On soil genesis in temperate humid climate. IV. The "Low Humus Podzols"

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Summary

The "Low Humus Podzols" do not possess a spodic horizon. The podzolic soil formation in co-operation with predominantly reductional conditions give rise to an eluviated profile. They have an umbric epipedon (Umbraquepts). The B-horizon is intermediate between the A- and C-horizon with respect to contents of iron and aluminium. The humus occurs mostly as disperse humus. A fifth subgroup is proposed for these soils, *viz.* Psammic Umbraquepts.

1. Introduction

Under Dutch climatic conditions Podzols (generally called Humus Podzols in the Netherlands) occur on materials extremely poor in weatherable minerals. Several authors have described these soils (see o.a.: EDELMAN, 1950; STEUR, 1960; PAPE, 1960; SCHELLING, 1960). The parent materials are generally the young cover sands deposited in very late pleistocene times and the "white sands" deposited during the Risz ice time (CROMMELIN, 1953; SCHELLING, 1960).
Recently, it was shown that podzol formation under Dutch conditions greatly depended on the clay content (VAN SCHUYLENBORGH, 1962). The materials with a clay content less than 2 % were extremely well suited for podzol formation.
Dutch soil-survey workers divide the Podzols into High, Medium-High, and Low Humus Podzols, dependent on the position above the ground-water level and on certain morphological characteristics. It was shown by the author (1961), that there is no essential difference in the genesis of many of these soils. The extremely low profiles, however, show different characteristics and it is the purpose of this paper to discuss three profiles of this group.

2. Methods

The same procedure was followed as described in parts I and III of this series (1962, 1964). Ca and Mg were not determined because of the extremely low contents of these elements. The nomenclature, developed in the 7th Approximation (Soil Survey Staff, 1960), was used. The profile descriptions can be found in the APPENDIX at the end of this paper.

3. Results and discussion

One of the three profiles (profile XXI) was situated on pushed preglacial brown

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fluviatile sand with a very low clay content (1,1—1,6 %) and the other two (profile XXII and XXIII) on yellowish brown young cover sand with a clay content of 1,5 to 1,9 %. Both profiles occurred in low parts of a slightly undulating area. At some periods of the year the ground water is at or even above the land surface.
From the grain-size distribution analyses (TABLE 4) it is evident, that prof. XXI has been formed in two layers of different textures, which is common for soils developed

TABLE 1. Analytical data of the soils

Prof.	Hor.	Thickness cm	C %	N %	C/N	pH H_2O	pH 0,01 M $CaCl_2$	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %	MnO %
XXI	A_1	0—13	2,24	0,069	32,5	3,96	3,34	88,2	2,01	0,26	0,18	0,003
	B	13—41	0,56	0,028	20,1	5,10	4,13	90,7	2,77	0,58	0,19	0,005
	II C	+ 41	0,17	0,008	20,6	5,32	4,45	90,2	2,58	0,66	0,13	0,004
XXII	A_{11}	0— 6	2,92	0,094	31,1	4,10	3,09	87,1	1,63	0,20	0,33	n.d.
	A_{12}	6—17	2,51	0,081	31,1	4,23	3,48	87,8	2,36	0,27	0,34	n.d.
	B	17—31	1,40	0,047	29,8	4,18	3,70	89,6	2,74	0,33	0,34	n.d.
	C	+ 31	0,38	0,015	25,3	4,66	3,96	89,2	3,39	0,50	0,44	n.d.
XXIII	A_{11}	0—13	9,64	0,340	28,4	3,58	3,17	76,0	2,19	0,30	0,40	n.d.
	A_{12}	13—19	5,13	0,149	34,4	3,98	3,39	82,3	2,44	0,25	0,40	n.d.
	B	19—30	2,42	0,088	27,5	4,36	3,63	87,3	2,82	0,31	0,35	n.d.
	II C	+ 30	0,43	0,015	28,7	4,62	3,84	91,5	2,38	0,30	0,24	n.d.

in fluviatile deposits. The mineralogical spectrum of the two materials is similar; the C-material, however, contains less quartz than the solum, whereas also the feldspar contents are slightly different (TABLE 5). The clay fraction, as a matter of fact, can be expected to be quite identical originally. For the establishment of the translocation of iron, aluminium and silica, the analysis of the clay fraction will give a better picture than the analysis of the total soil. Profile XXII seems to be satisfactorily homogeneous, although here too the C-material tends to be slightly different

TABLE 2. Analytical data of the clay separates

Prof.	Hor.	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %	MnO %
XXI	A_1	45,6	20,5	3,44	1,11	0,014
	B	51,9	25,9	5,47	1,13	0,014
	II C	46,5	27,2	7,02	0,77	0,015
XXII	A_{11}	38,0	13,9	1,20	n.d.	n.d.
	A_{12}	38,6	14,1	1,85	n.d.	n.d.
	B	42,1	15,7	2,69	n.d.	n.d.
	C	41,5	15,8	3,94	n.d.	n.d.
XXIII	A_{11}	47,9	13,9	0,93	0,29	n.d.
	A_{12}	42,6	15,3	1,33	0,48	n.d.
	B	45,2	18,1	3,03	0,40	n.d.
	II C	46,4	18,3	4,10	0,34	n.d.

(TABLE 5). The increasing contents of K-feldspars and plagioclases and the decreasing contents of quartz can be explained by the stability of these minerals. Quartz, as the most resistent mineral, is accumulated relatively, while the feldspars are weathered and dissolved especially in the A-horizon. Profile XXIII is certainly not formed in uniform material; the C-material, although of the same origin, has a coarser texture than the solum. It may be assumed, however, that the clay fraction of these wind-blown sands was originally the same all over the profile, so that the translocation of Fe, Al, and Si can be studied from the changes in chemical composition of the clay separates.

TABLE 3. Molar ratios of the soils and clay separates

Prof.	Hor.	Soil				Clay separate			
		$\frac{SiO_2}{R_2O_3}$	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{Al_2O_3}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{Al_2O_3}{Fe_2O_3}$
XXI	A_1	69	75	919	12,3	3,42	3,78	35	9,34
	B	49	56	420	7,56	3,00	3,40	25	7,43
	II C	51	59	366	6,17	2,49	2.90	18	6,08
XXII	A_{11}	84	91	1116	12,3	4,40	4,64	84	18,2
	A_{12}	59	63	861	13,6	4,30	4,65	55	11,9
	B	51	55	707	12,8	4,12	4,57	42	9,15
	C	41	45	480	10,7	3,86	4,48	28	6,29
XXIII	A_{11}	54	59	666	11,3	5,63	5,88	138	23,4
	A_{12}	54	57	857	15,0	4,47	4,72	85	18,1
	B	49	53	766	14,6	3,83	4,24	40	9,34
	II C	61	66	803	12,3	3,78	4,31	30	7,00

The results of the chemical analysis of the soils and of the clay separates are shown in TABLE 1 and 2; the molar ratios of silica and sesquioxides are given in TABLE 3. It is obvious from these results that the distribution of Al and Fe over the profile is quite different from that of Podzols. No illuviation horizon can be observed. Fe and Al are eluviated from the solum, Fe being more eluviated than Al. This is quite

TABLE 4. Grain-size distribution (mm) of the soils [1]

Prof.	Hor.	Thickness cm	> 2 %	2—1 %	1—0,5 %	0,5—0,25 %	0,25—0,10 %	0,10—0,05 %	0,05—0,002 %	< 0,002 %
XXI	A_1	0—13	0,8	3,8	18,0	19,9	35,7	9,9	10,7	1,2
	B	13—41	0,8	3,0	18,5	16,9	37,5	11,9	9,8	1,6
	C	+ 41	1,6	7,1	13,5	13,6	58,5	2,1	2,5	1,1
XXII	A_{11}	0— 6	—	0,3	0,7	4,5	49,3	32,0	11,5	1,8
	A_{12}	6—17	—	0,4	0,6	5,5	49,4	31,3	11,6	1,2
	B	17—31	—	0,1	0,6	3,9	43,2	33,9	16,8	1,5
	C	+ 31	—	—	0,1	2,0	31,5	45,0	20,0	1,4
XXIII	A_{11}	0—13	—	0,1	0,4	4,8	32,9	35,4	24,6	1,8
	A_{12}	13—19	—	0,1	0,3	3,0	33,9	38,1	22,8	1,8
	B	19—30	—	—	0,3	3,7	35,0	40,6	18,5	1,9
	C	+ 30	—	0,2	0,8	5,7	63,2	24,3	4,8	1,0

1 Expressed in percentage of the humus-free soil.

understandable as the soil is in a reduced state during a considerable part of the year; iron therefore occurs predominantly in the reduced state and can be easily washed down either in combination with organic matter (which is disperse; see APPENDIX) or not. The eluviation of Al is either subjected to the solubility of the hydroxide or to the complexing or chelating activities of the organic acids, depending on the stability of the Fe- and Al-complexes or chelates. A conclusive answer can only be given after the study of the properties of the organic matter in these soils.

TABLE 5. Mineralogical composition of the soils

Profile	Horizon	Quarz	K-feldspars	Plagioclase	Misc.
XXI	B	78	6	9	7
	II C	71	10	6	13
XXII	A_{11}	91	5	2	1
	A_{12}	88	7	2	3
	B	71	18	6	5
	C	81	10	6	3
XXIII	A_{11}	97	2	tr.	1
	A_{12}	97	2	tr.	1
	B	87	9	1	3
	II C	85	10	tr.	5

4. Classification

The analyses show clearly that there is no spodic horizon in these profiles. The name Podzol or Spodosol is therefore misleading. The soils have an umbric epipedon, and are therefore Inceptisols. Because the soils have characteristics associated with wetness, they can be classified as Umbraquepts. The profiles discussed cannot be placed in one of the four subgroups. As the parent material is too poor to produce motting, it is proposed to include a fifth subgroup, *viz.* the Psammic Umbraquepts.
It is evident that these profiles have nothing to do with Podzols. The soil-formation process is a podzolic one, but, because of the extremely wet conditions, there is no humus- or sesquioxydes-illuviation horizon. The only reason for the maintenance of the term "Low Humus Podzols" in the Netherlands would be the fact that they frequently occur in association with true podzols. This, however, is an feature external to the soil that cannot be used in soil classification.

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APPENDIX: Profile descriptions

Profile XXI. Epe (Veluwe, Gelderland). Elevation 20 m. Undulating land. Low part in the area. Drainage poor. Permeability good. Vegetation birch, juniper (*Juniperus communis* L.), *Molinia coerulea*. Mean annual rainfall 800 mm. Mean annual temperature 10 °C.

A_1	0—13 cm	Grey-brown (10YR 5/2 : dry) to very dark brown (10YR 2/2 : moist) sand. Very weakly developed blocky structure. Slightly firm. Bleached sand grains. Organic-matter type small moder. Bulk density 1,508. Clear and smooth on
B_h	13—41 cm	Pale brown (10YR 6/3 : dry) to dark brown (7.5YR 3/2 : moist) sand. Massive. Slightly firm. Vertical very dark brown lines and dots of decayed Molinia roots. Organic-matter type small moder and disperse humus as coatings on the sand grains. Bulk density 1,849. Gradual and smooth on
II C	+ 41 cm	Very pale brown (10YR 7/3 : dry) to brown (10YR 5/3 : moist) fine sand. Single grain. Loose. Some disperse humus as coatings on sand grains. Bulk density 1,760.

Profile XXII. Haren (N.-Brabant). Elevation 9 m. Undulating land. Low part in the area. Drainage very poor. Permeability good. Vegetation heather and *Molinia coerulea*. Mean annual rainfall 700 mm. Mean annual temperature 10 °C.

O	3— 0 cm	Dark reddish grey-brown (5YR 3/1½ : dry) to black (5YR 3/1 : moist) filty, partly decomposed organic material. Abrupt and smooth on
A_{11}	0— 6 cm	Brown (7.5YR 4½/2 : dry) to dark reddish-brown (5YR 2/2 : moist) fine sand. Massive. Firm. Abundant roots. Organic-matter type small moder. Sand grains strongly bleached. Bulk density 1,468. Abrupt and smooth on
A_{12}	6—17 cm	Dark brown (7.5YR 4/3 : dry) to dark reddish-brown (5YR 2/2 : moist), fine sand. Massive. Slightly firm. Many roots. Black dots of decayed Molinia roots. Organic-matter type small moder and disperse humus as coating on sand grains. Bulk density 1,286. Abrupt and smooth on
B_h	17—31 cm	Yellowish-brown (10YR 4½/4 : dry) to dark brown (10YR 3/3 : moist), loamy, fine sand. Weakly developed medium-blocky structure. Slightly firm. Few roots. Black dots of Molinia roots. Organic-matter type small moder and disperse humus as coatings on sand grains. Bulk density 1,252. Gradual and smooth on
C	+ 31 cm	Very pale brown (10YR 7/4 : dry) to yellowish-brown (10YR 5/4 : moist), loamy, fine sand. Very weakly developed, blocky structure. No roots. A few dots of decayed Molinia roots. Some very fine dots of disperse humus on sand grains. Bulk density 1,578.

Profile XXIII. Haren (N.-Brabant). Same area as prof. XXII. Lowest spot in the area. Groundwater level normally at the surface. Vegetation *Molinia coerulea*.

O	1— 0 cm	Dark reddish-grey brown (5YR 3/1½ ; dry) to black (5YR 3/1 : moist), filty, partly decomposed raw organic material. Abrupt and smooth on
A_{11}	0—13 cm	Black (5YR 2/1 : dry and moist) loamy, fine sand. Weakly developed thin platy structure. Smeary. Numerous roots. Sand grains bleached. Organic-matter type dense moder clusters and very fine dots of disperse humus. Bulk density 1,006. Clear and smooth on
A_{12}	13—19 cm	Dark reddish-brown (5YR 2/2 : dry) to black (5YR 2/1 : moist), loamy, fine sand. Weakly developed thin platy structure. Smeary. Some sand grains bleached. Organic-matter type very fine dots of disperse humus. Bulk density 1,134. Clear and smooth on
B_h	19—30 cm	Brown (7.5YR 4/4 : dry) to dark reddish-brown (5YR 2/2 : moist), loamy, fine sand. Very weakly developed blocky structure. Slightly firm. Many black dots of decayed Molinia roots. Sand grains coated with disperse humus. Bulk density 1,344. Gradual and smooth on
II C	+ 30 cm	Light yellowish-brown (10YR 6/4 : dry) to dark yellowish-brown (10YR 4/4 : moist), fine sand. Single grain structure. Loose. A few black dots of decayed Molinia roots. Some sand grains coated with disperse humus. Bulk density 1,735.