On soil genesis in temperate humid climate
I. Some soil groups in the Netherlands

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Summary

The translocations of constituents resulting in the formation of Podzols, Grey Brown Podzolic Soils, Acid Brown Earths, Brown Podzolic Soils and Gley soils are discussed. It is emphasized that the organic matter is one of the most important agents for these translocations. Organic matter delivered by leaf fall and roots decomposes by bacterial attack and forms different organic acids (such as polyuronic acids, aminoacids, carbonic acid, etc.). These acids percolate through the soil material, react with primary minerals and the constituents, set free by weathering of the parent rock, move to a certain depth and precipitate, or are completely removed by rains to the rivers. When excepting this mechanism, it will be obvious that soil formation will then be a function of:

1° The nature of organic acids; this nature is, in its turn, determined by vegetation and mode of decomposition of the dead leaves, twigs and roots. Here the climate and parent material has a strong effect. The formed organic acids are mobile and react with certain constituents to form chelates or complexes. As soon as complex- or chelate formation has proceeded to some extent, the complex or chelate becomes insoluble and precipitate, so that illuviation horizons are formed. The stability constants of these complexes may therefore give an idea about soil formation. Hence, translocation and precipitation will be a function of

2° the amount of the organic acids produced and

3° the nature of the parent material. As a consequence of this fact one can see that the A_2-horizon becomes thicker, the poorer the parent material (see *fig.* 1), climate being identical. The reaction of the organic acids with the parent material, will be dependent on the time of contact and this is affected by

4° amount of rainfall and

5° permeability of parent material and groundwater level.

It was concluded, that, in the Netherlands, Podzols had been developed on very poor and acid parent material (low in silt and low in clay, i.e. < 2 %). Acid Brown Earth and Brown Podzolic Soils on poor parent materials (some silt and some clay (2—5 %)) and Grey Brown Podzolic Soils and Gley soils on richer parent materials (loess and riverloams).

1. Introduction

Soil genesis can be defined as translocation of inorganic and/or organic substances. Generally this translocation proceeds in a vertical sense. In humid climates one finds always a downward and in arid climates an upward movement. Under influence of

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these translocations a differentiation into horizons takes place in the substrate (parent material). This process of horizon formation can be weakened or even suppressed by biological effects to form more or less homogeneous soils. The substances which are translocated are: organic matter, clay, silicic acid, iron and aluminium oxide, calcium and magnesium. Sodium and potassium are very mobile and are either removed almost completely from the profile (e.g. podzols) or accumulated (e.g. alkali soils).
The rate of translocation depends on the parent material, the climate (temperature, precipitation, evaporation) and topography (groundwater level). Both climate and groundwater level effect the type of vegetation, that in its turn influences soil formation. When parent material, climate and groundwater level do not change or change only slightly during soil formation, the formation of autochtonous soils is the result. These soils are very important for the study of the chemical soil-forming processes. However, in many areas, e.g. in Holland, the climate has changed strongly: warmer and colder, humid and less humid periods have alternated and have so affected soil formation. The parent material too has changed in many cases by erosion (water- or wind erosion) and by alluviation and wind deposition. This has led to either the formation of decapitated profiles, or to polygenetic ones.
It will be evident that for a good understanding of rate and type of soil formation, a quantitative evaluation of the translocated substances is indispensable. The chemical and physical analysis of the horizons of the profile is a means. It will also be evident, that only autochtonous soils are suited for this purpose, as here the whole profile is composed from one and only one parent material, and the now present C-horizon corresponds in its composition with the substrate from which the other horizons are formed. This paper deals with the study of such profiles as far as possible.
The wide variability of climate and parent rock has led to the formation of a large number of soils and it was necessary to create a classification scheme. Soil scientists in America have recently developed a new scheme (1960) and also other countries, among which Holland (SCHELLING, 1960; STEUR, 1960; PAPE, 1960; PIJLS, 1960), have paid much attention to these problems. The soils are divided into different categories and, without discussing the problem further, it can be said that from the viewpoint of soil formation the category of the "Great Soil Groups" is very important.
In this paper some soil groups occurring in the Netherlands will be discussed, viz. the Podzols, the Grey-Brown Podzolic Soils (shortly: Grey-Browns), the Acid Brown Earths (Sols Brun Acides) and Brown Podzolic Soils and, finally, the Gley soils.

2. Methods

Before air-drying the soil samples, certain quantities were taken for the pH-determination and for the size-distribution analysis. For the pH-determination 10 g of soil were suspended in 25 ml of distilled water or in 25 ml 0,01 Mol. $CaCl_2$-solution. The pipet-method was used for the mechanical analysis using 25 ml 0,12 Mol. $Na_4P_2O_7$-solution as the peptiser. The sand fraction ($> 50\ \mu$) was sieved in a dry state according to the american system.
Organic carbon was determined by oxidation with chromic acid (ALLISON, 1935) and the concentration of the green Cr^{+3}-ions was determined colorimetrically at a wavelength of 585 mμ.
Nitrogen was determined with the Kjeldahl method, while NH_3 was steam-distilled

into a solution of boric acid and titrated with $KH(IO_3)_2$-solution of known strength (SILVERSTEIN and PERTHEL, 1950) using a mixture of bromcresolgreen and methylred as the indicator. The C/N ratio gives an idea about the qualification of the organic matter present, because nitrogen occurs predominantly in organic form, which is especially true in the Podzols investigated.

The method of the elemental analysis was followed for the investigation of the translocation of some elements. The determination of "free aluminium" or "free iron", therefore, was omitted, as the interpretation of such values is difficult (only the "free iron" contents of some profiles were determined according to JACKSON, 1958); changes in "free iron" content do not necessarily coincide with changes in total iron content. A higher content of "free iron oxide" in one horizon does not necessarily mean that iron has been translocated into this horizon; it can be present in a different form. It can only be concluded to a translocation of iron if an increase in "free iron oxide" coincides with an increase in "total iron oxide" content. A determination of total iron is, therefore, more to the point. In many cases the free iron will be present in the clay separate ($< 2\ \mu$) and in many cases this will not be true (e.g. see TABLE 4, profile IX). Therefore, it was decided to perform an elemental analysis of the soil as well as of the clay separate. By substraction, it is then possible to calculate the elemental composition of the sand + silt separate.

The soil and the clay separate were fused with soda. The silica was separated by dehydration with hydrochloric acid, filtrated, heated to 800 °C and weighed. After volatilization of the silicium with hydrofluoric acid, heating the residu to 800 °C and weighing, the loss of weight was taken as the weight of silica. The residue was dissolved in hydrochloric acid and added to the filtrate of the silica separation.

The filtrate was made up to volume and specified portions were taken to determine iron by titration with EDTA and sulfosalicylic acid as the indicator (KUANG LU CHENG, *et al.*, 1953), aluminium by colorimetric analysis with aluminon at pH 4,2 and wavelength of 525 m μ (SANDELL, 1959), titanium by colorimetric analysis with H_2O_2 in 5 % sulfuric acid solution and at a wavelength of 410 m μ (WEISLER, 1935) and manganese by colorimetric analysis with formaldoxim at a wavelength of 450 m μ (SCHUFFELEN, *et al.*, 1961). Of some soils Ca was determined by complexometric titration, using calcein as the indicator (VAN SCHOUWENBURG, 1961) while the phosphate interference was eliminated by the addition of ammoniummolybdate (MIDDLETON, 1961).

The nomenclature of the Soil Survey Manual (1951) and colour indication of the Munsell Soil Color Charts were used as far as possible for the discription of the soil profiles.

3. Results and discussion

a. *The Podzols.* Especially the Humus Iron- and Humus-Podzols were investigated. The proposed American name for these soils is Spodosol.

The podzols belong to the most investigated soils. Nevertheless there are some points that the author wants to discuss. A long time ago the idea has been accepted in the Netherlands, that the Podzols might be formed under the influence of a heather vegetation. Recently, however, EDELMAN (1960) has raised much doubt about this idea, supported by the occurrence of Podzols under a forest vegetation in other countries (e.g. North-America, Russia and others). Because in the Netherlands hardly any Podzols can be found which have not beared a man-affected vegetation, two examples

of Humus Iron Podzols will be discussed here, the vegetation of which has not been influenced by human interference.
One profile is situated in Tapanuli (Sumatra, Indonesia) and the other in Germany (Schwarzwald). The profile descriptions are as follows:

Profile I. Residency Tapanuli (Sumatra). Near village Laepondom. Altitude: 1600 m. Rainfall: 2500 mm/year. Mean temp.: 16.5° C. Hilly area. Flat part. Good drainage. Parent material: liparitic volcanic ash. Vegetation: primary tropical rainforest.

A_0	0—20 cm	Partly decomposed raw humus. When dry, the material is difficult to be wetted.
A_2	20—30 cm	Grey (5YR5/1) to dark reddish grey (5YR3/1) sandy loam. Weak fine crumb. Many roots. When dry, it is difficult wettable. Clear and smooth on
B_{2h}	30—50 cm	Reddish brown (5YR5/3) to dark reddish brown (5YR3/2) sandy loam. Thick platy. Firm. Few roots. Dark reddish grey (5YR4/2) mottling (root mottling). When dry, difficultly wettable. Abrupt and smooth on
B_{2ir}	50—55 cm	Yellow (10YR7½/6) to reddish yellow (7.5YR6/8) loam. Irregularly platy. Very firm. No roots. Clear and smooth on
C	+55 cm	White (10YR9/1) to pale yellow (2.5Y7/4) loam. Massive. Yellowish red (5YR5/8) and yellow (10YR7/8) mottling. Remnants of pumice stones.

Profile II. Forbach. Schwarzwald (Germany). Altitude: 720 m. Mountainous area. Slope: 20—30°. Well-drained. Parent material: glacial till from Buntsandstein. Vegetation: primary forest of fir and spruce; further Vaccinium myrtillus, Aira flexuosa, Sphagnum spec., Polytrichum formosum, Hypnum Schreberi.

A_1	0—5 cm	Dark reddish brown (5YR3/2—5YR2/2) sand with raw humus and Sphagnum moder. Many bleached sand grains. Abrupt and wavy on
A_2	5—40 cm	Pink (5YR6½/3) to reddish brown (5YR5/3) sand with disperse humus. Single grain structure. Loose. Clear and wavy on
B_{2h}	40—50 cm	Reddish brown (5YR4/3½—5YR3/2) loamy sand. Blocky and firm.
B_{2ir}	50—80 cm	Yellowish red (5YR5/6) to reddish brown (5YR4/4) sand. Massive. Very firm. Clear and wavy on
C	80—120 cm	Reddish yellow (7.5YR6/5) to reddish brown (5YR4/4) sand. Massive and compact. Abrupt and smooth on
D	+120 cm	Light reddish brown (5YR6/4) to reddish brown (5YR4/3) cemented sand. It is composed of other material than the solum.

Both profiles are completely autochtonous (see *table* 1 and 3) and human influence is nearly absent. The vegetation can be considered to be the original vegetation.

A striking fact of these forest podzols is the reddish hue in the A_2-material, and this is not found in the heather podzols as will be shown later. Probably this is caused by the different nature of the organic material occurring in both types of Podzols. From TABLE 1 and 2 the following well-known facts can be recognized: there is a distinct humus- and clay-accumulation horizon (B_{2h}) and a distinct iron-accumulation horizon (B_{2ir}). Less well-known is the fact that aluminium with respect to iron accumulates in the A_2 and B_{2h} (see: Al_2O_3/Fe_2O_3-ratios of TABLE 1 and 2), permitting the conclusion that iron is more mobile than aluminium. Well-known is the fact, that the organic matter, that accumulates in the B-horizon, has a different composition from that of the A-horizons (see: C/N ratios of TABLE 1). Further details can be found in the work of a.o. SCHLICHTING (1953), SCHEFFER and WELTE (1950) and FLAIG *et al.* (1955).
As it is now realised that iron and aluminium are translocated either as complexes

FIGURE
Podzol on (left) white ("poor") sand and on (right) brown ("richer") sand. Boundary between white and brown sand indicated by dotted line. Note the thick A_2-horizon on poor parent material compared with the thinner A_2-horizon on richer parent material

with organic acids (JONES and WILSON, 1929; GALLAGHER, 1942; BLOOMFIELD, 1953, 1954, 1955, 1959; SCHEFFER *et al.*, 1959; SCHEFFER and ULRICH, 1960) or as electrostatic combinations of oppositely charged colloids (MATTSON, 1931; DEB, 1949; SCHNITZER and DELONG, 1955), it is obvious to relate the organic matter in the various horizons with the separation of iron and aluminium in the case of Humus Iron Podzols. If the organic matter with the higher C/N-ratio forms with iron a more stable complex than with aluminium under the prevailing conditions, then it is possible to account for the different mobility of iron and aluminium. It is more difficult to give an acceptable explanation for the deposition of the organic matter complexes in the B-horizon. If we assume that the pure organic polyacids are soluble, but become insoluble after a certain degree of "saturation" with iron and/or aluminium, than a correlation would exist between the composition of the parent material and the upper boundary of the B_{2h} horizon, climatic and drainage conditions being equal; the smaller the Fe and Al-content of the parent material the deeper the upper boundary of the B_{2h}-horizon below the surface. This can be frequently seen in the case of Podzols, occurring in the Netherlands (see FIGURE).

However, little is known about the complexing properties and solubilities of the different constituents of soil organic matter, so that it is not possible to obtain an exact picture of the formation of podzols.

Passing on to the Humus Iron Podzols in Holland, three profiles will be discussed.

P r o f i l e III. Horst. Altitude: 20 m. Gently rolling land. Perfectly drained. Parent material: young cover sand (older Dryas: late glacial). Vegetation: young forest of birch and fir; probably reafforested heather land.

A_1	0—10 cm	Grey (10YR5/1) to dark grey (10YR4/1) sand. Single grain and very loose. Many bleached sand grains. Many roots. Clear and smooth on
A_2	10—25 cm	Light grey (10YR7/1½) to grey (10YR5/1) sand. Single grain and very loose. Few roots. Abrupt and smooth on
B_{2h}	25—30 cm	Dark brown (7.5YR4/2) to dark reddish brown (5YR2/2) sand. Massive and slightly firm. Abrupt and wavy on
B_{2ir}	30—40 cm	Reddish yellow (7.5YR6/6) to reddish brown (5YR4/4) sand. Massive and very firm. The upper boundary of this horizon consists of a 3 mm thick layer, cemented by iron oxide, with yellowish red (5YR4/6) to dark red (2.5YR3/6) colour. Diffuse and smooth on
B_3	40—97 cm	Pale brown (10YR7/4) to brown (10YR5½/3) sand with many ondulating horizontal grey brown (10YR4/2) humus-iron fibers. Clear and smooth on
C	+97 cm	Pale yellow (2.5Y8/4) to light yellowish brown (2.5Y6/3) sand. Single grain and very loose.

P r o f i l e IV. Horst. Altitude: 20 m. Gently rolling land. Well-drained. Parent material: young cover sand (older Dryas: late glacial): somewhat loamier than that of profile III. Vegetation: young forest of birch and fir on reafforested heather field.

A_1	0—12 cm	Dark grey (10YR4½/1) to very dark grey (10YR3/1) sand. Single grain and loose. Abrupt and smooth on
A_2	12—28 cm	Grey (10YR5/1) to very dark grey (10YR3/1) sand. Single grain and very loose. Common, moderate, coarse, light grey (10YR7/1) to grey (10YR6/1) mottling (root-mottling). Clear and wavy on
B_{2h}	28—36 cm	Brown (7.5YR4/2) to dark reddish brown (5YR2/2) loamy sand. Massive and firm. Abrupt and irregular on
B_{2ir}	36—48 cm	Brown (10YR5/3) to dark brown (10YR3/3) loamy sand. Single grain and loose. Many, prominent, fine, pale brown (10YR7/3) to light yellowish brown (10YR6/4) mottles. Gradual and wavy on
C	48—70 cm	Yellow (10YR8/6) to light yellowish brown (10YR6½/4) sand. Single grain and very loose.

TABLE 1. Chemical data of the soil profiles

Profile	Horizon	Thickness in cm	pH		C %	C/N	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	SiO_2/R_2O_3	SiO_2/Al_2O_3	SiO_2/Fe_2O_3	Al_2O_3/Fe_2O_3	TiO_2 %	MnO %	CaO %
			H_2O	0,01 m $CaCl_2$												
I	A_0	0—20	3,42	n.d.	47,8	22,3	—	—	—	—	—	—	—	—	—	—
	A_2	20—30	4,72	n.d.	7,4	22,2	93,3	1,70	0,22	86	93	1111	12,9	0,55	n.d.	n.d.
	B_{2h}	30—50	5,13	n.d.	11,6	37,3	89,1	4,92	0,29	30	31	825	27	0,24	n.d.	n.d.
	B_{2ir}	50—55	5,75	n.d.	1,9	42,9	91,0	4,42	0,95	31	35	257	7,33	0,15	n.d.	n.d.
	C	+55	5,79	n.d.	0,2	—	94,1	3,78	0,43	39	42	581	17,8	0,06	n.d.	n.d.
II	A_1	0—5	4,38	4,05	8,8	17,5	85,8	1,98	0,48	64	74	477	6,47	0,12	n.d.	n.d.
	A_2	5—40	4,09	3,27	0,9	16,1	93,7	2,48	0,45	58	64	558	8,70	0,16	n.d.	n.d.
	B_{2h}	40—50	4,38	3,55	4,3	21,0	86,1	4,73	1,81	25	31	127	4,11	0,20	n.d.	n.d.
	B_{2ir}	50—80	5,16	3,97	2,4	25,1	84,8	6,20	2,04	19	23	110	4,75	0,21	n.d.	n.d.
	C	80—120	5,32	4,26	1,5	27,4	86,9	5,42	1,39	23	27	166	6,10	0,15	n.d.	n.d.
	D	+120	6,70	6,51	1,2	22,3	84,0	7,24	2,13	17	20	105	5,34	0,13	n.d.	n.d.
III	A_1	0—10	4,49	4,18	1,3	43,9	94,6	1,14	0,21	126	141	1210	8,60	0,20	0,002	n.d.
	A_2	10—25	5,00	4,19	0,4	49,3	97,1	1,07	0,13	141	154	2020	13,1	0,20	0,002	n.d.
	B_{2h}	25—30	4,44	4,21	1,8	19,9	90,2	2,59	0,37	55	60	654	10,9	0,18	0,002	n.d.
	B_{2ir}	30—40	4,30	4,42	0,5	29,2	91,7	3,50	1,18	36	43	207	4,77	0,20	0,006	n.d.
	BC	40—97	4,97	4,55	0,2	30,8	95,1	2,46	0,49	58	66	511	7,80	0,20	0,005	n.d.
	C	+97	5,02	4,34	0,1	—	95,2	2,26	0,44	64	72	566	7,94	0,17	0,004	n.d.
IV	A_1	0—12	4,49	4,04	2,1	51,0	88,5	1,24	0,38	102	122	614	5,04	0,24	0,004	n.d.
	A_2	12—28	4,52	4,00	1,2	64,3	90,2	1,36	0,34	98	113	716	6,35	0,26	0,006	n.d.
	B_{2h}	28—36	4,37	4,18	2,3	33,9	83,1	2,35	0,72	50	60	308	5,12	0,27	0,007	n.d.
	B_{2ir}	36—48	4,36	4,33	1,4	32,8	84,5	2,64	0,96	44	54	235	4,32	0,25	0,007	n.d.
	C	48—70	4,42	4,30	0,5	46,0	87,3	1,64	0,46	77	90	502	5,54	0,25	0,008	n.d.
V	A_1	0—14	3,60	2,92	25,2	30,0	56,9	0,71	0,16	118	135	948	7,00	0,10	0,003	n.d.
	A_2	14—29	4,18	3,14	1,4	44,3	94,8	0,62	0,08	239	259	3158	12,5	0,14	0,003	n.d.
	B_{2h}	29—48	4,25	3,43	4,7	37,7	84,8	1,90	0,21	71	76	1087	14,6	0,14	0,004	n.d.
	B_{2ir}	48—64	4,64	3,85	1,5	40,0	91,6	1,23	0,29	111	136	848	6,65	0,16	0,004	n.d.
	C	+64	5,02	4,22	0,4	55,0	93,7	1,18	0,36	107	135	710	5,18	0,17	0,006	n.d.
VI	A_p	0—20	4,57	4,77	1,9	13,7	80,7	4,48	2,20	23	31	97	3,19	0,64	0,048	n.d.
	A_2	20—52	4,72	4,20	0,4	10,9	83,4	5,05	2,20	22	28	101	3,59	0,66	0,072	n.d.
	B_1	52—70	6,43	5,50	0,5	10,7	81,5	5,98	2,56	18,2	23	85	3,66	0,71	0,042	n.d.
	B_2	70—115	6,75	6,30	0,3	8,7	75,5	7,49	3,80	12,8	17,1	51	2,96	0,68	0,049	n.d.
	B_3	115—140	6,94	6,34	0,2	7,9	77,1	6,91	3,78	14,1	18,9	55	2,87	0,69	0,044	n.d.
VII	A_p	0—20	4,82	4,24	1,2	10,6	83,9	6,56	2,31	17,8	22	97	4,46	0,36	0,064	0,30
	A_2	20—33	4,53	4,00	1,0	10,5	81,5	7,50	2,92	14,8	18,5	74	4,02	0,44	0,091	0,29
	B_1	33—53	4,62	4,07	0,5	7,5	80,8	8,42	2,80	13,5	16,3	77	4,72	0,49	0,124	0,30

	B_{21}	53—68	4,89	4,28	0,4	5,6	79,8	9,00	3,26	12,3	15,1	65	4,33	0,51	0,134	0,32
	B_{22}	68—89	5,55	4,89	0,3	4,5	78,3	10,0	3,97	10,6	13,3	53	3,96	0,52	0,099	0,40
	D	89—100	5,62	5,21	0,1	2,5	80,3	9,18	3,38	12,0	15,0	63	4,26	0,31	0,051	0,45
VIII	A_1	0—5	4,70	3,95	2,5	27,6	88,6	2,43	0,89	50	62	264	4,26	0,33	0,015	n.d.
	$(B)_1$	5—32	4,70	4,60	0,3	20,7	92,2	2,53	0,85	51	62	290	4,68	0,38	0,035	n.d.
	$(B)_3$	32—52	4,74	4,56	0,3	38,0	91,7	2,59	0,82	52	60	300	5,00	0,38	0,025	n.d.
	C	+52	4,75	4,45	0,2	40,0	92,7	2,07	0,87	60	77	286	3,72	0,30	0,020	n.d.
IX	A_1	0—22	4,20	3,72	5,3	29,4	84,2	3,28	1,68	33	43	136	3,13	0,19	0,010	n.d.
	$(B)_1$	22—34	4,58	4,26	3,0	30,6	89,2	3,46	1,69	33	44	140	3,20	0,16	0,011	n.d.
	$(B)_3$	34—55	4,60	4,54	1,0	24,4	91,9	4,37	1,64	29	36	150	4,21	0,19	0,012	n.d.
	C	+55	4,64	4,46	0,4	23,1	89,8	3,88	1,36	32	39	176	4,47	0,16	0,030	n.d.
X	A_1	0—15	3,36	2,95	3,9	37,6	85,6	2,69	1,21	42	54	187	3,48	0,24	0,011	0,067
	$(B)_1$	15—38	4,35	4,33	1,4	30,0	88,3	3,84	1,40	32	39	170	4,33	0,25	0,014	0,077
	$(B)_3$	38—63	4,40	4,33	0,2	11,0	89,0	4,09	1,47	30	37	161	4,35	0,25	0,018	0,076
	C	63—81	4,53	4,22	nih.	—	90,5	3,91	1,50	32	39	160	4,08	0,17	0,016	0,066
	D_r	81—97	4,59	4,13	nih.	—	89,8	4,06	1,46	31	38	160	4,38	0,14	0,017	0,053
XI	A_1	0—8	4,46	3,78	2,8	41,3	81,4	7,07	2,11	16,4	19,6	103	5,25	0,78	0,021	0,66
	A_{2g}	8—25	4,25	3,73	0,8	23,6	83,8	7,47	2,52	15,7	19,1	88	4,63	0,78	0,026	0,58
	B_{1g}	25—45	4,41	3,80	0,4	12,3	79,5	9,95	4,26	10,7	13,6	50	3,67	0,86	0,055	0,59
	B_{2g}	45—95	4,84	4,20	0,2	6,9	74,0	11,7	6,29	8,01	10,8	31	2,92	0,81	0,082	0,68
	B_{3g}	95—120	4,88	4,21	0,3	8,4	73,8	12,0	5,73	8,01	10,4	34	3,29	0,80	0,064	0,73
XII	A_1	0—10	4,18	3,71	3,6	11,2	79,1	5,61	3,16	17,6	24	67	2,78	0,43	0,051	n.d.
	A_{2g}	10—30	4,46	3,78	2,9	20,1	72,3	7,92	2,62	12,8	15,5	74	4,74	0,77	0,035	n.d.
	B_{1g}	30—46	4,70	3,84	0,6	8,3	74,7	8,86	3,19	11,8	14,5	62	4,34	0,75	0,068	n.d.
	B_{2g}	46—65	4,76	3,92	0,6	6,6	62,9	15,8	9,04	4,95	6,74	18,5	2,73	0,86	0,142	n.d.
	B_{3g}	65—83	4,72	3,90	0,4	5,6	68,4	13,5	5,55	6,84	8,63	33	3,80	0,69	0,095	n.d.
	D_g	+83	4,72	3,93	0,2	18,8	95,7	1,95	0,43	73	83	590	7,07	0,06	0,023	n.d.
XIII	A_1	0—7	4,14	3,54	15,2	23,5	57,7	4,30	1,67	18,3	23	92	4,06	0,49	0,017	n.d.
	A_{2g}	7—24	4,22	3,77	4,7	38,4	76,8	4,68	1,32	24	28	156	4,60	0,62	0,014	n.d.
	B_{1g}	24—29	4,55	4,11	1,0	29,3	81,3	5,56	1,26	22	25	172	6,90	0,61	0,015	n.d.
	B_{2g}	29—48	4,56	4,14	0,5	31,5	81,5	4,82	1,51	24	29	145	5,03	0,62	0,015	n.d.
	B_{3g}	48—86	4,18	3,92	0,4	23,5	80,6	6,35	3,45	16,0	22	62	2,88	0,64	0,017	n.d.
	D_g	86—140	4,72	4,12	0,3	17,7	80,7	5,28	3,66	18,0	26	59	2,26	0,47	0,049	n.d.
XIV	A_1	0—16	6,78	6,25	3,7	17,6	74,9	6,90	3,24	19,7	29	62	2,13	0,72	0,046	n.d.
	A_{2g}	16—32	6,56	6,14	1,4	15,7	78,6	7,01	2,60	22	30	81	2,70	0,78	0,030	n.d.
	B_{2g}	32—50	6,60	6,06	0,4	14,0	79,2	7,98	3,00	19,2	27	70	2,65	0,80	0,084	n.d.
	B_{1g}	50—95	6,56	6,07	0,1	7,0	74,6	10,2	4,49	13,5	19,5	44	2,27	0,85	0,109	n.d.
	G	+95	5,56	4,97	nih.	—	79,3	8,18	2,85	19,2	26	74	2,87	0,86	0,035	n.d.

TABLE 2. Chemical composition (partial) of the clay separates

Pro-file	Hori-zon	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	$\frac{SiO_2}{R_2O_3}$	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{Al_2O_3}{Fe_2O_3}$	TiO_2 %	MnO %
I	A_0	—	—	—	—	—	—	—	—	—
	A_2	28,3	18,1	2,35	2,45	2,66	32	12,2	2,75	n.d.
	B_{2h}	12,7	38,8	2,30	0,54	0,56	14,8	26	1,09	n.d.
	B_{2ir}	26,4	36,2	7,77	1,07	1,21	8,84	7,32	0,67	n.d.
	C	32,7	43,0	4,89	1,21	1,30	18	13,8	0,37	n.d.
II	A_1	40,5	16,9	3,24	3,62	4,06	37	8,23	0,68	0,016
	A_2	43,6	19,9	4,26	3,28	3,73	27	7,32	0,83	0,032
	B_{2h}	40,7	22,4	5,66	2,65	3,09	19,1	6,21	0,86	0,036
	B_{2ir}	40,9	23,8	7,16	2,47	2,94	15,2	5,17	0,82	0,044
	C	34,9	22,4	5,78	2,28	2,65	16,1	6,08	0,63	0,037
III	A_1	59,2	12,3	2,78	7,15	8,17	57	6,93	2,21	n.d.
	A_2	58,5	18,6	2,70	4,89	5,35	58	10,8	2,80	n.d.
	B_{2h}	55,5	18,3	3,11	4,66	5,16	48	9,23	1,66	n.d.
	B_{2ir}	41,7	17,3	12,4	2,81	4,09	8,98	2,20	1,71	n.d.
	BC	47,5	8,13	1,63	8,81	9,94	78	7,81	1,08	n.d.
IV	A_1	58,1	15,2	2,02	6,01	6,52	77	11,8	1,79	0,017
	A_2	57,5	16,6	1,60	5,54	5,88	96	16,3	1,91	0,026
	B_{2h}	50,0	17,5	2,42	4,54	4,94	56	11,4	1,59	0,035
	B_{2ir}	42,4	20,6	10,7	2,63	3,51	10,6	3,01	1,45	0,050
	C	51,4	20,9	4,08	3,73	4,19	34	8,02	1,52	0,032
VI	A_p	47,4	21,1	10,8	2,87	3,81	11,6	3,05	1,25	0,032
	A_2	47,7	21,2	10,0	2,94	3,82	12,7	3,32	1,28	0,033
	B_1	48,1	21,6	11,0	2,82	3,78	11,7	3,09	1,29	0,036
	B_2	74,5	20,3	13,8	2,60	3,74	8,62	2,31	1,12	0,033
	C	46,0	20,2	13,5	2,71	3,87	9,07	2,35	1,17	0,038
VII	A_p	51,5	22,3	8,06	3,19	3,92	16,1	4,34	1,09	0,034
	A_2	46,0	21,3	9,09	2,89	3,67	13,5	3,68	1,16	0,050
	B_1	49,0	22,3	8,59	2,99	3,72	15,2	4,08	1,09	0,050
	B_{21}	48,3	22,2	8,60	2,96	3,69	15,0	4,05	1,06	0,056
	B_{22}	44,7	22,9	9,06	2,65	3,31	13,1	3,97	0,98	0,042
	D	45,0	21,3	9,67	2,79	3,60	12,4	3,45	0,80	0,040
VIII	A_1	50,1	21,4	8,10	3,20	3,97	16,5	4,15	1,56	n.d.
	$(B)_1$	50,9	22,8	8,00	3,09	3,79	17,0	4,48	1,37	n.d.
	$(B)_2$	50,3	22,7	7,24	3,07	3,70	18,2	4,91	1,42	n.d.
	C	50,0	22,5	8,44	3,05	3,78	15,8	4,17	1,50	n.d.
IX	A_1	42,5	18,5	9,26	2,99	3,90	12,2	3,13	1,13	0,130
	$(B)_1$	45,5	20,8	10,2	2,83	3,72	11,8	3,19	1,14	0,207
	$(B)_2$	46,7	21,2	10,3	2,87	3,76	12,1	3,24	1,14	0,182
	C	44,8	22,7	10,9	2,57	3,36	11,0	3,29	1,06	0,254
X	A_1	42,4	13,0	7,55	3,45	4,49	15,0	3,33	1,17	0,039
	$(B)_1$	40,6	19,3	10,6	2,65	3,57	10,2	2,86	1,04	0,068
	$(B)_2$	35,9	19,6	10,9	2,30	3,11	8,79	2,82	0,91	0,058
	C	31,8	18,7	12,3	2,04	2,88	6,88	2,39	0,91	0,055
	D	24,8	14,1	11,2	1,99	2,99	5,09	1,97	0,71	0,040
XI	A_1	45,9	19,3	3,80	3,60	4,05	32	7,95	1,32	0,010
	A_{2g}	47,3	19,8	3,18	3,68	4,06	40	9,76	1,45	0,008
	B_{1g}	53,0	22,2	4,68	3,58	4,06	30	7,45	1,39	0,010
	B_{2g}	42,2	19,2	10,1	2,80	3,74	11,2	3,00	0,90	0,018
	B_{3g}	42,8	19,8	9,66	2,80	3,68	10,1	3,21	1,05	0,018

Profile	Horizon	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	$\frac{SiO_2}{R_2O_3}$	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{Al_2O_3}{Fe_2O_3}$	TiO_2 %	MnO %
XII	A_1	45,6	31,0	6,82	2,18	2,50	17,4	6,98	0,86	0,120
	A_{2g}	47,7	33,7	5,88	2,16	2,41	21,6	8,98	0,90	0,080
	B_{1g}	47,6	34,5	6,42	2,09	2,37	19,8	8,44	1,01	0,625
	B_{2g}	43,2	35,2	14,8	1,64	2,09	7,76	3,72	0,70	0,334
	B_{3g}	45,8	33,6	8,31	2,01	2,31	14,7	6,35	0,67	0,174
XIII	A_1	50,7	22,3	3,15	3,54	3,86	43	11,1	1,34	0,017
	A_2	48,2	22,0	2,65	3,45	3,72	48	13,0	1,45	0,017
	B_{1g}	51,8	24,1	3,47	3,35	3,66	40	10,8	1,44	0,020
	B_{2g}	51,2	23,7	3,98	3,32	3,67	34	9,33	1,50	0,016
	B_{3g}	45,2	21,1	5,41	3,14	3,65	22	6,09	1,14	0,020
XIV	A_1	41,3	18,7	9,70	2,82	3,75	11,3	3,02	1,02	0,033
	A_{2g}	42,3	19,1	9,86	2,83	3,77	11,5	3,04	1,01	0,030
	B_{1g}	42,5	19,2	9,83	2,84	3,76	11,5	3,05	1,01	0,037
	B_{2g}	43,8	19,0	12,4	2,77	3,92	9,41	2,40	0,99	0,042
	G	39,3	16,3	8,23	3,10	4,10	12,7	3,10	0,78	0,016

Profile V. Rolde. Altitude: 12 m. Gently rolling land. Moderately drained. Parent material: young cover sand (older Dryas: late glacial). Vegetation: heather with few firs.

A_1	0—14 cm	Dark brown (10YR3/3) to very dark brown (10YR2/2) peaty, felty, root mass. Abrupt and smooth on
A_2	14—29 cm	Light grey (2.5Y6½/0 to light brown grey (10YR6/2) sand. Single grain and loose. Few roots. Abrupt and smooth on
B_{2h}	29—48 cm	Dark brown (7.5YR3/2) to dark reddish brown (5YR2/2) sand. Felty root mass on water stagnating B_{2ir} . Abrupt and smooth on
B_{2ir}	48—64 cm	Dark brown (7.5YR4/3) to dark brown (5YR3/4) sand. Massive and firm. Horizontal humus-iron fibers. Many, prominent, moderate, brown (7.5YR4/4) mottles. Gradual and smooth on
C_D	+64 cm	Yellow (10YR7½/6) to reddish yellow (7.5YR6/6) older young cover sand. Weak blocky. Friable.

Profile III and IV are autochtonous (see *table* 1 and 3); profile V, however, not. The CD horizon is not composed of the material form which the profile is formed.

The profiles III, IV and V differ from profiles I and II in the colours of the A_2 and in the organic matter distribution. The colour of the A_2-horizon is grey without the reddish hue of the A_2 of the forest podzols; this is a consequence of the heather vegetation.

Whereas in profiles I and II the organic matter fraction with the high C/N-quotient accumulates in the B-horizon, we see in the profiles III and IV an accumulation of organic matter with low C/N ratio in the B-horizon; in profile V there is no difference in composion. This has to be attributed to the dominant effect of the heather vegetation on soil formation in the case of profiles III and IV, whereas in profile V an effect of the original forest as well as an effect of the heather vegetation is observable, leading to a more or less equal composition of the organic matter over the whole profile.

The mobilities of the different elements is comparable with those in profiles I and II and, as a consequence, it has now to be assumed that iron forms the most stable complex with the organic acid of low C/N-ratio. This is not very astonishing because it is very well imaginable that various organic acids form complexes with comparable stabilities with iron and aluminium. Once again it is obvious that it is not possible to obtain a good insight in soil formation without a good knowledge of the organic matter of the soil.
Soil Survey workers in the Netherlands classify profiles I, II and III as High Humus Podzols and the profiles IV and V as Lower Humus Podzols (STEUR, 1960; PAPE, 1960). The qualification high and low refers to the position with respect to the groundwater and is therefore a hydrographic classification. In the U.S. of America profiles I and II would probably be classified as Orthods, III and IV as Humods and V as an Aquod. Without discussing the merits of these classifications, it has to be remarked here that there is no difference from a genetic point; all profiles show a humus- and clay-accumulation horizon and an aluminium- and iron-accumulation horizon. Also the distribution of the different constituents over the profile is the same. However, the level of the contents of iron and aluminium is different; in the cases of profiles I, II, III and IV this can be attributed to a difference in parent material, but in the case of profile V to a difference in hydrographic position. The genesis of this last profile can be represented in the following way: after the deposition of the parent material the groundwater level was raised, so that the material was affected by reduction conditions which led to an impoverishment of iron. After a lowering of the groundwater level in later times a normal podzol formation started on this poor parent material with the consequent translocation and deposition of constituents, characteristic for a Humus Iron Podzol. From a genetic viewpoint, all these soils belong to the Humus Iron Podzols; however, they have a different value as a habitat for plants. Considering this fact and the fact, that the iron content of profile V is very low, it is justified to classify this profile as a Humus Podzol.

b. *The Grey Brown Podzolic Soils.* Profiles VI and VII are examples. They belong to the Udalfs according to the 7th approximation and to the High Grey Brown Podzolic Soils according to the dutch classification-scheme.

Profile VI. Sittard. Quarry "Op den Kamp". Altitude: 57 m. Hilly land. Nearly level high part. Well-drained. Parent material: Würm-loess (Pleniglacial B). Cultivated land.

A_p	0—20 cm	Brown (10YR5½/3) to dark grey brown (10YR4/2) loess. Well developed crumb structure. Friable. Clear and smooth on
A_2	20—52 cm	Pale brown (10YR7/4) to brown (7.5YR4/4) loess. Very weak thick platy. Very porous and friable. Gradual and smooth on
B_1	52—70 cm	Light yellowish brown (10YR6/4) to brown (7.5YR4½/4) loess. Moderate subangular blocky. Very porous and friable. Clear and smooth on
B_2	70—115 cm	Brown (7.5YR5/4) to reddish brown (5YR4/3) loess. Weak prismatic. Distinct coatings on structural units. Very porous and friable. Gradual and smooth on
B_3	115—140 cm	Strong brown (7.5YR5½/6) to reddish brown (5YR4/4) loess. Moderate subangular blocky. Coatings on structural units. Very porous and friable.

Below this loess deposit another deposit occurs which, however, cannot be considered as the parent material of this profile. The profile is well rooted and biological activity is good (many worm-tracks).

Profile VII. Ottersum. Altitude: 12 m. Level land. Well-drained. Parent material: river loam (river levee of the Niers: Alleröd). Vegetation: grasses.

A_p	0—20 cm	Brown (10YR5½/3) to dark brown (10YR3½/3) sandy loam. Strong human interference.
A_2	20—33 cm	Yellowish brown (10YR5½/4) to brown (7.5YR4½/4) sandy loam. Blocky structure with crumbly units. Friable. Many worm excrements and roots.
B_1	33—53 cm	Brown (7.5YR5½/4) to reddish brown (5YR4/3½) loam. Moderate blocky. Porous and friable. Many worm tracks. Many fine roots. Weakly developed clay coatings.
B_{21}	53—68 cm	Reddish yellow (7.5YR6/5) to reddish brown (5YR4/3½) loam. Well developed blocky structure. Porous and friable. Well developed coatings on structural units. Few roots. Worm tracks.
B_{22}	68—89 cm	Reddish yellow (7.5YR6½/4) to reddish brown (5YR5/4) loam. Weakly developed prismatic structure. Porous and friable. Well developed coatings. No roots. Worm tracks.
D	89—100 cm	Reddish yellow (5YR5½/6) to yellowish red (5YR4/6) sandy loam.

The A_p-horizon contains little stones and potsherds belonging to material, that was used as fertilizer; the lowest horizon consists of quite a different material than the solum, as can be seen from *table* 3. Both horizons, therefore, cannot be taken into account when considering soil genesis.

TABLE 1 and 2 show that distinct textural and iron and aluminium accumulation horizons are present; there is no organic matter accumulation. The A_2 horizon is only weakly developed compared with that of the Podzols. However, the distribution of the elements is essentially equal to that of the Podzols, although the differentiation is less pronounced. This latter fact is caused by the lower organic matter content of the Grey Browns and possibly by the great biological activity (worms) in these profiles, leading to a certain mixing of the different horizons. The translocation of iron and aluminium is not only a function of the nature of the organic matter, but also of the amount of it; as this amount is smaller, translocations of the metals will also be lower. The nature of the organic matter is different from that in the Podzols, which is shown by the C/N-ratios, whereas this ratio decreases with depth. As in the case of the heather podzols the organic matter fraction with the lower C/N ratio appears to form stable complexes with iron under the prevailing conditions resulting in the greater mobility of iron compared with aluminium. Although the value of the C/N ratio of these soils might have been influenced by the cultivation measures it must be remarked, that in similar tropical soils (where human influence was certainly not present) the same coarse in C/N ratio was found (VAN SCHUYLENBORGH, 1958) while light absorption studies of the organic matter (TAN and VAN SCHUYLENBORGH, 1961 b) supported the conclusions.
It can be concluded, that the translocation of constituents in both soils are essentially identical, although the theoretical background is obscure because of the insufficient knowledge of the properties of soil organic matter.

c. *The Acid Brown Earths (Sols Bruns acides) and the Brown-Podzolic Soils.* Three out of fifteen analyzed profiles will be discussed here.

Profile VIII. Kessel-Eyck (Limburg). Altitude: 30 m. Gently rolling land. High part. Well-drained. Parent material: loamy, fine, young, coversand. Vegetation: oak shrubs.

A_1	0—5 cm	Grey brown (10YR5/2) to dark grey brown (10YR4/2) loamy sand. Weak crumb structure. Loose. Many roots. Clear and smooth on

$(B)_1$	5—32 cm	Very pale brown (10YR7/4) to brown (10YR5/3) loamy sand. Weak crumb structure. Loose. Many prominent, very fine, black, mottles. Gradual and smooth on
$(B)_3$	32—52 cm	Very pale brown (10YR7$^1/_2$/4) to pale brown (10YR5$^1/_2$/3) loamy sand. Single grain structure. Very loose. Many prominent, very fine, black mottles. Gradual and smooth on
C	+52 cm	Very pale brown (10YR8/4) to pale brown (10YR6/3) loamy sand. Single grain. Very loose. Few, faint, medium, brown (10YR5$^1/_2$/5) mottles.

Profile IX. Epe (Veluwe). Altitude: 30 m. Rolling land. High, flat part. Parent material: pushed preglacial deposits of fluviatile material: gravelly, loamy sand. Vegetation: Birch, oak, Mollinia.

A_1	0—22 cm	Dark brown (7.5YR3/2) to very dark grey (5YR3/1) loamy sand. Weak crumb structure. Very friable. Many roots. Clear and smooth on
$(B)_1$	22—34 cm	Brown (10YR5/3) to dark brown (7.5YR4/2) sand. Very weak subangular blocky structure. Friable. Well rooted. Gradual and smooth on
$(B)_3$	34—55 cm	Very pale brown (10YR7/3) to light brown (7.5YR5$^1/_2$/4) sand. Single grain. Loose. Moderately rooted. Gradual and smooth on
C	+55 cm	Very pale brown (10YR7/4) to light yellowish brown (10YR6/4) sand. Single grain. Few, faint, coarse, pale brown (10YR6/3) mottles. Few roots.

Profile X. Loenen (Veluwe). Altitude: 58 m. Rolling land. High, nearly horizontal part. Parent material: as prof. IX. Vegetation: Oak, fir, grasses.

A_0	7—0 cm	Strongly decomposed, dark reddish brown (5YR2/2) litter.
A_1	0—15 cm	Brown (7.5YR4/2) to very dark reddish brown grey (5YR3/1$^1/_2$) loamy sand. Weak subangular and crumb structure. Very friable. Few bleached sand grains present. Many roots. 2.8 % gravel.
B_1	15—38 cm	Reddish yellow (7.5YR5$^1/_2$/6) to dark and strong brown (7.5YR4/4 and 7.5YR5/6) loamy sand. Very weak crumb structure. Very friable. Very porous. Many roots. 7.3 % gravel.
B_3	38—63 cm	Reddish yellow (7.5YR7/6) to strong brown (7.5YR5/7) loamy sand. Very weak subangular blocky. Very friable. Very porous. Many roots. 10.2 % gravel.
C	63—81 cm	Yellow (10YR7/6) to yellowish brown (10YR5/6) sand. Single grain. Loose. Moderately rooted. Porous. 5.2 % gravel.
D_r	81—97 cm	Very pale brown (10YR6$^1/_2$/4) to yellowish brown (10YR5/6) sand. Single grain. Few roots. 3.6 % gravel.

The characteristic differences of these profiles (with the exception of profile X) and those of preceding soil groups are:

1. no translocation of clay, so that the clay content decreases with depth;
2. the mobility of iron and aluminium is small: the iron content of the soil (TABLE 1) decreases with depth or is nearly constant and the aluminium content increases with depth; apparently, aluminium is more mobile than iron (see Al_2O_3/Fe_2O_3-ratio in TABLE 1);
3. the iron content of the clay separate (TABLE 2) is practically constant, whereas the Al-content increases with depth, supporting conclusion 2;
4. the C/N ratio does not show a certain trend, sometimes it is constant, sometimes it increases; it seems to be more or less constant;
5. in profile X the iron content increases with depth; the C/N ratio decreases with depth.

It is evident that the soil formation process differs from that of the Podzols and

Grey Browns. Moreover, the same soils occur in the tropics (VAN SCHUYLENBORGH, 1958; TAN and VAN SCHUYLENBORGH, 1959, 1961 a). The greater mobility of aluminium can be explained either by assuming that the organic matter form such a stable complex with iron that aluminium is not chelated and has been transported as ion, or by assuming that there is no complexation at all, so that the translocation of these oxides is determined by their solubility products, or by assuming that the vegetation absorbs more iron than aluminium, leading to a more or less even distribution of iron [1]. Again we cannot give a certain conclusion because of the lack of sufficient knowledge of the properties of soil organic matter.

Profile X is different from VIII and IX in that it has similar characteristics as the profiles of the Podzols; there is some bleaching and a removal of iron from the surface horizon; it has been more strongly podzolized. It seems to be an intergrade between profiles VIII and IX and a Podzol.

Soil survey workers in the Netherlands classify the soils as Humus Iron Podzols, because of the occurrence of a podzol-B horizon (horizon of accumulation of iron and aluminium, together with organic matter or of organic matter alone) and the presence of moder-humus. The latter is true, but a podzol-B horizon (the occurrence of such a horizon is based on the colour of this horizon in comparison with A- and C-horizon) is certainly not present: the iron as well as the "free iron" content decreases with depth in profiles VIII and IX (see TABLE 4). Hence, the colour is a misleading criterion for the presence of iron. The reddish hue of the B-horizon must be ascribed to the fact, that iron is present in another form than in the A- and C-horizon (see also: LAATSCH, 1938).

There is much confusion concerning the classification of brown soils in spite of the elucidating study of TAVERNIER and SMITH (1957). They conclude that the french and american classification scheme agree very well and accepting their conceptions, it is evident that profiles VIII and IX has to be classified as Acid Brown Earths (Sols bruns acides) and profile X as an Acid Brown Earth-Podzol intergrade or Brown Podzolic Soil.

In the recent american classification scheme (1960) these soils belong to the Order of the Inceptisols and the Suborder of the Ochrepts. This suborder is divided into 5 groups; the soils under discussion cannot be grouped in one or more of these.

d. *The Gley-soils.* Four examples of this group will be discussed here.

Profile XI. Kottenforst (1 km S.W. of Röttgen). Altitude: 180 m. Mountainous area. Flat part. Poorly drained. Temp.: 9.4° C. Rainfall: 600 mm/year. Vegetation: oak, beech, hornbeam (150 years old). Parent material: Würm-loess (late pleistocene) on gravel and sand of the river Rhine (old-pleistocene).

A_1	0—8 cm	Light brown grey (10YR6½/2) to dark grey brown (10YR4½/2) loess. Granular structure. Friable. Many roots. Clear and wavy on
A_{2g}	8—25 cm	Light yellow (2.5Y8/3) to light olive brown (2.5Y5/4) loess. Blocky structure. Slightly firm. Few, faint, fine, pink (7.5YR7/5) to yellowish red (5YR4/6) mottles. Moderately rooted. Gradual and smooth on

[1] Still another explanation was supposed in a personal communication by Dr. W. H. VAN DER MAREL, who stated that the greater mobility of aluminium would be only apparent. If there is in the profile a translocation of an Al-rich clay mineral, whereas Al-poor clay minerals remain in the surface horizons, also an increasing Al_2O_3/Fe_2O_3 ratio would be found. However, then the SiO_2/Al_2O_3-ratio of the clay fraction would increase with depth. This was not found in the analyses, so that the author declines VAN DER MAREL's suggestion.

B_{1g}	25—45 cm	Light grey (10YR7½/2) to light brown grey (10YR6/2½) loess. Blocky. Slightly sticky. Common, distinct, fine, pink (7.5YR7/4) to yellowish red (5YR5/8) mottles. Few roots. Clear and smooth on
B_2	45—95 cm	Light brown (7.5YR6/4) to reddish yellow (7.5YR6/6) loess. Prismatic and platy. Sticky. Many, prominent, coarse, strong brown (7.5YR5/8) to yellowish red (5YR4/6) mottles. Few roots. Abrupt and smooth on
B_{3g}	95—120 cm	Light yellowish brown (10YR6/4) to yellowish brown (10YR5/4) loess. Compact and hard. Water stagnating.

This profile is called Pseudogley in Germany.

TABLE 3. Grain-size distribution of the profiles

Profile	Horizon	2000—1000 μ %	1000—500 μ %	500—250 μ %	250—100 μ %	100—50 μ %	50—2 μ %	< 2 μ %
I	A_0	—	—	—	—	—	—	—
	A_2	4,5	22,9	21,2	18,9	8,2	14,8	9,5
	B_{2h}	0,8	11,7	17,8	20,9	7,2	29,0	12,6
	B_{2ir}	0,6	7,1	12,2	18,5	9,5	40,8	11,3
	C	1,0	7,8	12,5	19,0	11,8	37,3	10,6
II	A_1	2,6	16,1	36,8	31,4	5,2	6,6	2,2
	A_2	2,0	14,7	37,0	31,7	4,8	7,4	2,4
	C	2,5	15,2	32,7	29,1	4,5	8,4	7,6
	B_{2h}	3,3	20,3	31,6	25,3	3,5	9,0	7,0
	B_{2ir}	8,9	33,4	29,7	17,2	2,1	5,1	3,6
	D	13,0	47,6	20,8	6,1	1,2	5,0	6,3
III	A_1	0,0	0,6	5,8	65,8	19,9	6,3	1,5
	A_2	0,2	0,6	4,1	66,9	22,8	4,3	1,2
	B_{2h}	0,1	0,7	6,4	69,3	17,8	3,8	1,9
	B_{2ir}	0,1	0,6	5,4	68,9	18,9	3,7	2,4
	BC	0,1	0,5	4,0	62,7	26,3	4,7	1,7
	C	0,1	0,7	8,1	65,5	21,9	2,2	1,5
IV	A_1	0,0	0,4	3,7	49,9	32,4	11,8	1,8
	A_2	0,1	0,2	3,4	48,9	33,6	12,3	1,5
	B_{2h}	0,1	0,4	3,3	49,1	33,2	11,6	2,3
	B_{2ir}	0,1	0,3	3,0	48,1	34,8	11,6	2,1
	C	0,1	0,4	3,5	48,0	34,9	11,2	1,9
V	A_1	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.
	A_2	3,1		23,5	56,0	14,3	2,8	0,3
	B_{2h}	1,3		17,9	59,6	17,5	1,7	2,0
	B_{2ir}	2,3		19,1	56,8	18,0	2,3	1,5
	C	5,7		21,3	43,4	26,0	1,5	2,1
VI	A_p	0,4	0,8	1,6	4,1	9,8	74,0	9,3
	A_2	0,2	0,3	0,9	3,0	8,5	77,3	9,8
	B_1	0,0	0,1	0,5	2,6	8,4	74,7	13,7
	B_2	0,1	0,0	0,4	1,0	7,5	70,5	20,5
	C	0,1	0,1	0,2	0,9	8,2	72,2	18,3
VII	A_p	0,7	5,9	20,9	29,0	7,7	23,2	11,9
	A_2	0,3	2,9	12,9	26,4	9,6	32,0	5,9
	B_1	0,2	2,5	10,6	24,7	10,2	34,6	17,0
	B_{21}	0,2	2,3	8,8	22,0	10,1	36,1	20,5
	B_{22}	0,2	1,4	6,3	25,6	10,0	33,6	22,9
	D	0,0	0,1	1,3	62,8	12,3	7,8	15,7

Profile	Horizon	2000—1000 μ %	1000—500 μ %	500—250 μ %	250—100 μ %	100—50 μ %	50—2 μ %	< 2 μ %	> 2 mm
VIII	A_1	0,0	0,3	2,0	40,5	34,0	19,1	4,1	
	$(B)_1$	0,0	0,1	1,7	40,5	34,8	19,0	3,9	
	$(B)_3$	0,0	0,1	1,7	41,1	34,1	19,6	3,4	
	C	0,0	0,2	2,2	49,7	33,6	11,9	2,4	
IX	A_1	2,3	14,1	29,2	29,6	4,5	9,2	5,3	5,8
	$(B)_1$	5,3	11,6	25,8	31,3	4,9	8,0	3,8	9,3
	$(B)_3$	4,5	15,2	25,2	33,7	5,6	6,6	2,8	6,4
	C	4,6	18,6	28,1	29,2	3,6	5,7	3,0	8,2
X	A_1	1,8	10,7	26,6	33,6	6,6	13,1	4,8	2,8
	$(B)_1$	1,5	9,8	25,1	34,5	5,8	10,9	5,1	7,3
	$(B)_3$	1,0	8,2	22,6	37,5	5,8	10,4	4,3	10,2
	C	1,0	14,2	30,9	38,0	3,9	4,5	2,3	5,2
	D_r	6,7	15,5	27,9	38,5	3,3	3,1	1,4	3,6
XI	A_1	—	0,4	1,0	1,9	4,5	79,9	12,3	
	A_{2g}	0,4	0,4	0,6	2,0	4,5	82,4	9,7	
	B_{1g}	0,1	0,1	0,2	0,9	2,8	80,4	15,5	
	B_{2g}	0,2	0,4	0,6	1,5	2,7	62,7	31,9	
	B_{3g}	0,1	0,3	0,6	1,4	3,0	63,7	30,9	
XII	A_1	1,1	9,1	24,3	17,4	3,4	22,3	22,4	
	A_{2g}	0,1	1,5	5,4	10,8	4,5	44,1	33,6	
	B_{1g}	0,2	1,5	6,6	13,4	5,0	41,9	31,4	
	B_{2g}	0,3	0,6	2,1	4,9	2,3	46,6	43,2	
	B_{3g}	1,4	3,0	5,5	10,2	3,6	30,4	45,9	
	D_g	1,7	15,9	58,3	18,8	0,3	1,8	3,2	
XIII	A_1	—[1]	—[1]	—[1]	—[1]	—[1]	61,9	11,8	
	A_2	0,0	0,2	1,1	5,4	9,4	73,4	10,5	
	B_{1g}	0,0	0,1	1,0	4,9	10,1	73,4	10,5	
	B_{2g}	0,0	0,1	0,8	4,7	10,6	75,8	8,0	
	B_{3g}	0,2	0,3	1,0	5,0	9,3	71,1	13,1	
	D_g	0,2	0,6	9,4	36,0	18,4	26,4	9,0	
XIV	A_1	0,9	0,7	0,8	1,1	5,1	76,3	15,1	
	A_{2g}	0,9	1,4	1,4	2,1	6,4	71,4	16,4	
	B_{1g}	0,9	1,0	0,7	0,8	4,1	74,5	18,0	
	B_{2g}	0,1	0,2	0,2	0,5	3,0	71,1	24,9	
	G	0,9	0,8	0,9	1,6	4,1	75,0	16,7	

[1] Total sand : 26,3 %.

P r o f i l e XII. Schandeloo (Limburg). Altitude : 20 m. Flat area. Poorly drained. Vegetation : oak, alder, ferns. Parent material : riverloam (low terrace of the river the Meuse : late glacial).

A_1 0—10 cm Light brown (10YR6/3) to grey brown (10YR4½/2) fine sandy clay loam. Moderate crumb. Friable. Well-rooted. Clear and wavy on

A_{2g} 10—30 cm Light yellow (5Y6½/3) to grey brown (2.5Y5/2) clay loam. Weak platy. Friable. Few, very faint, fine, rusty mottles. Moderately rooted. Gradual and smooth on

B_{1g} 30—46 cm Light grey (2.5Y7/6) to light brown grey (2.5Y5½/3) clay loam. Moderate blocky. Slightly sticky. Clay and black coatings on structural units. Common, prominent, medium, yellow (10YR7/6) to brownish yellow (10YR5½/6) mottles. Few roots. Clear and smooth on

B_{2g}	46—65 cm	Strong brown (7.5YR5/6) to yellowish red (5YR5/6) silty clay. Strong coarse blocky. Slightly sticky. Many, prominent, medium, light grey (10YR7/2) to grey brown (10YR5/2) mottles. Black coatings on structural units. Gradual and smooth on
B_{3g}	65—83 cm	Light grey (5Y6/1) to olive grey (5Y4½/2) clay. Weak prismatic. Sticky. Clay coatings on structural units. Vertical reddish yellow (7.5YR6/8) to yellowish red (5YR5/6) streaks (root channels). Clear and smooth on
D_g	+83 cm	Light grey (10YR6½/1) to grey brown (10YR5/2) sand. Single grain. Loose Rusty.

This profile has an admixture of a younger deposit in the A_1-horizon, while the D_g -horizon is not the parent material of the profile. However, horizons A_{2g} -B_{3g} are formed in the same material.

TABLE 4. Total Fe_2O_3- and "free Fe_2O_3"-content of the soil and Fe_2O_3-content of the clay separates of some profiles

Profile	Horizon	Total Fe_2O_3 %	"free Fe_2O_3" %	Fe_2O_3 in clay %
VI	A_2	2,20	0,85	10,0
	B_1	2,56	1,07	11,0
	B_2	3,80	1,69	13,8
	B_3	3,78	1,60	13,5
VII	A_2	2,92	1,25	9,09
	B_1	2,80	1,15	8,59
	B_{21}	3,26	1,27	8,60
	B_{22}	3,97	1,50	9,06
VIII	A_1	0,89	0,40	8,10
	$(B)_1$	0,85	0,39	8,00
	$(B)_3$	0,82	0,33	7,24
	C	0,87	0,33	8,44
IX	A_1	1,68	0,51	9,26
	$(B)_1$	1,69	0,49	10,2
	$(B)_3$	1,64	0,46	10,3
	C	1,36	0,39	10,9
X	A_1	1,21	0,53	7,55
	$(B)_1$	1,40	0,69	10,6
	$(B)_3$	1,47	0,60	10,9
	C	1,50	0,60	12,3
	D	1,46	0,54	11,2

Profile XIII. Limbricht (Limburg). Altitude: 35 m. Gently rolling land. Low part. Poorly drained. Parent material: Würm-loess (pleniglacial-B). Vegetation: oak, alder, ferns.

A_1	0—7 cm	Dark grey brown (10YR4/1½) to very dark brown (10YR2/2) loess. High content of badly decomposed organic matter. Abrupt and wavy on
A_{2g}	7—24 cm	Grey brown (10YR5/2) to dark grey brown (10YR4/2) loess. Weak crumb. Friable. Many roots. Many, faint, medium, light brown (10YR6/3) to brown (10YR5/3) mottles. Clear and smooth on
B_{1g}	24—29 cm	Light yellow (2.5Y8/3) to light brown grey (2.5Y6½/2) loess. Platy. Friable. Well-rooted. Clear and smooth on
B_{2g}	29—48 cm	White (2.5Y8/2) to light yellow (2.5Y7/3) loess. Platy. Sticky. Common, distinct, medium, yellow (10YR7/6) to brownish yellow (10YR6/6) mottles. Few roots. Gradual and smooth on

B_{3g}	48—86 cm	White (10YR8/1) to light brown grey (2.5Y6/2) loess. Blocky. Sticky. Some faint coatings. Many, prominent, coarse, reddish yellow (7.5YR6/8) to strong brown (7.5YR5/8) mottles. No roots. Clear and smooth on
D_g	86—140 cm	Light grey (2.5Y6½/2) to light brown grey (2.5Y6/2) sandy loam. Massive. Sticky. Many, distinct, medium, reddish yellow (7.5YR5½/6) to strong brown (7.5YR5/6) and fine black iron-manganese mottles. This horizon is not the parent material of the solum.

Profile XIV. Kleeberg (Limburg). Altitude: 130 m. Hilly land. Slope: ± 20 %. Poorly-drained. Parent material: Würm-loess (pleniglacial-B). Vegetation: grass.

A_1	0—16 cm	Light brown grey (10YR7/2) to dark grey (10YR4½/1) loess. Moderate fine blocky. Sticky. Well-rooted. Rusty along roots. Clear and smooth on
A_{2g}	16—32 cm	Light grey (10YR7/2) to dark grey (10YR4½/1) loess. Moderate fine blocky. Sticky. Common, distinct, fine, brownish yellow (10YR6/8) to yellowish-brown (10YR5/6) mottles. Moderately rooted. Clear and smooth on
B_{1g}	32—50 cm	Light grey (2.5Y7/2) to dark grey (10YR4½/1) loess. Moderate fine blocky. Sticky. Common, distinct, fine, brownish yellow (10YR6/8) to yellowish brown (10YR5/6) mottles. Moderately rooted. Clear and smooth on
B_{2g}	50—95 cm	Light yellow (5Y7/3) to greyish green (5G6/1) loess. Prismatic. Sticky. Many, distinct, medium, strong brown (7.5YR5/6) to brown (7.5YR5/3) mottles and concretions. No roots. Clear and smooth on
G	+95 cm	Light grey (5Y7/2) to greyish green (5Y5/1) loess. Massive. Few concretions. Practically constant reduction layer.

TABLE 1 demonstrates, that all profiles are characterized by an, although not very strong, illuviation of clay, a very low pH (except profile XIV), a decrease of the C/N-ratio with depth, an illuviation of iron and aluminium, while iron is again more mobile than aluminium, and finally by a strong illuviation of manganese. They seem to have an intermediate position between the Grey Browns and the Podzols. The analyses of the clay separate lead to the same conclusions. Profile XIV is unlike the other three profiles in that the pH is much higher and that the translocations are less pronounced. Undoubtedly these are the result of the slope, so that the percolation with rainwater is smaller on account of the surface run-off.
Furthermore the analyses show, that there is no difference in soil formation whether the reduction conditions are caused by a high groundwater level (profiles XII and XIII) or by a temporarily saturation of the soil by an impermeable layer (profile XI).
Finally it can be stated that the soil formation process, responsible for the formation of Podzols, Grey Brown Podzolic Soils and Gley-soils, is essentially the same.
Soil Survey workers in the Netherlands classify the soils, discussed above, as Low Grey Brown Podzolic Soils, whereas the american literature describes them as Humic Gley or Low Humic Gley Soils. In the new american classification scheme they belong to the Order of the Ultisols, the Suborder of the Aquults and the group of the Umbraquults.

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