equation of the line indicating the relationship between the activity and the age is

$y = -b \log x + 2b.$

If we now obtain the ^{14}C dating of an illuvial layer of 5570 years and a ^{14}C dating of 11400 for the recipient peat, we can see from the graph that there has been a 25% increase in activity. Assuming the C-content and the moisture percentage to be the same, the 25% increase in activity may have been caused by illuviation of 25% of mobile organic matter aged o years and also by $\frac{25}{71} = 35\%$ aged 2785 years.

3. SITUATION DESCRIPTIONS

Fig. 2 shows the situations, referred to in the introduction, in which we encountered illuvial layers.

Situation A.

Illuvial horizons of mobile organic matter in the peat

In situation A we found illuvial layers of mobile organic matter at the transition from the old moss peat to the Scheuzeria peat.

This organic matter closely resembles the dopplerite described in the peat literature. Dopplerite, which takes its name from Doppler who first described it in 1849, is described by von Bülow (1929) in the following terms: „*Dopplerit ist Humus in der reinst vorkommenden Form, ähnlich offenbar der sog. Phyto. Kollit, ausgefälltte Humussäuren in Verbindung mit einigen Mineralstoffen (Ca, Al_2O_3, Fe_2O_3 u.a.). Frisch graubraun bis schwarz, von kan schuckartiger Elastizität, homogen, fettglanzend, nicht klebend und geruchlos. Trocken, stark schrumpfend, glänzend pechschwarz, Kanten durchscheinend (rötlich braun), eckig zerspringend mit muschligem Bruch und Härte 2–2.5, Spez. Gew. rund 1.4; im Gegensatz zu Torfen äuszerst arm an alkohollöslichen Bestandteilen, auch in Wasser nicht löslich. Aschegehalt 2–5%, in bes. Fallen bis 10–14% ansteigend*".

His chemical analyses show that the C/N quotient is greater than 48, whereas in the ash the chief components are CaO (57%) and Fe_2O_3 and Al_2O_3 (12–50%).

In the north-east of the Netherlands dopplerite chiefly occurs in the form a filling of fissures and root passages in the peat. We have described these deposits together with the other peat minerals (Van Heuveln, 1959).

It does not occur so often in a continuous horizon.

In a comparable situation in the high moor peat layer the dopplerite was of still more recent date, viz. GRO 2058 3900 ±80.

Thus the data in table 1 show that the dopplerite together with the peat may certainly be dated as 1200 years later than the pure peat. The soil colours denote a distinct iron enrichment. The organic matter was apparently eluviated from a higher level and precipitated on the ferrous *Scheuzeria peat.*

1. The GRO numbers are registration numbers of the ^{14}C laboratory at Groningen, Netherlands.
2. The soil colours are given according to the Munsell Color Notation.

Conversion via the activity graph in fig. 2 gives a 12.5% increase in activity. Since in these areas in which buckwheat firing cultivation was practised a considerable amount of the topmost peat was burnt. We can put the age of the pre-drainage topsoil at about 1400 years. The illuviated organic matter would then be not less than $\frac{12.5}{84} = 15\%$ where it was formed at the surface

Table 1 The most important data on situation A (see fig. 2)
De belangrijkste gegevens van situatie A (zie fig. 2)

Depth below surface *Diepte beneden maaiveld*	Description *Aard*	Age *Ouderdom*	Munsell notation *Kleurnotatie vlg. Munsell*
270 cm	Old moss peat *Oud mosveen*	GRO 804: 5970±145	10YR 8/6
275 cm	Dopplerite *Doppleriet*	GRO 803: 4485 ±110	2.5YR 4/8
280 cm	Scheuzeria peat *Scheuzeria-veen*	GRO 805: 6040 ±120	10YR 3/6

and more with an increasing age of the parent layer of the mobile organic matter.

SITUATION B.

Illuvial horizons of mobile organic matter underlying the peat in the mineral subsoil

In this situation the ancient moss peat usually lies immediately above the mineral subsoil in which a humus podzol has developed with humous illuviation bands deep in the C horizon. The data in table 2 is taken from the description of a profile of this type (Van Heuveln, 1959).

TABLE 2. The most important data on situation B (see fig. 2)
De belangrijkste gegevens van situatie B (zie fig. 2)

Depth relative to peat/sand interface *Diepte t.o.v. grens veen/zand*	Description *Aard*	Age *Ouderdom*	pH Truog	Texture *Textuur*			Ignition color according to Munsell notation *Gloeikleur naar Munsell*
				<2	2/50	M 50	
+ 18 cm	Old moss peat *Oud mosveen*	GRO 1019: 3230 ±75	4.5	—	—	—	—
— 18 cm	B2h	GRO 1016: 2090 ±50	4.5	0	2	110 – 150 mu	10YR 8/1
— 145 cm	B bands *Banden B*	GRO 710: 1535 ±85	5.2	2	6	75 – 110 mu	7.5YR 8/6

The organic matter from the B2h and the B bands is obviously later in date than the overlying ancient moss peat and apparently percolated through it here.

The B2h consists of black and the B bands of brown organic matter. Preliminary experiments make it seem likely that the organic matter of the B2h mostly consists of humic acids and that of the B bands more of fulvo acids.

Since the B2h is situated in very humus-deficient sand and the B bands in non-humous material the dating of the B bands in particular is fairly reliable. Hence we gain the impression that the humus was formed in the top portion of the high moor peat layer. Since, buckwheat firing cultivation was practised here as well as in situation A and much of the most recent peat was burnt in the process, this dating indicates that the source of the mobile organic matter is to be found in or near the surface.

Situation C

Illuvial horizons of mobile organic matter at the transition from the peat to the mineral subsoil

Topographically this situation occupies an intermediate position, as is outlined in fig. 2. As in situation B, the ancient moss peat lies immediately above the mineral subsoil. During peat excavation a few dm of peat were left. At the bottom of this solid peat a very dense layer is encountered which is termed gliede. In many respects this gliede resembles dopplerite. It only contains a minor amount of sesquioxides or CaO. In its reduced state it is greasy black, unlike the brown peat. It is not elastic, but extremely greasy and non-adhesive.

It is homogeneous and contains few plant residues. In its dry state it is dull, fairly and of a nutty structure. Like dopplerite it has a very poor capacity for reabsorbing moisture. We regard this gliede as an illuvial layer of mobile organic matter. It is presumably derived from the tilth. On the high moor peat reclamation soils the land use is predominantly agriculture, the principle crop being potatoes. To this end the sand is regularly ploughed up with the underlying recent moss peat. Especially as potato cultivation requires a low pH, it would seem likely that a large surplus of non-binding organic matter is formed in the lutum- and sesquioxide deficient tilth. A part of this would be eluviated. The survey of these soils showed that the „gliede" is more in evidence according as the land has been longer under cultivation.

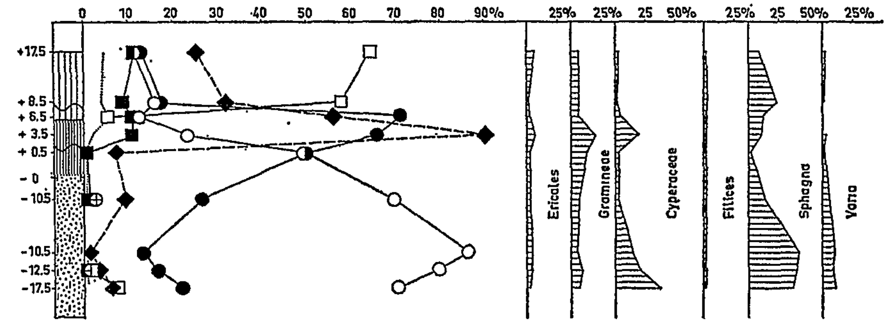
Marsh peat occurs below the ancient moss peat at the bottom of the slope in the high moor peat reclamation soils. The interlocking layer of „gliede" is absent here, but dopplerite is found in the root passages of the few peat.

Table 3 shows the datings of the „gliede" and the ancient moss peat. In themselves these datings are very little to go on, so that the pollen analysis of the base of this peat is shown in fig. 4.

Described in broad outline, the bottom seven spectra represent the Boreal. The Boreal-Atlantic interface is situated at the pine-alder crossing viz. at about 7.5 cm. Above this the peat is Atlantic. For the dated layers this means that the ancient moss peat was formed in the Atlantic and that the „gliede" was incorporated in peat of Boreal age.

TABLE 3. The most important data of situation C (see fig. 2)
De belangrijkste gegevens van situatie C (zie fig. 2)

Depth relative to the peat/sand interface *Diepte t.o.v. grens veen/zand*	Description *Aard*	Age *Ouderdom*
+ 25 cm	Old moss peat *Oud mosveen*	GRO 826: 7310 ±115
+ 5 cm	„Gliede" *Gliede*	GRO 825: 7310 ±110



Ancient moss peat / *Oud mosveen* — Pinus — Corylus

„Gliede" / *Gliede* — Betula — Salix

Humose sand / *Humeus zand* — Alnus — Ulmus

Sphagnum — Querceto mixtum

Fig. 4
Pollen diagram of the base of the ancient moss peat.
Pollendiagram van de basis van het oude mosveen.

Van Zeist (1957) gives a ^{14}C dating of the palynological stratigraphy of a number of high moor profiles. These datings show that the spectrum of + 6.5 cm has an age of at least 7750 ± 135 years. Hence the peat in which the „gliede" was incorporated is much older. Van Zeist dates the commencement of the Boreal with the first rise of Corylus at 6657 ± 180 B.C., viz. absolutely at 8635 ± 180 years. If we compare the entire pollen pattern at the peat-sand interface with Van Zeist's diagram we arrive at the conclusion that the peat-sand interface must have an age of 8600 years.

This means that the „gliede" was incorporated in peat at an age of between 7750 ± 135 and 8600 years, viz. about 8175 years. With a mixed dating of 7310 for „gliede" with the recipient peat, we find after calculating back via fig. 3 that the „gliede" caused a 5% increase in ^{14}C activity. As in situation A, we assume that owing to the buckwheat firing cultivation the recent moss peat was burnt up to an age of 1400 years. Hence the ploughed-up peat in the tilth will be at least this age, and since it was tipped back ungraded it will very probably have a still greater average age. If we assume the average age to be 2000 years, it is possible that 6.5% of organic matter was illuviated from the tilth, as shown when calculating back via fig. 3.

ORGANIC B.

We can see from the foregoing that ^{14}C dating enables us to determine whether certain layers in and below peat consist of illuviated mobile organic matter derived from this peat.

In modern soil classification systems the organic soils are considered separately from the mineral soils.

We suggest employing the description „B horizon in organic soils" (abbreviated „organic B") for peat profiles in which it is possible to identify a layer characterized by an „accumulation of illuviated colloidal or dissolved material" (Soil Survey Manual, 1951). Since without the expensive ^{14}C dating it is difficult to distinguish the organic B underlying peat from B horizons in humus podzols, it would seem desirable to restrict the organic B to illuvial layers in the peat.

For use in map legends it will obviously be possible to specify *minimum* standards of thickness, percentage of identifiable plant residues, homogeneity horizontal continuous course and depth of occurrence.

(April, 1960)

4. SAMENVATTING

Met behulp van ^{14}C-datering wordt aangetoond, dat in organische gronden lagen voorkomen, die zijn ontstaan door ophoping van mobiele organische stof.

Voorgesteld wordt deze lagen de naam te geven van organische B.

Er is een methode uitgewerkt om de ^{14}C-datering van dergelijke lagen om te rekenen tot het percentage ingespoelde organische stof van een bepaalde ouderdom.

In drie situaties in het hoogveen en de hoogveenontginningsgronden van noord-oost Nederland wordt gedemonstreerd hoe dergelijke ^{14}C-gegevens kunnen worden gehanteerd.

5. LITERATURE

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