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TOUR A

Landcapes, soils and land use of the Federal Republik of Germany

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INTERNATIONAL SOCIETY OF SOIL SCIENCE

HAMBURG, GERMANY

Guidebook

Tour A

Landscapes, soils and land use of the Federal Republic of Germany

by

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Preface

The aim of this excursion was to demonstrate the typical and important soil landscapes of West-Germany and to relate them to the agriculture and forestry present in the same area.
The striking feature of the soil cover in Central Europe is the extremely high variabilitiy, which is mainly caused by the variability in petrography and age of the landscape. The differences in petrography are so dominant because almost all soils have developed during the holocene and late würmian glacial period. In addition, a high proportion of the soil substrates was formed by glacial and periglacial processes, like the moraines and fluvioglacial sediments of the northern and alpine glaciation, like the periglacial aeolian loesses which cover the hilly areas and river terraces or like the periglacial scree or solifluction deposits which cover the slopes of all mountainous areas.
Although we attempted to present a cross section of Germany's soils we had to leave out important landscapes, which we passed through but where we didn't show soils, as in the alpine moraine landcapes,the jurassic limestone mountains and the floodplains of the great rivers Rhine and Elbe. Furthermore, there was no example of soils developed from cristalline rocks or metamorphic shists or gneisses to be demonstrated. We hope these missing links may be the reason for a return to Germany for most of the participants. The soils we did show have been selected in order to cover the dominant types of important parts of the country. In addition, we included some typical soils which are rather rare but stand for special environments and genesis like the "Tangelrendzina", the "Iron pants" soil,the acid "Lockerbraunerde" or the "Ironstone" gley. The research that has been carried out to explain their genesis and dynamics have been among the highlights of German pedology in the last decades.

This excursion was prepared by a great number of experienced soils scientists and by even more young enthusiastic assistants. We are very grateful for the work they have done for the benefit of this excursion. We are not able to list them here all, although we feel that we should do so.
The interests of soil scientists vary like the properties of the soils they deal with. This individualism might have been a slight problem, in the pursuit of our objectives. We tried to keep the general theme in mind while we offered the variability. We thank all the participants of this excursion for their polite patience and especially their enormous interest in our soils and work. We are proud that you have been with us.

Berlin and Kiel, Sept. 1986 Karl Stahr and Hans-Peter Blume

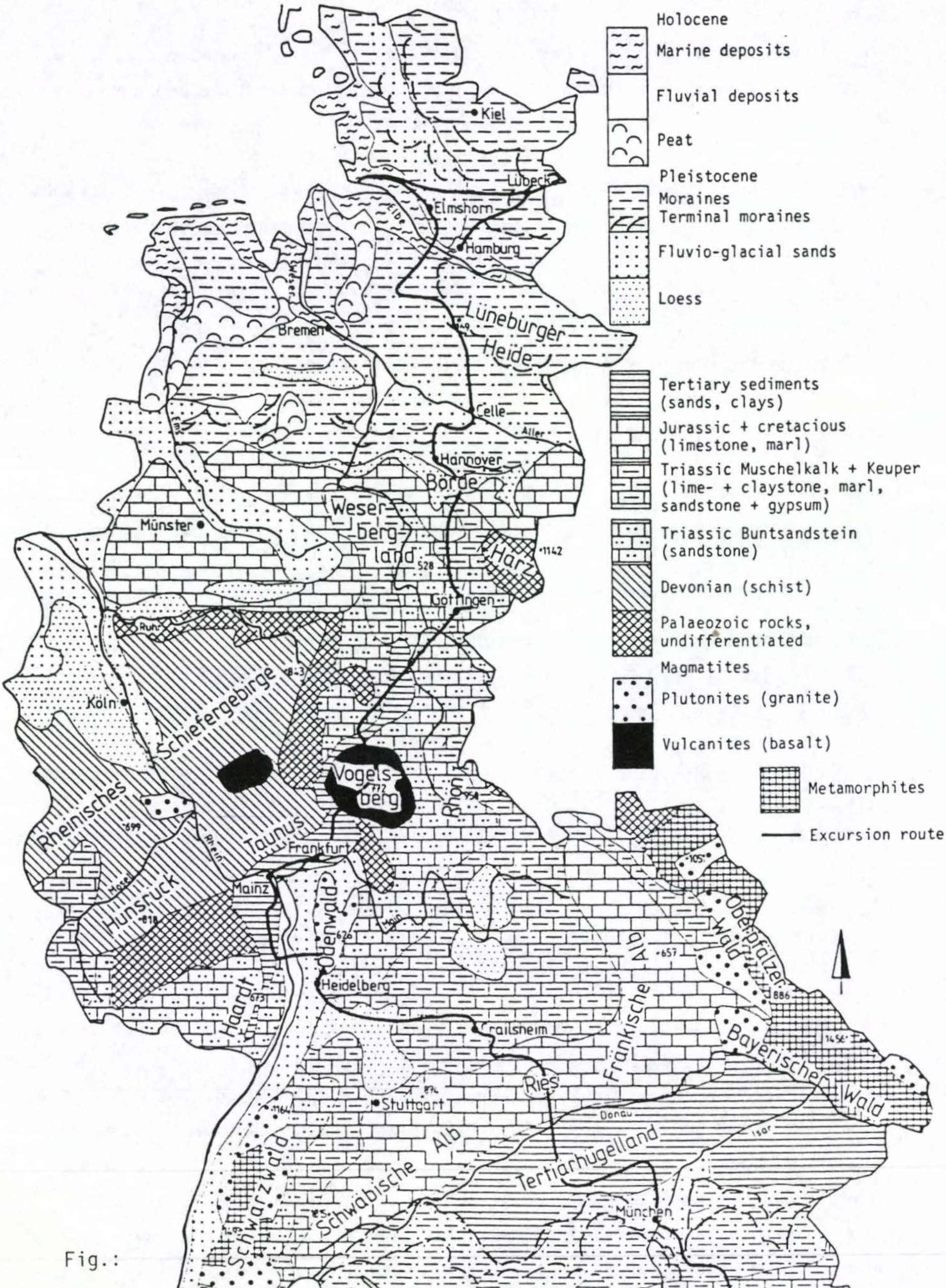


Fig.:

Generalized geological landscapes

of the Federal Republic of Germany with route of Excursion A

Mitteilungen Dtsch. Bodenkundl. Gesellschaft, 46, 7 - 9, 1986

Exkursion A, 1st day
Soils and Agriculture in the Bavarian Alps

by

Wittmann, O.+ and W. Grottenthaler, W. Zech, H. Rodenkirchen, H. Ruppert, H. Silbernagel, G. Spatz, R. Horn

Route description:

Munich: From the city into SE direction using the highway (Autobahn) towards Salzburg

Munich "Schotterebene" (gravel plain): glacifluviatile gravel from the "Würm" Ice Age (low-lying gerrace) in the southern part with soils havirg a deep-lying water table near Holzkirchen we cross "Würm" Ice Age gullies and gravel of the penultimate ice age (high-lying terrace)

Mangfall Bridge/Weyarn Autobahn exit: After crossing the deeply cut valley of the Mangfall (drinking water supply for Munich) we reach the "Würm" Ice Age terminal moraine landscape of the Inn glacier.

Wexarn: Baroque monastery church from the 17th and 18th century, carved works by Ignaz Günster; we drive along the "Würm" Inn glacier to Miesbach (county seat); to the west, the wooded molasse elevation (Miocene) of the Taubenberg.

Hausham: former coal mining (pitch coal from brackish water strata of the Tertiary, late Oligocene); geomorphological Alpine edge; crossing of the terminal "Würm" Schliersee glacier.

Schliersee: Valley formed by Alpine glaciation; to the south the Kalkalpen; drive through the valley of the Aurach and the Leitzach.

Bayrischzell: Mentioned as Benedictine monastery in 1o77.

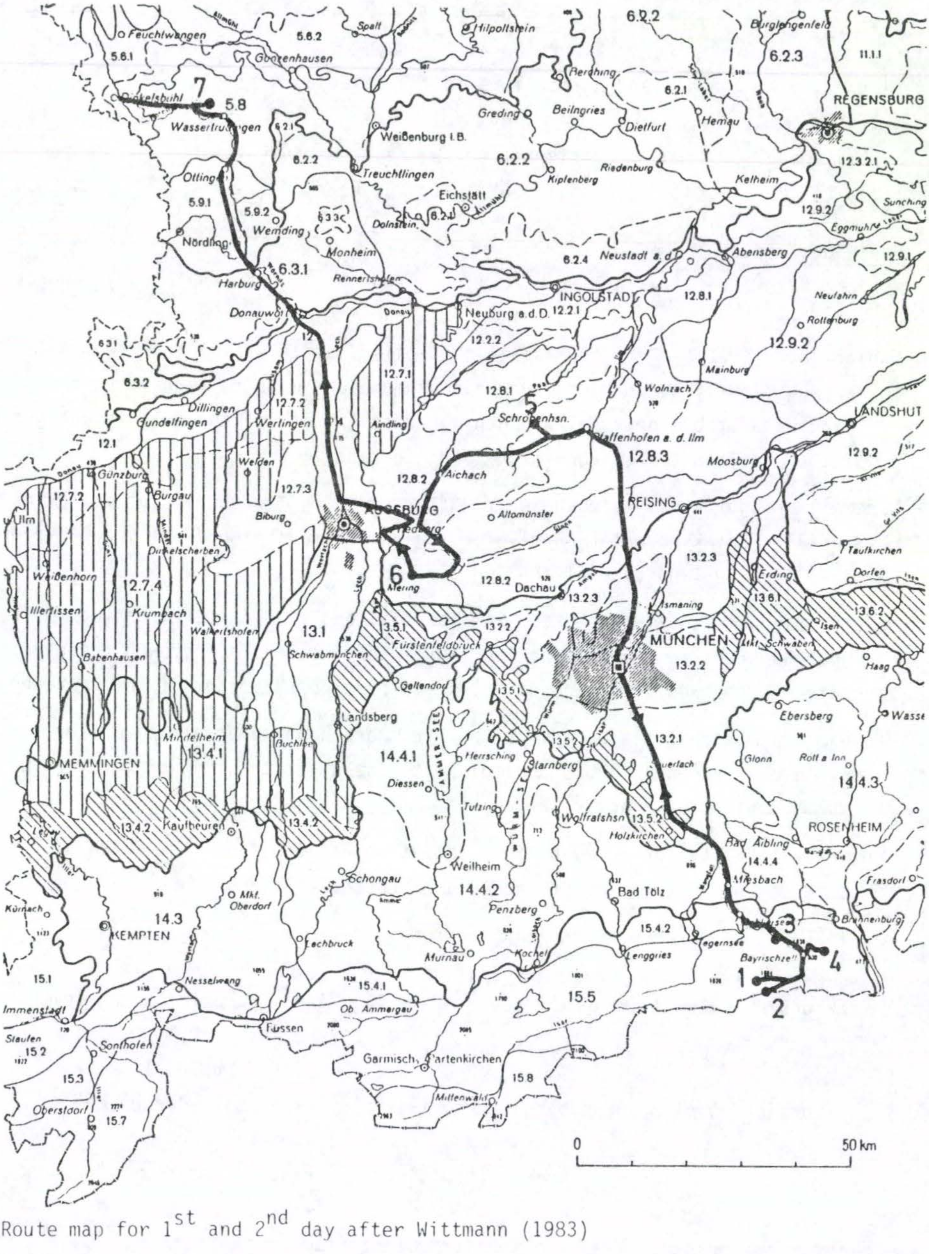
Kloaschau Valley:

Excursion point 1 (Grundalm):	Profile 1.1	"Tangelrendzina" (subalpine rendzina),
	Profile 1.2	"Moder-Rendzina",
Excursion point 2 (Grundberg)	Profile 2.1	"Terra fusca-Braunerde" (Cambisol)
	Profile 2.2.	"Eisen-Humus-Podsol" (Podsol).

Osterhofen:

Excursion point 3 Visit to the farm of E. Stadler.

+Bayer Geol.Landesamt, D8ooo München 4o, Heßstr. 128



Route map for 1st and 2nd day after Wittmann (1983)

Sudelfeld: Excursion point 4

Alpine grazing meadow of E. Stadler: effect of grazing and winter sport on vegetation and soils;

Profile 4.1 "Braunerde-Rendzina",

Profile 4.2 "Rendzina-Braunerde" (Calcaric Regosol) under
and 4.3 various grazing use

Profile 4.4 "Naßgley" (Calcaric Gleysol).

Situation of the area between the mountain mass of the Wendelstein (radio and television transmitters, solarobservatory, meteorological observatory, cog railway and cable car lines) and the Traithen-Brünnstein Chain; terrain features are marked by geological structures.

Reference: Wittmann, O.: Standortskundliche Landschaftsgliederung v.Bayern. With map 1:1.ooo.ooo.- Materialien, Heft 21, 3o pp. Bayr.Staatsministerium für Landesentwicklung und Umweltfragen, München 1983.

Mitteilungen Dtsch. Bodenkundl. Gesellschaft., 46, 1o - 18, 1986

Excursion area Bavarian Alps and Alpine Foreland

by

W. Grottenthaler +

Geography

The excursion touches two geographic units on the trip and return; The Munich plain, weakly inclined to the north and the Inn-Chiemsee hill country. The Alpine part of the excursion brings us to the Mangfall Mountains. It includes the section of the Kalkalpen (Northern Limestone Alps) between the transverse valleys of the Isar and Inn Rivers (peak altitudes 18oo-19oo m m.s.l.) as well as the foothills of the Flysch and Helvetic-zone (peak altitudes around 13oo m m.s.l.), whose northern slope forms the geomorphological Alpine margin.

Climate

The average annual precipitation between Munich and the Alpine edge increases from 95o mm to 14oo mm. In the Alpine valleys, 14oo-16oo mm are reached; on the higher mountains in excess of 2ooo mm, where 3o-4o % of the precipitation falls as snow. The mean annual temperatures are around 7^{o}C in the Alpine foreland between 6 and 7^{o}C in the Alpine valleys; at high elevations the isotherm is less than 4^{o}.

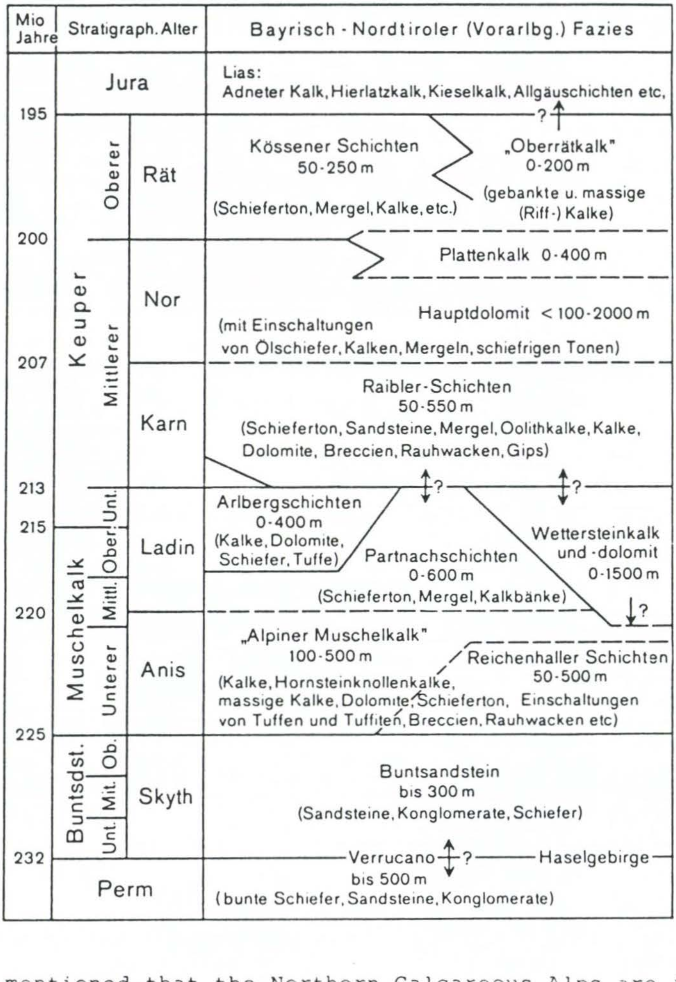
Geology

The North Alpine Margine of the Eastern Alps is divided into several lithofazies zones, with east-west extension, according to teh Alpine mountain ranges. From north to south the following zones can be distinguished:

- Molasse Zone of the Northern Foredeep (Lower and Upper Tertiary)
- Helvetic Zone (Upper Jurassic to Lower Tertiary)
- Flysch Zone (Lower Cretaceous to Lower Tertiary)
- Northern Calcareous Alps (Permo-Triassic to Upper Cretaceous)

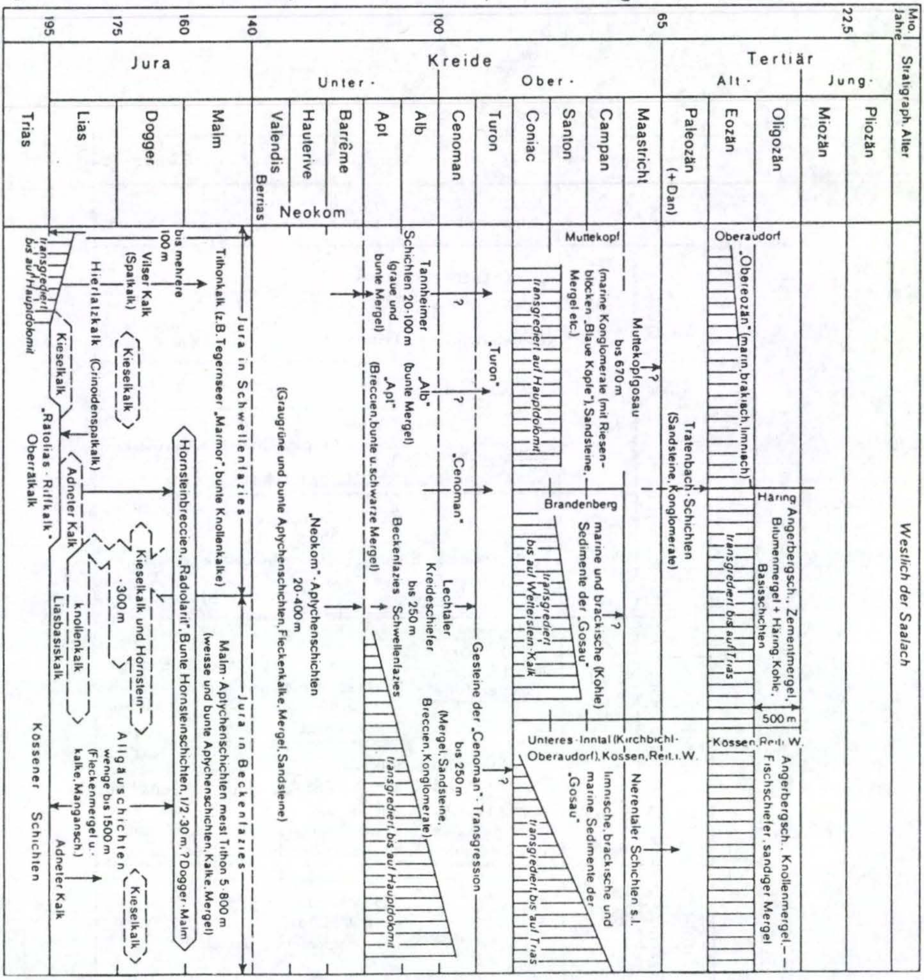
Tables 1 and 2 show you the stratigraphy of the Northern Calcareous alps, the main part of our excursion today.
As the name suggests, carbonate lithologies are predominating, but also clastic sediments are frequent. The sedimentaion area was part of the Tethyan Sea during Mesozoic. The recent geological structures are the result of the Alpine orogenesis (Cretaceous-Tertiary).

Tab. 1: Stratigraphic table of the Northern Calcareous Alps between the rivers Rhein and Saalach (after Erläuterungen zur Geologischen Karte von Bayern 1:500 000, 4. Auflage 1981).



It must be mentioned that the Northern Calcareous Alps are in a complete allochthoneous position. They were detached from their original basement and moved to the north. Now they are situated on younger beds of the Molasse Zone, the Helvetic Zone and the Flysch Zone.

Tab. 2: Stratigraphic table of the Northern Calcareous Alps between the rivers Rhein and Saalach (after Erläuterungen zur Geologischen Karte von Bayern 1:500 000, 4. Auflage 1981).



The internal tectonic structuresof the Northern Calcareous Alps are characterized by thrust-sheets and fold-systems. In Fig. 1 the fold structures of the Sudelfeld-area (Stop 2) are illustrated. Remnants of Jurassic sediment-rocks, consisting of marls, marlstones and siliceous limestones, are preserved in the core of some synclines. The most extended rock-sequence at the surface is the Hauptdolomit (Upper Triassic), which was sedimented in a lagoonal environment of shallow hypersalinar water.

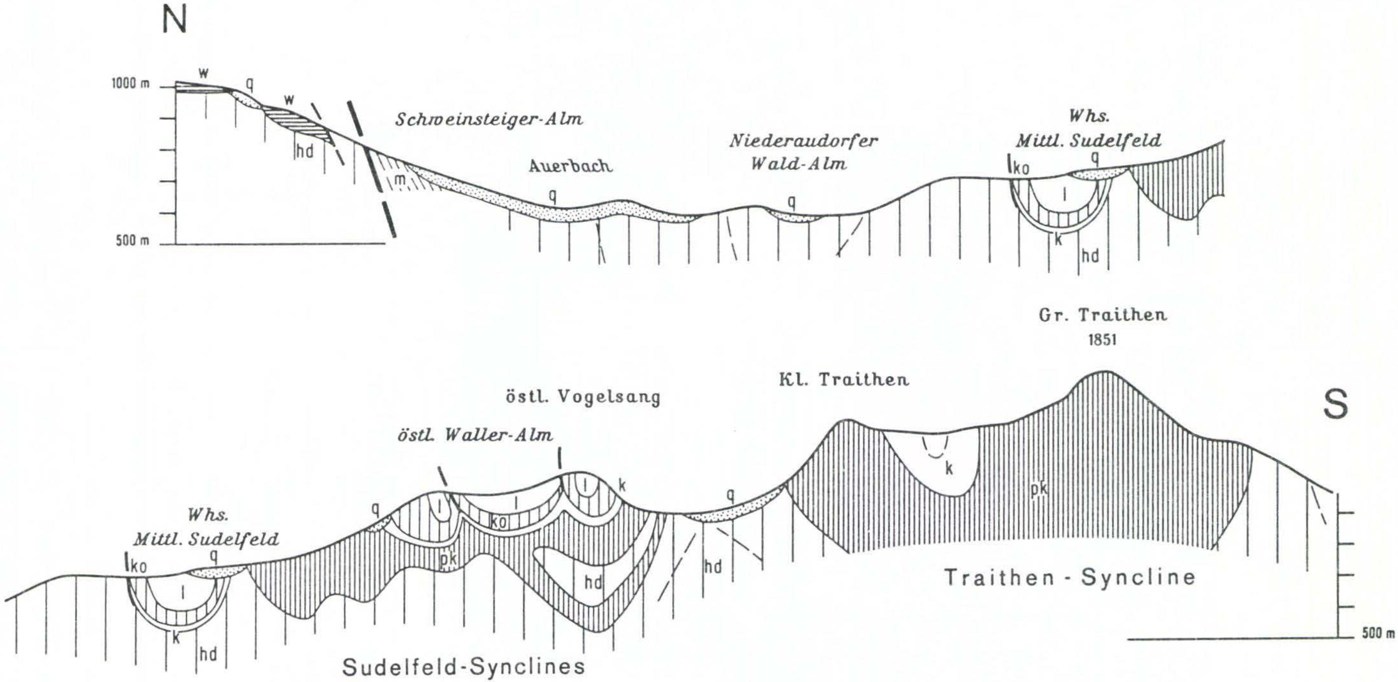


Fig. 1: Cross-section through the Sudelfeld-area (after H. WOLFF, 1986). m= Alpiner Muschelkalk; hd= Hauptdolomit; pk= Plattenkalk; k= Kössener Schichten; ko= Kössener Kalk; l= Lias; w= Malmkalk; q= Quartär

During the Pleistocene glaciations the Alps were covered by a pattern of glaciers which reached far into the forelands. End- and ground-morains were deposited and sites of many lakes were shaped by glacial aktivities too. In the Alps strong erosion happened. U-shaped valleys and other glacial phenomena got formed and also glacial deposition took place. The last glacial epoch was the Würm, named after a Bavarian river. Younger (post-Würmian) sediments are for example rock fall debris, talus fans, peats and river deposits.

Parent material, landscape and soils

(cf. "Standortkundliche Landschaftsgliederung" route description, Fig.1)

Southern gravel plain of München (Munich) (13.2.1)

Geol.Unit: würmzeitliche (wisconsinian) gravel (groundwater in large depth)

Parent Material: sandy, slight silty gravel

Landscape: level terrace plain

Soils: "Parabraunerden" (Luvisols), increase of solum depth to the south (3-10 dm)

Older moraine of Isar -glacier (13.5.2)

Geol.Unit.: older moraine (pre- Würm- ian), highterrace, partly sheets of loess-leam

Parent Material: very gravelly sandy loam; sandy, slight silty gravel, silty loam

Landscape: plain crests, terrace plains

Soils: "Parabraunerden", "Braunerden" (Cambisols), frequently layer-profiles

Young moraine of Inn -glacier (14.4.4)

Geol.Unit.: sandy-gravelly moraine

Parent Material: gravelly silty -loamy sand

Landscape: hills and tops of terminal moraine

Soils: "Parabraunerde", "Pararendzinen" (Rendzinas) (eroded soils), "Kolluvium" (accumulated soil-material)

Geol.Unit.: silty-gravelly moraine

Parent Material: gravelly sandy-silty loam

Landscape: mainly plain crests and tops, between them depressions and valleys

Soils: "Parabraunerden" and "Braunerden", partly impermeable wet; "Pararendzinen"; in valleys "Gleye" (Gleysols)

Geol.Unit.: gravelly-silty moraine

Parent Material: gravelly, sandy-loamy silt to slight clayey loam; tight stratification

Landscape: very plain crests and depressions of groundmoraine areas, valleys

Soils: Proceeding soils to "Stau-"and "Haftnässeböden" and well developed "Pseudogleye" (Planosols); in valleys and depressions "Gleye" and "Moore" (bogs)

"Tegernseer Flyschberge" (15.4.2)

Geol. Unit.: marl-rich layers

Parent Material: cover layers out of silty loam to loamy clay, partly stony

Landscape: medium to strongly inclined slopes

Soils: "Braunderden", "Pelosole" (Vertisols), "Hang-" and "Quellwassergleye" (Slope- and Spring-Gleysols), "Stau-" and "Haftwasserböden" (Planosols)

Geol.Unit.: sandstone-rich layers

Parent Material: cover layers out of very stony loamy sand to sandy loam

Landscape: medium to strongly inclined slopes

Soils: "Braunerden", "Parabraunerden"; at calcareous sandstones; proceeding soils to "Podsole" (Podzols)

"Mittlere Bayerische Kalkalpen" (Bavarian Limestone-Alps) (15.5)

Geol.Unit.: triassic and jurassic limestones and dolomites (cf. Tabl. 1 und 2)

Parent Material: carbonaceous rock with small amounts of clay

Landscape: strongly inclined to steep slopes

Soils: "Rohböden" (Lithosols) and "Rendzinen", "Terrae fuscae" (Limestone-Brownloam), "Kalkbraunerden" (limestone-Cambisols), frequently proceeding soils to Planosols; soils with thick humic layers; sometimes podzolised

Geol.Unit.: limy-silicated layers of Jurassic, sandstones of "Raibler Schichten", of "Cenoman" and of "Gosau" (Cretaceous) (cf. Tabl. 1 and 2)

Parent Material: silicated limestones, limestones with hornstone-clods ("Hornsteinknollenkalke"), sandstones and their weathering products

Landscape: medium to very steep slopes, slope crests and depressions

Soils: "Rohböden" to "Braunerden","Parabraunerden", "Podsole"; sometimes proceeding to Planosols

Geol.Unit.: marly-clayey layer of Triassic, Jurassic and Cretaceous (e.g. "Partnach"-marl, "Raibler"-slateclay, "Kössener"-marl, "Fleckenmergel" of Jurassic, "Aptychen"-layers; cf. Tabl. 1 and 2)

Parent Material: marl, slateclay, marl-limestones and their weathering products

Landscape: medium to steep slopes, slope depressions, spring recesses

Soils: "Braunerden, Pelosole, Hang- und Quellengleye, Stau- und Haftnässeböden"; besides also "Rohböden" and "Pararendzinen"

Geol.Unit.: loose sediment rock of Quaternary (moraine, gravel, lake sediments, rubble slope)

Parent Material: block-rich, very gravelly, sandy-silty loam, sandy gravel, sandy to clayey silt; sandy grus, very stony sandy loam to loamy clay

Landscape: hills and tops; plane valley floors, alluvial cones and rubble slopes; slope positions

Soils: "Braunerden" and "Parabraunerden", at lake sediments "Gleye" and "Pelosol-Gleye", at rubble slopes different soil developments

Soil erosion in the Alpine region

In the Alps, a relatively young mountain system with unstable relief conditions, the eroding forces play a significant role, and in many places the soils are in an extremely unstable equilibrium. For this reason, long-term soil cultivation is possible only if greater attention is paid to erosion protection.

To prevent soil losses, the processes causing erosion must first be identified. By an analysis of the factors controlling erosion processes at each particular location, a further step is made toward effective countermeasures. In the following, a brief description is given of the superficially significant forms of soil erosion. Frequently several erosion forms appear together at a single location, i.e. combinations or successions of various processes cause soil losses (cf. LAATSCH & GROTTENTHALER, 1973).

With certain winter weather sequences, slowly gliding snow covers or also avalanches cause soil skimmings in steeper high elevations. In our region, unwooded N to SE exposed slopes are particularly affected. They tend to form overhanging snow masses on the leeward side of the prevailing west winds.

Another form of soil erosion occurs predominantly on deforested dolomite and limestone slopes. Their usually shallow soils (rendzinas) suffer humus loss through increased solar radiation, i.e. to loss of mass through increased microbial decomposition of the organic substance. As a result, soil aggregates are more easily washed or blown away. While humus loss is associated with shallow, low-clay soils, turf displacement - meaning the downhill shoving of parts of the grass turf through grazing animals - leads to erosion damages on steeply inclined slopes with permanently wet or periodically sodden loam and clay soils.

Slope erosion in the form of slow creeping and gliding movements as well as earth slide occurs principally on marly rocks or in thick Quaternary loose masses. Where there is heavy surface flow, exposed loose sediments are subjected to a depth erosion forming grooves and furrows, resulting not infrequently in erosion ravines.

The soils of the Alpine region are endangered not only by mass losses but also by accumulation. During extreme flow phenomena, the danger exists of inundation of valuable soil surfaces with pebbles, boulders or rock stream debris.

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Agricultural utilization in Bavaria covering the production areas along the route of Excursion A

by

O. Wittmann

On the 1st and 2nd day, Excursion A proceeds through pedologically and climatically greatly differing regions. The figures shown in Tab. 1 for the agricultural utilization of these areas (after WÜRFL, DÖRFLER and RINTELEN 1984) refer spatially to the map with the excursion route, which is a detail from the "Standortkundliche Landschaftsgliederung von Bayern" 1 : 1 000 000 (WITTMANN 1983).

Wooded area: Greatest at 57.3 % in the unfavorable climate and relief of the Alpine foothills and the Kalkalpen, it decreases greatly as a function of climate up to the Danube (20 -25%) and again reaches area shares of around 40 % on the "Alb" (in some places, very shallow soils) and in the "Albvorland" (Alb foreland) (high-clay soils).

Cultivated area: is in reverse ratio to the wooded area and at over 70 % has the highest proportion in the high-loess-loam "Tertiärhügelland" (Tertiary upland hills), in the flat "Donauried" and in the "Ries Kessel" (Ries Depression).

Assessment according to the Agrarian Master Plan Mapping System

The Agrarian Master Plan Mapping System differentiates areas with favorable (V), average (D) and unfavorable (U) production conditions.

Greatest area shares:

- with unfavorable production conditions: in the Alpine foothills and the Kalkalpen (83 %) as well as in the southern young moraines (47 %);
  Land use: Alpine meadow grazing and grasslands (fodder area: 95.7 - 99.0 %);
- with average production conditions: in the southern (49 %) and northern young moraines (52 %);
  Land use: grasslands with arable quota of 7.7 to 30 % (fodder area: 81.1 to 95.5 %);
- with favorable production conditions: on the Munich gravel

Table 1: Agricultural structure in the area of excursion A (in 1979; according to WÜRFL et al. 1984)

agricultural districts	ecological districts (WITTMANN 1983)	precipitation mm/year	aver. annual temperature (°C)	land use (in%) agric. land	land use (in%) forest	productivity class (in % of agric. land) V	D	U 1)
Oberbayer. Voralpen u. Kalkalpen (Upper Bavarian Forealps and Limestone Alps)	15.4; 15.5; 15.6; 15.9	1500-2500	4.5 - 6.5	21.3	57.3	0	17	83
Jungmoräne, südl.; mit Molassevorbergen (Southern young moraine with molasse elevations)	14.4.2; 14.4.4	1000-1600	6.0 - 7.0	56.3	33.6	4	49	47
Jungmoräne, nördl. einschl. Altmoräne d. Isar-Loisach-Ammergletscher (Northern young moraine; incl. old moraine	14.4.1; 14.4.3; 13.5.1; 13.5.2	950-1400	7.0 - 7.5	59.7	33.8	33	52	15
Münchener Schotterebene (Munich gravel plain)	13.2	800-1100	6.5 - 7.5	66.1	29.6	76	19	5
Ober- u. Niederbayer. Tertiärhügelland lößlehmreich (Tertiary upland hills, rich in loess-loam)	12.8.2; 12.8.3; 12.9.1; 12.9.2	700- 850	7.0 - 8.0	73.2	23.4	79	15	6
Oberbayer. Tertiärhügelland, sandig (Upper Bavarian Tertiary upland hills, sandy)	12.8.1	700- 800	7.5 - 8.0	62.4	34.3	57	30	13
Donauried	12.1	700	7.0 - 8.0	76.4	20.4	82	14	4
Mittlere u. Südl. Frankenalb und Riesalb (Middle and Southern Franconian and Ries Alb)	6.3.1; 6.2.1; 6.2.2; 6.2.3	700- 800	6.5 - 7.5	54.4	42.5	68	23	9
Ries	5.9.1 + 5.9.2	650- 700	7.5	77.1	21.0	77	21	2
Mittleres und Südliches Albvorland (Middle and Southern Foreland of the Franconian Alb)	5.8	650- 750	7.0 - 7.5	60.3	37.0	53	31	16

1) V=favourable, D=average, U=unfavourable conditions of production

Continuation: Table 1; Agricultural structure in the area of excursion A (in 1979; acc. to WÜRFL et al. 84)

agricultural districts	average farm size agric. land in ha	use of agricultural land (% of land) ploughed land	small grain	cereal maize	root crops	fodder area	special crops	livestock density animals per 100 ha agricultural land cattle	hogs	sheep
Oberbayer. Voralpen u. Kalkalpen (Upper Bavarian Forealps and Limestone Alps)	12.7	1.3	0.4	-	0.1	99.0	0.1	95	5	20
Jungmoräne, südl. mit Molassevorbergen (Southern young moraine with molasse elevations)	16.0	7.7	3.7	-	0.2	95.5	0.2	165	9	5
Jungmoräne, nördl. einschl. Altmoräne des Isar-Loisach-Ammergletschers (Northern young moraine; incl. old moraine)	14.5	30.0	16.6	0.5	0.6	81.1	0.3	195	22	6
Münchener Schotterebene (Munich gravel plain)	20.4	77.7	44.7	1.7	9.4	40.9	0.3	139	73	8
Ober- u. Niederbayer. Tertiärhügelland lößlehmreich (Tertiary upland hills, rich in loess-loam)	14.7	77.0	45.8	7.4	6.4	37.1	3.2	122	227	5
Oberbayer. Tertiärhügelland, sandig (Upper Bavarian Tertiary upland hills, sandy)	12.9	67.0	40.9	1.4	12.3	36.5	9.7	105	176	6
Donauried	14.5	72.2	42.6	2.1	12.5	42.7	0.4	147	201	12
Mittl. u. Südl. Frankenalb und Riesalb (Middle and Southern Franconian and Ries Alb)	13.0	75.1	47.9	0.8	6.6	45.3	0.2	123	168	12
Ries	11.9	75.6	45.1	2.1	8.9	45.5	0.2	167	393	9
Mittl. u. Südl. Albvorland (Middle an Southern Foreland of the Franconian Alb)	10.6	61.4	40.2	0.2	7.4	52.8	0.3	145	165	10

plain (76 %), in the high-loess-loam "Tertiärhügelland" (79%), in the "Donauried" (82 %), on the "Frankenalb" (Jura) (68 %) and in the "Ries" (77 %).
Utilization: arable area with arable proportion of 75.1 - 77.7 % (fodder area 37.1 to 45.5 %).

Important field crops: Grain: Consistently between 40 and 48% of the agricultural area in the excursion regions north of the young moraines: wheat and barley predominate; cereal maize: in the "Tertiärhügelland" 7.4 % of the agricultural area, particularly in the warmer locations, otherwise less than 2 %; root crops 9.4 % of the agricultural area on the Munich gravel plain and 12.3 % (potatoes) in the "Tertiärhügelland" and 12.5 % in the "Donauried" (principally sugar beets); special crops: higher proportions in the "Tertiärhügelland" (3.2 and 9.7 %), mainly hops.

Cattle density: Greatest cattle density is in the "Kalkalpen" and Alpine foothills as well as in the southern young moraines (dairy farming), also in the "Ries" (bull fattening); in addition the largest swine density in Bavaria is in the "Ries".

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TANGELRENDZINA AND MODERRENDZINA

von

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GENERAL INFORMATION

In the Bavarian Alps soils derived from parent materials rich in carbonates e.g. compact mesozoic dolomites like "Hauptdolomit" (carbonate = 90 - 98 %) are very frequent. Typical soils have O-C, O-Ah - C or Ah - C profiles. Soil organic substances play an important role in the genesis of these soils and their ecological properties. An O-C (= Tangelrendzina) and an O-Ah - C profile (= Moderrendzina) were prepared for presentation on the ISSS field trips. Besides standard soil analyses, organic substances were studied in detail. Both profiles are situated in the Kloaschau-Valley, south of Bayerischzell. Mean annual temperature is 4 - 5^{o}C, mean annual precipitation about 1700 mm.

PROFILE NO.1.1= TANGELRENDZINA

Site description:

Location	near Grundalm in the Kloaschau-Valley, south of Bayerischzell, in lower slope position north of the Sonnwendjoch R: 44 9685, H: 52 7520 (TM No. 8337/8437 Josephsthal,1:25.000)
Elevation	1.000 m a.s.l.
Landform	slope debris
Inclination	25 - 30^{o}
Vegetation	Erico-Rhododendretum (with Abies alba, Acer pseudoplatanus, Picea abies, Pinus mugo, Amelanchier ovalis, Daphne mezereum, Rhododendron hirsutum, Vaccinium spec., Sorbus spec., Erica carnea)
Use	pasture land for cattle during summer

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Parent material	coarse, loose dolomite debris (Hauptdolomit), poor in fine material
Humusform	Tangelmoder
Soil classification	Lithic Borofolist (US-Soil Taxonomy) Tangelrendzina (German) Moder Skelettosol (BOCHTER, 1984)

Profile description:

(GLA-Kartieranleitung, 3. ed. 1982 and BOCHTER, Doctor thesis, University Bayreuth, 1984).

Ln	25 - 24 cm	fresh litter of Vaccinium vitis-idaea, Vaccinium myrtillis, Erica carnea, Pinus mugo, Picea abies, Sorbus spec., Rhododendron hirsutum
Lv	24 - 23 cm	slightly decomposed litter, not aggregated
Of	23 - 22 cm	mainly undecomposed needle litter, decreasing contents of slightly aggregated, decomposing leaf litter, first fine roots, Allolobophera viride
Ofh	22 - 19 cm	needle fragments, many fine roots, fecal pellets abundant (Ø 1 - 3 mm) hyphae of Cortitium bicolor
Oh1	19 - 11 cm	fine, amorphous substances, crumby structure, some aggregates with sharp edges, root diameter > 1 cm, Cortitium bicolor
Oh2	11 - 5 cm	black fine crumbs, decreasing contents of coarse roots, partly rotten, weak compactness
OhCa	5 - 0 cm	very black crumby aggregates, many fine roots, Allolobophera viride (length 10 cm)
x̄Cv	0 - 20 cm	dolomite debris, poor in fine material

PROFILE NO.12 = MODERRENDZINA

Site description:

Location	near Grundalm in the Kloaschau-Valley south of Bayerischzell, in south exposed lower slope position north of the Sonnwendjoch R: 44 9698, H: 52 7553 (TM No. 8337/8437 Josephsthal, 1:25.000)
Elevation	960 m a.s.l.
Landform	slightly convex slope debris near the plane valley bottom
Inclination	20 - 25^{0}
Vegetation	Aposerido-Fagetum (Fagus sylvatica, Picea abies, Acer pseudoplatanus, Daphne mezereum, Sorbus spec., Oxalis acetosella)
Use	pasture land for cattle during summer

Parent material	dolomite debris (Hauptdolomit), fine material abundant
Humusform	Moder
Soil classification	Lithic Rendoll (US-Soil Taxonomy) Rendzina (FAO) Moderrendzina (German)

Profile description:

(GLA-Kartieranleitung, 3. ed. 1982)

Lv	11 - 10 cm	loose beech leaves and spruce needles
Of	10 - 9 cm	partly decomposed needle and leaf litter, relatively more needles abundant than leaves, first fine roots
Ofh	9 - 6 cm	fragments of needles and leaves, crumby structure, earth worms, about 5 % stone fragments
Oh	6 - 0 cm	black organic material, fine and coarse crumbs, about 10 % stone fragments, fine roots abundant
Ah	0 - 9 cm	black silty loam, 30 % stones, crumby structure, many fine and medium roots
AhCv	9 - 20 cm	dolomite debris (~ 80 %) mixed with brown sandy silt loam, slightly compacted
Cv	20 - 45 cm	yellow-brown dolomite debris

INTERPRETATION OF PROFILES NOS. 1.1 + 1.2

Profile No.1.1is composed of organic layers (L- and O-horizons) and physically weathered dolomite. Therefore this soil was classified as a Moder Skelettosol (BOCHTER, 1984), Tangelrendzina (German) and lithic Borofolist (US-Taxonomy), respectively. It was not possible to classify this soil according to the FAO soils nomenclature because the unit Histosol is restricted to taxonomy organic soil having H-horizons.

In contrast to profile No.1.1Ah- and AhCv-horizons were formed in profile No. 2. Thus it was classified as a Moderrendzina (German), Rendzina (FAO), and as a lithic Rendoll (US-Taxonomy), respectively.

The Ah- and AhCv-horizons of profile No.1.2 exhibit lower carbonate contents (63 % AhCv, 18 % Ah) and higher Fe_d-contents (10.4 mg/g AhCv, 6.4 mg/g Ah) than the underlying Cv-horizon (93 % $CaCO_3$, 1.6 mg Fe_d/g) which is supposed to be due to carbonate weathering. Increasing Fe_o-values from the Cv- to the Ah-horizon of profile No.1.2also indicated weathering in this soil.

Table 1: Tangelrendzina (profile No.11)

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ln	25-24	0											
1	Lv	24-23	0											
1	Of	23-22	0											
1	Ofh	22-19	0											
1	Oh_1	19-11	0									}	916	296
1	Oh_2	11-5	0											
1	OhCa	5-0	0											
1	Cv	0-20+	> 90	8	1	14	23				66	11	n.d.	n.d.

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	Ln							4.30	4.40		0.04		0.08	
1	Lv							7.78	7.29		0.20		0.07	
1	Of							4.75	4.60		0.30		0.05	
1	Ofh							4.83	4.40		0.45		0.05	
1	Oh_1	} 0.15	90	-	55.2	44.6	20	4.60	4.75		0.85		0.00	
1	Oh_2							4.90	4.92		0.55		0.00	
1	OhCa							6.78	6.55		1.18		0.00	
1	Cv	1.60	43	-	6.4	4.9	1	7.51	7.35	1.2	0.85	0.71	0.03	0.004

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	car-bonate %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ln	50.0	8.0	63:1										
1	Lv	47.5	9.8	49:1		767	620	2 32	16	49	35	4 35	0	43
1	Of	46.4	14.2	33:1		885	652	2 50	13	54	8	5 60	0	37
1	Ofh	46.2	14.9	31:1	}									
1	Oh_1	46.0	17.0	27:1		1258	746	3 21	13	84	33	8 07	0	36
1	Oh_2	45.3	12.9	35:1										
1	OhCa	39.9	15.2	26:1		1395	1058	7 57	6	2 76	0	0	0	75
1	Cv	7.0	4.0	17:1	85	317	342	2 09	7	1 01	0	0	0	100

Table 2: Moderrendzina (profile No. 1.2)

No	hor.	depth	sto.	texture in % of humus-/carb. free fine soil									kf	
				sand				silt				clay		
		cm	%	c	m	f	Σ	c	m	f	Σ		cm/d	var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	Lv	11-10	0											
2	Of	10- 9	0											
2	Ofh	9- 6	0											
2	Oh	6- 0	10										784	51
2	Ah	0- 9	30	9	4	9	22	-	-	-	50	29	1130	218
2	AhCv	9-20	78	22	5	13	40	-	-	-	45	17	1410	268
2	Cv	20-45	85	35	8	14	57	-	-	-	33	10	774	440

No	hor.	bulk dens.	GPV	water content in % at pF				pH		Fe_d	Fe_o	Fe_o:	Mn_o	P_a
		g/cm^3	%	0.6	1.8	2.5	4.2	H_2O	$CaCl_2$	mg/g		Fe_d	mg/kg	
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
2	Lv							5.06	4.80		0.65		0.13	
2	Of							5.20	5.07		1.18		0.20	
2	Ofh							5.11	5.20		1.70		0.24	
2	Oh	0.19	88.4	-	40.3	35.9	20	4.93	5.15		2.55		0.15	
2	Ah	0.53	74.4	-	37.2	33.6	18	6.86	6.77	6.4	4.38	1.46	0.58	
2	AhCv	1.32	48.7	-	21.1	18.3	3	7.55	7.15	10.4	2.75	3.78	0.38	
2	Cv	1.72	38.7	-	18.7	14.9	1	8.39	7.87	1.6	0.50	3.20	0.03	

No	hor.	$C_{org.}$	N_t	C:N	car-borate	CEC		exchang. cations in meq/kg						V
						p	a							
		%	mg/g		%	meq/kg		Ca	K	Mg	Na	H	Al	%
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
2	Lv	48.0	10.2	47:1		714	n.d.	2 30	15	70	0	3 99	0	44
2	Of	46.8	11.7	40:1		918	653	3 36	12	91	0	4 79	0	48
2	Ofh	42.3	12.6	34:1	}	1088	707	4 01	10	1 34	0	5 43	0	50
2	Oh	36.0	13.6	27:1										
2	Ah	16.0	10.6	15:1	18	875	794	6 22	4	2 49	0	0	0	100
2	AhCv	5.6	3.7	15:1	63	282	264	1 87	8	87	0	0	0	100
2	Cv	1.4	0.5	28:1	93	-	-	-	-	-	-	-	-	-

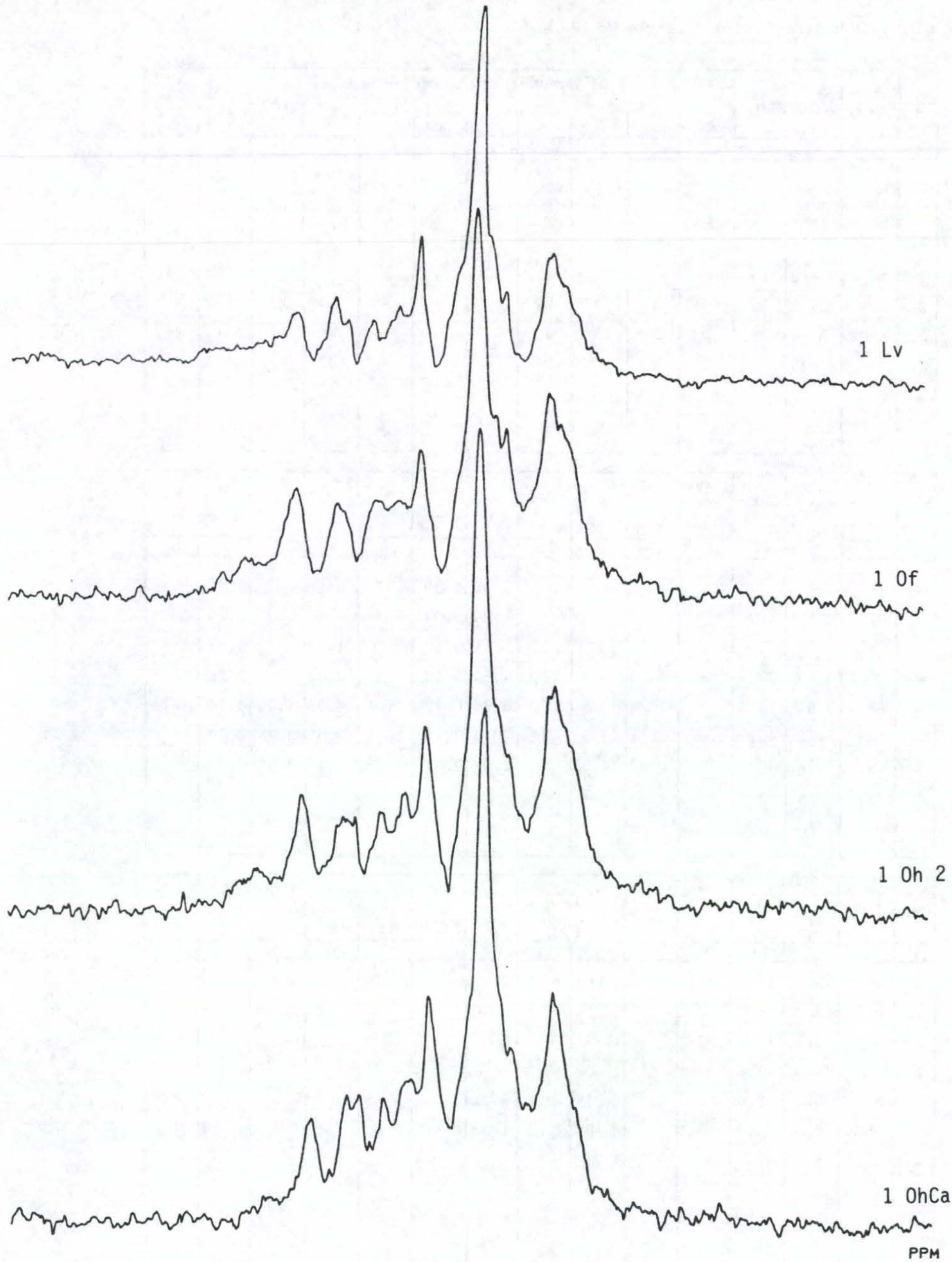

Fig. 1: CPMAS ^{13}C NMR spectra of the different horizons of the Tangelrendzina

Organic layers of both soils are characterized by high contents of organic material (C_{org} > 36 %) and wide C/N-ratios. Both parameters are decreasing with depth. In contrast to the underlying material organic layers are free of carbonates. pH-values of L- and O-horizons are varying between 4 and 5. Within the organic layers of the lithic Borofolist (No.1.1) pH-values are increasing with depth whereas the pH depth function of organic layers of the lithic Rendoll does not show any tendency. The high pH of the Lv-horizon in profile No.1.1 could not be explained genetically. It may result from windblown carbonatic dust.

The CEC of both profiles is relatively high due to the large organic matter contents of their horizons. Even the Ah-, AhCv- and Cv-horizons showed CEC-values up to 875 meq/kg (CECp, Ah-hor., profile No.1.2). According to their pH-values base saturation of organic layers is varying between 37 % (Of-hor., profile No.1.1) and 50 % (Ofh-hor., profile No.1.2), whereas mineral horizons have a V-value of 100 %.

Iron and manganese contents of oxalate extracts reflect mainly organic bound portions of these elements. Fe_o-contents of the soils increase from the Ln- to the Oh-horizons whereas Mn_o-contents do not show tendencies within the profiles. It is supposed that manganese was neither enriched nor migrated within the organic layers of these soils.

From the physical point of view both soils are highly permeable, well aerated and have a medium amount of potential plant available water. The high permeability of mineral horizons results from their high stone contents (30 - 90 %).

CHARACTERIZATION BY SOLID STATE ^{13}C NMR SPECTROSCOPY

The Lv-horizon of the Tangelrendzina (No.1.1) has dominant peaks at 70 and 104 ppm due to the abundance of polysaccharides (fig. 1). Further peaks can be detected near 30 ppm (aliphatic C), 56 ppm (methoxy groups), 119 and 130 ppm (guaiacyl units), 150 ppm (O and N substituted aromates) and 175 ppm (carboxylic groups). During litter decomposition carbohydrates decrease, whereas signal intensities due to aliphatic and carboxylic C increase. Aromaticity is low and does not change significantly during humification. Similar results are obtained for the Moderrendzina.

Chemical analyses (tab. 3) confirm increase of carboxylic groups from Lv to Oh layers. Phenolic groups increase from 2.51 and 2.63 meq/g in the Lv horizons to 4.91 meq/g in the OhCa layer of the Tangelrendzina and to 3.28 meq/g

Table 3: Characterization of the organic substances in the Tangelrendzina and Moderrendzina by chemical analyses

	$C_{oxalate}$ (Ext.·10^3)	Total Acidity (meq/g)	COOH-groups (meq/g)	Phenolic OH-groups (meq/g)	Polysaccharides (Anthron) (mg/g)	Lignin (Dioxane/HCl Phloroglucine) (Ext./g)	Total phenols (Folin) (mg/g)	Petrolether extract (mg/g)	% α-amino-N after hydrolysis (% proteins)
1 Ln	n.d.	2.98	0.47	2.51	330.5 ± 0.11	1.22	95	44.5	0.34 (2.10)
1 Lv	99	3.60	0.45	3.15	208.7 ± 1.47	1.45	142	25.3	0.45 (2.81)
1 Of	63	4.46	0.56	3.90	183.0 ± 3.00	1.12	150	14.8	0.62 (3.88)
1 Ofh	74	4.61	0.63	3.98	155.8 ± 2.55	0.82	145	10.8	0.60 (3.76)
1 Oh1	58	4.81	0.85	3.96	116.2 ± 2.25	0.67	143	7.0	0.37 (2.33)
1 Oh2	58	5.38	0.77	4.61	128.2 ± 2.85	0.71	92	7.3	0.59 (3.66)
1 OhCa	311	5.27	0.36	4.91	87.0 ± 3.00	0.26	47	4.0	0.57 (3.58)
1 $\bar{\bar{x}}$Cv	2633	1.75	0.02	1.73	13.5 ± 1.35	0.02	7	0.6	0.13 (0.78)
2 Lv	116	2.98	0.35	2.63	246.3 ± 0.38	0.55	150	17.3	0.57 (3.58)
2 Of	128	3.05	0.38	2.67	189.6 ± 1.50	0.47	170	12.5	0.62 (3.88)
2 Ofh	192	3.25	0.40	2.85	128.2 ± 2.25	0.36	114	8.0	0.60 (3.65)
2 Oh	308	3.75	0.47	3.28	100.5 ± 6.90	0.15	69	2.8	0.58 (3.55)
2 Ah	1557	1.37	0.05	1.32	32.7 ± 1.50	0.12	14	0.4	0.42 (2.65)
2 AhCv	694	0.38	0.01	0.37	10.0 ± 0.15	0.01	2	0.2	0.13 (0.83)
2 Cv	121	0.11	0	0.11	< 1	0.01	0	0.3	0.10 (0.06)

in the Moderrendzina Oh (tab. 3). The ^{13}C NMR data reveal no pronounced increase near 150 ppm. According to the results of chemical analyses sugar breakdown is much more drastic than revealed by the NMR data.

Comments to the Pyrolysis-Field Ionization-Mass Spectra of the Soil Horizons from Profile No.1.1 (= Tangelrendzina)

Beside chemical degradation or physical nondestructive methods (IR- or ^{13}C NMR-spectroscopy) pyrolysis in combination with mass spectroscopy (MS) or gas chromatography and MS is a well established method to characterize soil organic matter or its fractions (humic and fulvic acids, humins or polysaccharides). Fragments released during pyrolysis and their subsequent analysis allow an effective conclusion on structure and composition of the soil organic polymers. It is advantageous to produce large fragments during the process of thermal degradation and to minimize the secondary fragmentation during the ionization process. These requirements are accomplished by Curie-point or oven pyrolysis of the soil organic matter in a high vacuum, followed by the ionization of the fragments with an electron impact ionizer operating at 15 eV or less. More effective to ionize larger fragments is the use of Field-Ionization (FI) where the fragments volatilized during pyrolysis are ionized at the tips of fine whiskers on a thin wire in a high electrostatic field.

For the analysis of soil samples from each horizon, a few milligrams were pyrolyzed in an oven and the fragments were ionized by FI and then analyzed by a conventional mass spectrometer. This method produces reliable "fingerprint" spectra and allows a fast comparison of the organic matter in the different horizons or of different soils. Additional information can be gained by registering the total ion current during the temperature rise time. The spectrum of the organic matter from each horizon of the profile (Lv, Of, Ofh, Oh1, Oh2 and OhCa) are dominated by peaks of polysaccharide and lignin fragments related to the parent plant residue material. This material gets altered and humified with increasing depth of the profile, but still the most prominent peaks are fragments related to plant cell wall constituents.

High signals at m/z 60, 84, 96, 98, 114, 128, 144 and 162 are typical fragments from the hexose and pentose units of cellulose and hemicelluloses of plant cell walls (fig. 2). They are related to acetic acid, furan and pyrone derivatives and to anhydrosugars or levoglucosane (m/z 144). Further high signals at m/z 124, 138, 150, 152, 164, 166, 178, 180 and 194 are assigned to the guaiacyl fragments of the lignin from pine and spruce

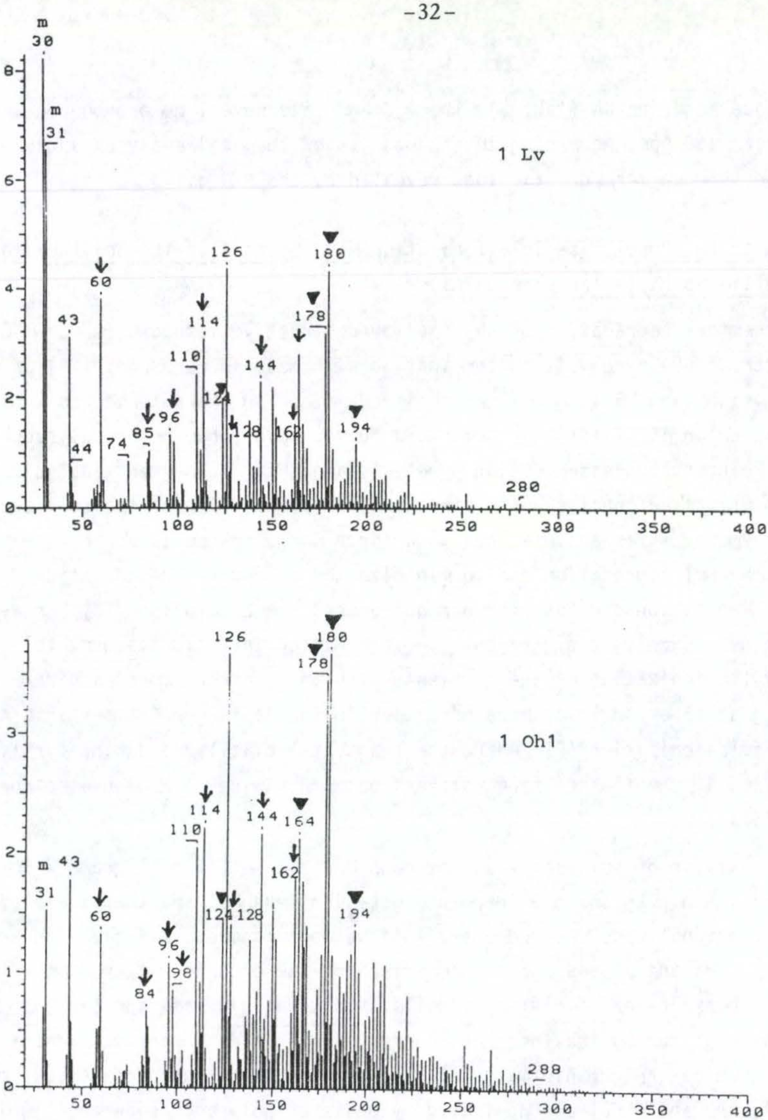

Fig. 2: Pyrolysis-Field Ionization-Mass Spectra from the Lv and Oh1 horizons from a Tangelrendzina (profile 1.1)

↓ = polysaccharides

▼ = guaiacyl fragments

m = methanol fragments

with coniferyl alcohol (m/z 180) as the highest peak. Very small or missing are fragments from syringyl or hydroxyphenyl components related to the lignin of deciduous trees or gramineous plants. High methanol related signals (m/z 30, 31) in the upper layers of the profile indicate the presence of still methoxylated lignin units, but these signals decrease consecutively with increasing soil depth. Together with an increase of a signal at m/z 110 (possibly a diphenol fragment) this points on a progressing demethylation of the lignin in deeper layers. The spectrum of the deepest organic layer in the profile (= OhCa horizon) shows more intense signals at m/z 30, 31, 60 and lower intensities at m/z 110, 180, and 194. In the Tangelrendzina under investigation this horizon is mainly formed by precipitation of materials leached through the profile. This precipitation is caused by high concentrations of Ca-ions at high pH-values. This probably leads to the observed accumulation of methylated phenols in this layer.

Two examples of the pyrolysis spectra are shown in fig. 2 for the Lv and Oh1 horizon of the profile.

The dominating signals from only partly decomposed parent plant material correlate with the high contents of organic carbon, sugars and lignin shown in tab. 3. Yet, already in the fermented litter layers (Of and Ofh) and more obvious in the humified Oh1 and Oh2 horizons of the profile, there is an increasing contribution of a regular pattern of signal pairs in the range between m/z 150 - 300 (see the spectrum of the Oh1 layer in fig. 1). This regular pattern indicates a contribution of branched aromatic-aliphatic hydrocarbon structures which develop under progressive humification. This pattern is most obvious in pyrolysis spectra of the soil organic matter from poorly drained or temporarily waterlogged soils and is less characteristic for the organic matter of soils with a more rapid turnover of the plant residue material.

Typical signals of N-acetyl amino sugars (m/z 59, 73, 125, 135, 151) which are indicative for a content of microbial biomass or residues are missing or obscured by other signals. More obvious in the more humified layers are signals from protein related fragments at m/z 67, 81 and 95. A contribution of nitrogenous material is also indicated by a lower C/N ratio in the horizons with progressed humification.

Results of the ^{31}P NMR spectroscopy

Tab. 4 shows that most of the alkali soluble P in the Moderrendzina (No. 1.2) is orthophosphate monoesters (inositol hexaphosphate, sugarphosphates,

Table 4: Results of ^{31}P NMR spectroscopic studies of the different horizons of a Moderrendzina (No.1.2)
(chemical shifts δ ppm; % of P extractable with NaOH)

	phosphonates δ = 19.5	inorganic orthophosphate δ = 6.2 - 7.0	orthophosphate monoesters δ = 4.6 - 5.5	orthophosphate diesters δ = + 0.1	pyrophosphate δ = 3.8 - 4.3	unknown
Lv	0	17	58	17	8	-
Of	0	17	54	21	8	-
Ofh	0	19	48	25	8	-
Oh	0	16	43	27	4	10
Ah	7	4	42	33	0	14
AhCv	8	7	65	14	0	6

mononucleotides). Their contents decrease from 58 % in the Lv horizon to 42 % in the Ah; in the AhCv the highest values (65 %) were found. Orthophosphate diesters (phospholipides, DNA, polynucleotides) behave vice versa: from Lv to Ah they increase (17 to 33 %); in the AhCv only 14 % could be detected. Inorganic orthophosphate comprises 16 - 19 % in the organic layers. They are free from phosphonates, but contain about 4 - 8 % pyrophosphate. In contrast, the mineral horizons (Ah, AhCv) contain 7 - 8 % phosphonates but no pyrophosphates.

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Terra fusca-Braunerde and Eisen-Humus-Podsol in the calcarous Alps of Bavaria - Bayrischzell/Kloaschautal

by

H.Rodenkirchen

Site 2.1

Growth region:	Bayrische Alpen
Growth destrict:	Mittlere Bayerische Kalkalpen
Location:	State forest district Schliersee, Kloaschautal near Bayrischzell, Grundberg
Elevation:	1ooo m above sea level
Topography:	Transition of middleslope to middleslope depression, Northnorthwest aspect, 12^{o}
Climate:	cool humid climate; mean annual temperature: 4,5-5,o^{o}C, mean annual presipitation: 17oo - 18oo mm (more or less uniformly distributed throughout the year; during winter months much of the precipitation as snow)
Parent material:	Slope deposit (slope moraine?) derived from Hauptdolomit (and few other limestone material), mixed with silt loam (aeolian origin?)
Vegetation:	Mountainous mixed forest (Hainlattich Tannen-Buchenwald, Aposerido Fagetum) Tree layer 1: height 27 m, cover 5o%, species: Abies alba, Picea abies Tree layer 2: height 9 m, cover 1o%, species. Fagus sylvatica Shrub layer: height o,75 m, cover 15%, species: e.g. Fagus sylvatica, Acer pseudoplatanus, Sorbus aucuparia Herb layer: height o,25 m, cover 7o%, specius: e.g. Vaccinium myrtillus, Carex alba, Lycopodium annorinum Adenostyles glabra, Athyrium filix-femina, Carex flacca

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Gentiana asclepiadea, Homogyne alpina, Oxalis acetosella, Sanicula europaea,

Moss layer: cover 30 %, species: e.g. Hylocomium splendens, Polytrichum formosum, Thiudium tamariscinum, Dicranum scoparium, Plagiomnium affine, Pleurozium schreberi

Land use: Forestry; natural regeneration on fenced plots after femel selection cutting

Soil classification: German: (alpine) Terra fusca-Braunerde, schwach hang-pseudovergleyt, schwach durchschlämmt

FAO: Luvic Eutric Cambisol

US-Soil Taxonomy: Ruptic-Alfic Eutrochrept

Profile Description:

Humus form: Rawhumus like moder, 10 - 14 cm thick, with moderate biologic activity

Horizon German	Horizon FAO	Depth (cm)	Description
L	O	0,5-0	Loose scattered, fresh litter mainly of Norway Spruce, Silver Fir, Beech, blueberry, grasses and mosses
Of 1	O	4 -0,5	Partially decomposed litter, interwoven by fungal hyphae, non-compact matted structure
Of 2	O	9/8-4	Partially decomposed litter residues, non-compact matted structure, abundant roots
Oh	O	11/13-9/8	Very dark brown to black (10 YR 2/2 $\frac{x}{m}$), well humified organic material (fine humus >70 % by volume), moderate loose, abundant roots, earthworms activity apparent, gradual boundary to the mineral soil

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x Munsell Color Charts, m = moist

Mineral soil:

German	FAO	Depth	Description
Ah	Ah	0-4	Very dark grey brown (10 YR 3/2 m); high content of humus; silty clay loam (utL[xx]); crumb to weak subangular blocky structure; loose; abundant roots; earthworms activity apparent; gradual, wavy boundary
AhBv	BA	4-19	Dark yellowish brown (10 YR 4/3 m); medium content of humus; silty clay loam (utL); subangular blocky structure; loose; weak pseudogleyic mottling; plentiful roots; wavy boundary
SwBv	Bwg	19-34	Dark yellow-brown (2,5 Y 6/4 m); moderate pseudogleyic mottling (7,5 YR 5/8 m) induced by slope wetness; silty clay loam (utL); subangular to angular blocky structure; peds here and there with coatings of clay (cutans); moderate loose; common roots; wavy boundary
II BhvT	2Bwh	34-40	Brown (7,5 YR 4/4 m) to dark brown (7,5 YR 3/4 m); loamy clay (lT), few coarse fragments (5 % by volume); angular blocky structure; weak pseudogleyic mottling; carbonates present; peds here and there with dark brown cutans; moderate loose to moderate compact; common roots
BvCv	CB	40-60	Grey-white (2,5 Y 8/2 m) freshly weathered coarse fragments (derived from Hauptdolomit and few other limestones) mixed with brown (7,5 YR 4/4 m) fine earth; stoney, strong silty sand (ūS), carbonates present in fine earth; moderate compact; few coarse roots; diffuse boundary
Cv	C	60-100	Grey-white (2,5 Y 8/2 m), weakly weathered, coarse parent material: angular Hauptdolomit stones and few other, gravelly limestones; low content (<20 % by volume) of silty (U) fine earth

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[xx] Texture class: nomenclatur of Kartieranleitung 1982

Terra fusca - Braunerde, Site 2.1

1. Soil physics

No.	hor.	depth	sto. % by vol.	texture in % of humus- free fine soil								clay	kf		bulk dens.	GPV	Watercontent in %			
				sand				silt									at pF			
		cm		c	m	f	Σ	c	m	f	Σ		cm/d,	var.	g/cm^3	%	0.6	1.8	2.5	4.2
1	O_{f1+2}																			
2	Oh																			
3	Ah	0-4	0	0,2	0,8	7	8	19	21	17	57	35	40 - 100		0,80	70	66	55	52	27
4	AhBv	4-19	< 1	0,1	0,9	5	6	18	19	17	54	40			0,92	71	66	54	51	29
5	SwBv	19-34	1-3	0	1	6	7	18	23	14	55	38	1 - 10		0,93	66	62	52	50	35
6	IIBhvT	34-40	5	3	3	9	15	15	14	8	37	48								
7	BvCv	40-60	60-70	25	13	10	48	18	20	7	45	7								

Terra fusca - Braunerde, Site 2.1 2. Soil chemistry

No.	hor.	depth cm	pH H_2O	pH $CaCl_2$	$C_{carb.}$ mg/g	$C_{org.}$ %	N_t mg/g	C:N	P_t mg/g	$C_{org}:P_t$	$P_{citric\ acid\ soluble}$ mg/kg	K_t mg/g	Mg_t mg/g	Fe_t mg/g
1	Of_{1+2}	9/8 - 0,5	5,65	4,90	0	41,7	15,78	26,4	0,67	622	46,5	8,0	3,5	16,5
2	Oh	11/13-9/8	5,30	4,60	0	41,6	16,79	24,8	0,59	705	26,6	2,8	4,7	7,8
3	Ah	0-4	5,87	5,32	0	8,5	4,68	18,2	0,37	230	7,4	13,3	8,0	25,4
4	AhBv	4-19	6,05	5,55	0	3,7	2,17	17,1	0,26	142	2,5	15,6	9,8	36,2
5	SwBv	19-34	6,35	5,75	0	2,5	1,65	15,2	0,28	89	1,4	15,5	9,5	38,5
6	IIBhvT	34-40	7,40	6,85	53,0	3,3	2,30	14,4	0,70	47	2,6	19,5	31,8	48,0
7	B_vC_v	40-60	8,25	7,45	116,3	0,5	0,27	18,5	0,15	33	1,0	3,0	53,8	5,6

No.	hor.	depth cm	Fe_d mg/g	Fe_o mg/g	Fe_o:Fe_d	Fe_d:Fe_t	Mn_d mg/kg	CEC_{pot} NH_4-acet meq/kg	exchang. cations in meq/kg (NH_4-acetate) Ca	K	Mg	Na	H	Al	V %
1	Of_{1+2}	9/8-0,5	4,89	0	0	0,30	186,3	867	323,5	8,7	156,8	34,8	343,2	0	60
2	Oh	11/13-9/8	2,45	0	0	0,31	108,1	1162	379,9	6,4	208,9	14,4	552,4	0	52
3	Ah	0-4	7,41	6,46	0,87	0,29	95,8	430	138,2	1,6	81,4	5,0	203,8	0	53
4	AhBv	4-19	10,64	6,35	0,60	0,29	300,3	315	93,0	1,3	65,2	1,4	154,1	0	51
5	SwBv	19-34	12,02	6,66	0,55	0,31	285,1	298	104,7	1,7	60,1	1,7	129,8	0	56
6	IIBhvT	34-40	14,18	7,97	0,56	0,30	290,4	451	289,8	1,7	169,0	0	0	0	100
7	BvCv	40-60	1,76	1,21	0,69	0,31	30,8	70	102,3	0,3	89,0	1,7	0	0	100

Site 2.2:

Growth region, Growth district, Location: see Site 2.1

Elevation: 1010 m above sea level

Topography: middleslope summit, level ground

Climate: see Site 2.1

Parent material: Silt loam sediment (aeolian origin?) overlying a slope deposit (slope moraine?) derived from Hauptdolomit

Vegetation: Mountainous mixed forest (Hainlattich Tannen-Buchenwald, Aposerido Fagetum), acid modification

Tree layer 1: height 25 m, cover 70 %, species: Abies alba, Picea abies, Fagus sylvatica

Tree layer 2: height 9 m, cover 10 %, species: Abies alba

Shrub layer: height 0,4 m, cover 1 %, species: Sorbus aria

Herb layer: height 0,1 m, cover 50 %, species: e.g. Vaccinium myrtillus, Carex alba, Galium rotundifolium, Agrostis tenuis, Calamagrostis varia, Carex digitata, Carex flacca, Hieracium sylvaticum, Homogyne alpina, Maianthemum bifolium, Mercurialis perennis, Sanicula europaea

Moss layer: cover 30 %, species: e.g. Polytrichum formosum, Dicranum scoparium, Hylocomium splendens, Leucobryum glaucum, Pleurozium schreberi, Cladonia pyxidata, Rhytidiadelphus loreus

Land use: Forestry

Soil classification: German: (alpiner) Eisen-Humus-Podsol, im Oberboden schwach pseudovergleyt

FAO: Orthic Podzol

US-Soil-Taxonomy: Haplic Cryohumod

Profile Description

Humus form: Raw Humus, 10 - 14 cm thick

Horizon German	Horizon FAO	Depth (cm)	Description
L		0,5/1-0	needle litter of Norway Spruce and Silver Fir + remains of mosses and blueberry
Of1	O	4/3-0,5/1	Partially decomposed litter, dense network of fungal hyphae, non-compact to compact matted structure
Of2		9/8-4/3	Partially decomposed litter residues, compact matted structure, abundant roots, sharp boundary
Oh		13/12-9/8	Dark reddish brown (2,5 YR 3/3 m), well humified organic material (fine humus > 80 % by volume), compact matted structure, abundant roots, sharp boundary to the mineral soil
Mineral soil:			
Aeh	AE	0-4/5	Dark grey (7,5 Y 3/1 m); high content of humus; silty loam (uL); bleached quartz particles; platy-structure; loose; abundant roots
(Sw)Ae1	E	4/5-9/10	Light grey (2,5 Y 8/1 m); here and there pseudo-gleyic mottles; very low content of humus; loamy silt (l'U); bleached quartz particles; fine granular structure to weak single grained; loose; common to few roots
SwAe2	Eg	9/10-13/15	Light grey (10 YR 8/1 m) areas changing with pseudogleyic mottles (10 YR 6/6 m); very low content of humus; strong loamy silt (l̄U); fine granular structure to weak single grained; loose; common roots; with tongues penetrating into the B horizon

Horizon		Depth	Description
German	FAO		
Bhs	Bsh	13/15-25/27	Light reddish brown (5 YR 5/6 m), here and there black manganese accumulation; medium content of humus; silty clayey loam (utL); subangular to weak angular blocky structure; plentiful roots; boundary with tongues
IIBshl	2Bhsl	25/27-42/52	Dark reddish brown (5 YR 3/6 m); strong humus accumulation (diffuse distribution + coatings in old root channels); medium clayey loam (t'L), few coarse fragments (5 % by volume); subangular to weak angular blocky structure; moderate loose to loose; plentiful roots; wavy boundary with tongues
Bsh2	Bhs2	42/52-51/54	Dark brown (7,5 YR 3/4 m), medium content of humus; weak clayey loam (t'L), few coarse fragments (5 % by volume); subangular blocky structure; moderate loose; low content of carbonates; plentiful roots; earthworms activity apparent; boundary with tongues
Bsh3	Bhs3	51/54-52/55	Very dark brown to black (10 YR 2/3 m); strong humus accumulation (peds with coatings of organic material); weak clayey loam (t'L), few coarse fragments (5 % by volume); subangular blocky structure; moderate loose; carbonates present; plentiful roots; wavy boundary
BvCv	CB	52/55-100	Grey-white (2,5 Y 8/2 m) freshly weathered, angular Hauptdolomit stones (Ø until 300 mm), mixed with dark yellowish-brown (10 YR 4/3 m) fine earth; Stoney sandy loamy silt (slU); moderate compact; few coarse roots; diffuse boundary to Cv

Terra fusca - Braunerde, Site 2.1

1. Soil physics

No.	hor.	depth	sto. % by vol.	texture in % of humus- free fine soil								clay	kf		bulk dens.	GPV	Watercontent in % at pF			
				sand				silt												
		cm		c	m	f	Σ	c	m	f	Σ		cm/d	var.	g/cm³	%	0.6	1.8	2.5	4.2
1	O_{f1+2}																			
2	Oh																			
3	Ah	0-4	0	0,2	0,8	7	8	19	21	17	57	35	40 - 100		0,80	70	66	55	52	27
4	AhBv	4-19	< 1	0,1	0,9	5	6	18	19	17	54	40			0,92	71	66	54	51	29
5	SwBv	19-34	1-3	0	1	6	7	18	23	14	55	38	1 - 10		0,93	66	62	52	50	35
6	IIBhvT	34-40	5	3	3	9	15	15	14	8	37	48								
7	BvCv	40-60	60-70	25	13	10	48	18	20	7	45	7								

Eisen-Humus-Podsol, Site 2.2

2. Soil chemistry

No.	hor.	depth cm	pH H_2O	pH $CaCl_2$	C carb. mg/g	$C_{org.}$ %	N_t mg/g	C:N	P_t mg/g	$C_{org.}:P_t$	Pcitric acid solub. mg/kg	K_t mg/g	Mg_t mg/g	Fe_t mg/g	Fe_d mg/g	Fe_o mg/g	Fe_o: Fe_d	Fe_d: Fe_t	Mn_d mg/kg
1	Of_{1+2}	9/8-1	5,15	4,40	0	50,0	16,64	30,0	0,64	781	100,3	1,5	5,0	2,33	0,80	-	0	0,34	46
2	Oh	13/12-9/8	4,35	3,62	0	51,9	17,87	29,0	0,58	895	69,9	1,0	2,1	1,95	0,66	-	0	0,34	4
3	Aeh	0-4/5	4,00	3,25	0	11,50	5,06	22,7	0,12	958	18,7	6,0	2,0	11,15	2,89	3,72	1,29	0,26	6
4	$^{(Sw)}Ae_1$	4/5-9/10	4,15	3,32	0	0,77	0,72	10,7	0,07	110	1,8	7,8	2,5	7,58	2,73	0,96	0,35	0,36	11
5	$^{Sw}Ae_2$	9/10-13/15	4,20	3,42	0	0,89	0,54	16,5	0,08	111	1,7	8,0	3,2	12,35	4,77	2,76	0,58	0,39	17
6	Bhs	13/15-25/27	4,85	4,10	0	4,13	1,66	24,9	0,16	258	5,0	9,5	4,5	32,64	12,94	12,13	0,94	0,40	32
7	IIBsh1	25/27-42/52	5,52	4,95	0	9,02	3,76	24,0	0,40	226	11,0	17,0	5,5	47,20	15,69	13,13	0,84	0,33	54
8	Bsh2	42/52-51/54	6,77	6,37	18,0	4,52	2,41	18,8	0,47	96	3,4	18,5	23,5	50,15	14,51	8,41	0,58	0,29	185
9	BvCv	51/54-100	8,17	7,47	110,3	0,51	0,34	15,0	0,25	20	1,3	3,5	71,2	9,38	1,89	1,43	0,76	0,20	46

Continuation: Eisen-Humus-Podsol, Site 2.2   2. Soil chemistry

No.	hor.	depth cm	Al_d mg/g	sodium pyrophosphate extraction mg/g: C	Fe	C:Fe	CEC Pot. NH_4-acet meq/kg	exchang. cations in meq/kg (NH_4-acetate): Ca	K	Mg	Na	H	Al	V %	exchang.cations in mm/kg (NH_4Cl): H	Al
1	Of_{1+2}	s.b.	0,30	13,20	0,26	50,8	873	269,8	15,9	102,9	14,4	470,0	0	46	7,2	0
2	Oh	s.b.	0,31	9,24	0,07	132,0	1250	306,2	7,0	130,5	7,0	799,3	0	36	21,6	0,5
3	Aeh	s.b.	1,18	22,17	1,95	11,4	361	31,7	2,1	19,5	3,9	303,8	0	16	49,8	120,5
4	(Sw) Ae_1	s.b.	0,90	3,43	0,50	6,9	88	0	0,3	2,5	2,8	65,5	16,9	6	80,1	104,0
5	Sw Ae_2	s.b.	1,58	3,37	1,37	2,45	69	0	0,4	2,9	2,2	49,5	14,0	8	84,5	142,8
6	Bhs	s.b.	6,16	19,08	3,29	5,79	296	3,4	0,6	6,2	2,8	266,8	16,2	4	42,4	89,4
7	IIBsh1	s.b.	17,27	64,82	5,38	12,0	601	27,6	0,9	19,9	1,5	513,6	37,5	8	1,7	11,8
8	Bsh2	s.b.	6,64	19,01	2,69	7,1	402	155,2	0,5	136,7	0	109,6	0	73	n.d.	
9	BvCv	s.b.	0,43	0,73	0,42	1,7	44	112,8	0,5	115,2	0	0	0	100		

Additional soil analysis:

- Heavy minerals in the fine sand fraction of some interesting horizons (Prof. Dr. Grimm, München), selected results:

	Percentage of special minerals in 400 heavy mineral grains		Quotient
	Garnet	Turmalin	Garnet: Turmalin
Terra fusca-Braunerde, site 1			
Horizons: 19 - 34 cm:	10 %	6 %	1,66
34 - 40 cm:	21 %	3 %	7,00
Eisen-Humus-Podsol, site 2			
Horizons: 9/10 - 13/15 cm:	10 %	6 %	1,66
13/15 - 25/27 cm:	9 %	5 %	1,80
25/27 - 42/52 cm:	23 %	3 %	7,66

There is clear evidence that these soils developed on stratified parent material.

- Clay mineralogy (Dr. Wilke, Bayreuth): the results confirmed, that both soil types (Terra fusca-Braunerde, Eisen-Humus-Podsol) have been formed under a recent cold humid climate. Dominating clay minerals are illite, mixed layer minerals, vermiculite (and chlorite); the content of kaolinite is very low (<10 %).

Soil association and interpretation of studies soil types

Because of small-scale change of parent material, topography and vegetation in the mountains region of Kloaschatal, a high diversity of soil forms exists.

Brown, loamy to clayey A-B-C soils (Terra fusca-Braunerde, site 2.1; Parabraunerde-Terra fusca) are found on gentle slopes, foot slopes and in slope depressions, predominantly with North-, Northwest aspect. These soils developed during holocene period on stratified slope deposits: slope moraines of Würm glaciation derived from Hauptdolomit, covered or mixed with silty loam of aeolian origin. Soil genesis: quick decalcification in the loose sediment under the conditions of a perhumid-cool climate, accumulation of silty clay residue in the lower part of the solum, silicate weathering in the upper silt loam layer leading to the formation of pedogenic ironoxides and clay minerals, different intensity of clay migration and hydromorphy (slope wetness). Soil ecology: good supply of all nutrients; the growth of trees is strongly determined by the potential storage of plant available water, dependent on the thickness of the A- und B horizons.

Carbonatsyrosems with initial soil development are restricted to few rocky areas. On middle and upper slopes with erosion, soil types with flat solum occur: Mull-, Moderrendzina, Terra fusca-Rendzina. The Tangelrendzina develops on coarse stoney Hauptdolomit deposits with Picea abies - Pinus mugo - Rhododendron hirsutum vegetation. Hanggleye and Hanganmoore are ocated in wet slope depressions.

The soil type of Site 2.2 (Eisen-Humus-Podsol) is a very unusual, small-scale form in the Hauptdolomit region. The secondary podzolisation may have been caused by the special microrelief, leading to high snow pack by wind drift in winter. Also this profile does not receive any calciumbicarbonate rich water from lateral flow.

The deep reaching humus accumulation in the solum is remarkable; possible reasons are: intensive formation of mobile fulvic acids, high amounts of percolating water with low content of electrolytes especially during snow melt, plentiful roots in the baserich lower soil horizons and possible formation of shrinking cracks during dry periods in summer in the clayey lower horizons.

Similar observations on Bh horizons below other B-horizons have been made by ZECH u. VÖLKL (1979), CARTER (pers,comm.1985), ROBERTS (pers.comm.1986) and UGOLINI (pers.comm.1986) in areas with high snow pack or a flush of percolating water from thunderstorms.

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Trace metals in soils of the Calcareous Alps in Bavaria

by H. Ruppert*

Excursion A: point 1 and 2; Bayrischzell/Kloaschautal

Detailed description of the soil profiles are presented in this excursion guide by Zech et al. ("Tangelrendzina", "Moderrendzina") and by Rodenkirchen ("Terra fusca-Braunerde", "Eisen-Humus-Podsol"). Ubiquitous anthropogenic immissions are responsible for the pronounced enrichment especially of lead and cadmium. Zinc, manganese, iron, copper and chromium are accumulated in variable proportions by physiological processes in the system plant-soil, by intermixing of mineral soil material, and also by atmospheric immissions. Calcareous and dolomitic rocks usually contain very low concentrations of heavy metals as can be seen from the analyses of the Cv- or Cn-horizons. In carbonates many of the investigated elements are primarily bound on the residual clay fraction which is represented by Terra-horizons. During dissolution additional cadmium, zinc, iron, and manganese are released from the carbonate framework and enriched by subsequent sorption onto the residual clays and hydrous iron oxides. This process is favored by high pH-values between 7.4 and 8.4 during dissolution and by the large adsorbing surface area of the clays. The enrichment of these metals positively correlates with the primary concentrations of the guest elements in the carbonate framework and decreases with increasing residual fraction. Values of up to 1730 ppm Mn, 7.5 % Fe, 310 ppm Zn, and 2.1 ppm Cd are observed in Terra-horizons. The last three profiles contain variable contens of silty loams of probably aeolian origin. Anthropogenic lead and to a lesser extent cadmium migrate downward within the soil column together with humic degradation products and are enriched in humus-rich mineral horizons. In podsols lead can be transferred into the sesqioxide- and/or humus-rich B-horizons. In general the concentrations of all the investigated elements are positively correlated with the contents of clay

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and iron oxide minerals in the soil. The metal concentrations depend on their concentration in the source material of soil formation (geological substratum and cover sediments), on the soil forming processes (clay, iron, and humus transfer; Eh-pH-conditions; soil-plant-interactions; bioturbation etc.), and on anthropogenic immissions.

Metal concentrations in soil profiles of the Calcareous Alps in Bavaria (Hauptdolomit, Norian):

horizon	depth cm	Cr ppm	Mn ppm	Fe %	Co ppm	Ni ppm	Cu ppm	Zn ppm	Cd ppm	Pb ppm	clay %	silt %	sand %	st. %
profile 1.1: Tangelrendzina (lithic borofolist)														
Ln	1	<5	78	<0.1	<3	<3	-	-	0.03	11	-	-	-	-
Lv	1	<5	118	<0.1	<3	3	7	103	0.36	54	-	-	-	-
Of	1	6	94	0.1	<3	4	10	140	0.68	100	-	-	-	-
Ofh	3	9	51	0.1	<3	3	-	135	1.05	107	-	-	-	-
Oh1	8	5	18	0.2	<3	3	7	148	1.09	125	-	-	-	-
Oh2	6	5	9	0.1	<3	<3	4	66	0.93	52	-	-	-	-
OhCa	5	9	30	0.2	<3	7	<2	47	0.70	92	-	-	-	-
X̄Cv	0- 20+	8	64	0.2	<3	3	3	16	0.15	43	11	66	23	90
profile 1.2: Moderrendzina (rendzina, lithic rendoll)														
Lv	1	7	89	0.1	<3	<3	7	85	0.38	44	-	-	-	-
Of	1	25	188	0.4	<3	32	8	105	0.39	70	-	-	-	-
Ofh	3	23	231	0.7	<3	12	7	122	0.68	89	-	-	-	~5
Oh	6	26	244	1.2	3	15	9	112	1.45	127	-	-	-	~10
Ah	0- 9	31	730	2.1	5	16	12	73	1.24	128	29	50	22	~30
AhCv	9- 20	16	405	1.1	4	11	2	28	0.37	30	17	45	40	~78
Cv	20- 54+	<5	63	0.3	<3	<3	<2	5	0.03	<3	10	33	57	85
profile 2.1: Terra fusca-Braunerde (luvic eutric cambisol; ruptic-alfic eutrochrept)														
Of1+2	~8	38	3.99	1.6	7	16	15	112	0.67	83	-	-	-	-
Oh	~3.5	18	2.42	0.8	<3	10	13	125	0.81	73	-	-	-	-
Ah	0- 4	59	301	2.6	6	18	10	88	0.42	57	35	57	8	0
AhBv	4- 19	68	680	3.6	14	29	11	94	0.34	72	40	54	6	<1
SwBv	19- 34	82	730	4.0	15	38	13	88	0.40	51	38	55	7	~2
IIBhvT	34- 40	92	710	4.4	17	39	14	102	0.59	47	48	37	15	5
BvCv	40- 60	18	108	0.6	<3	6	4	12	0.07	4	7	45	48	~65
Cv	60-100+	9	88	0.4	<3	<3	3	8	0.11	3	-	-	-	-
profile 2.2: Eisen-Humus-Podsol (orthic podzol; haplic cryohumod)														
Of1+2	~8	16	116	0.2	<3	<3	13	114	0.60	83	-	-	-	-
Oh	~4	10	18	0.2	<3	<3	8	58	0.42	66	-	-	-	-
Aeh	0- 5	77	115	1.2	<3	8	5	40	0.14	42	29	67	4	0
(Sw)Ae1	5- 10	61	114	1.0	<3	8	11	30	0.06	15	16	77	7	0
SwAe2	10- 14	60	134	2.2	3	12	6	45	0.06	16	23	71	6	<1
Bhs	14- 26	62	164	4.3	10	25	8	70	0.33	34	34	59	7	~2
IIBsh1	26- 47	80	171	3.9	16	39	8	70	0.50	43	40	47	13	5
Bsh2	47- 53	99	4.76	4.5	15	40	14	64	0.79	41	33	43	24	5
BvCv	53-100	15	1.35	0.7	<3	6	4	11	0.11	4	9	53	38	~65
CvCn	>100	11	94	0.4	<3	<3	4	9	0.10	<3	-	-	-	-

(methods: total digestion by fluoric-, perchloric, and nitric acid; measurements with flame or electrothermal atomic absorption spectroscopy)

Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 46, 51 - 54, 1986

Description of a Farm

Egid and Helene STADLER, "zum Wirtl" in Osterhofen (Community of Bayrischzell)

by H. Silbernagl +)

1. General Data:

Altitude (village site)	800 m above sea-level
Rainfalls	1800-2000 mm a year
Annual Average of Temperature	6.9 °C

2. Size of Farm:

Farm area	64 ha
Grassland	18 ha
thereof taken on lease	3 ha
Litter meadows	2 ha
Alpine pastures	32 ha
Woodland	12 ha

3. Livestock Numbers:

23 dairy cows
20 heads of young stock over 12 months
9 heads of young stock up to 12 months
2 breeding bulls (being raised)
2 horses

4. Milk Performance:

	kg milk	kg fat	% fat	kg protein	% protein
1983	5,543	235	4.24	190	3.42
1984	5,285	225	4.25	177	3.36
1985	5,197	209	4.02	169.8	3.27

+) Amt für Landwirtschaft, Münchener Str. 2, D-8160 Miesbach

5. Forage Farming:

Hay pasture: 1st cut is almost completely used for silage
2nd and 3rd cut is dried on the ground

Three trench silos: 2 x 100 m^3, 1 x 60 m^3

Actual silo contents: approximately 10 m^3 per cow

6. Machinery Stock:

2 tractors, 56 and 18 hp
1 "Unimog" 4-wheel-drive farm vehicle, 52 hp
1 self-loading wagon
1 rotary mower
1 fork-type hay tedder
1 rotary hay tedder

travelling crane in the barn (newly built)
grab hoist in the cross-building of the barn
winch-drawn dung channel scraper
pipe-line milking plant

7. Cowshed Equipment:

medium standing with feeding rack,
general feeding passage

8. Manpower:

Farmer	30% war-disabled
Son	agricultural master
Farmer's Wife	

9. Mountain Grazing:

a) Alpine Pasture "Wirtlalm":

17 ha property of the family
altitude: 850-1100 m
150 days of grazing
hilly ground and steep slopes
at a distance of 1 km from the farmstead

At the beginning of the grazing season (for two weeks) and in autumn after the return from the high alpine pasture, own young stock is kept on this area. During summer, cows are grazing here. There is manuring of the meadows and strip grazing. This year, for the first time, five young cows (one-and-a-half years old) will be kept here for the summer months; they are supposed to graze off the areas beyond the cow fences where, hitherto, had been so little grazing that grass became overmature.

Improvement Measures:

1953 reconstruction of the alpine lodge following to a fire in December 1952
1971 construction of farm tracks
1971 controlled burning and levelling of the ground
1974 construction of a liquid manure pit (40 m^3)
1974 construction of the water supply pipe-line

b) Niederaudorf Alpine Pasture "Waldalm" on Sudelfeld (Hochleger):

15 ha, equivalent to a share of 5/27 in the alpine common (six alpine farmers)
altitude: 1100-1240 m
100 days of grazing
hilly ground and steep slopes
at a distance of 6 km from the farmstead

Stocking: 5 calves
7 heads of young cattle (over 2 years old)
10 heads of young cattle (between 1 and 2 years old)
14 heads of cattle from other farms (1-3 years old)

In 1873, Caspar WIDMESSER, the grandfather of the farmer's wife, bought the shares in the Niederaudorf alpine pasture "Waldalm".

Centre of Skiing:

The operators of ski lifts on Sudelfeld, in collaboration with the Technical University of München/Weihenstephan, carry out measures of pasture renovation and fertilization for the areas used as ski courses.

10. <u>History of the Farm:</u>

"Wirtl-Hof": "Wirtl" means spindle or distaff. The first farmer settling on this ground in the middle of the 14th century presumably had been a carver of distaffs.

From 1793 the WIDMESSER family were owners of the farm and passed it on to their heirs over five generations. In 1954, Mr. Egid STADLER married into the farm.

Previously to 1960, tuberculosis had already been eradicated on this farm. In 1961, by bought-in silage, agents of brucellosis were introduced. The culling of cows that have shown positive reaction upon tests was not wholly successful; relapses occurred repeatedly. By rigorous instructions of the county commissioner (labelling "contaminated farm", distances of 2 m to be observed at the fences to the neighbouring pastures on "Wirtlalm", prohibition of grazing on the alpine common), in the end, the Stadlers felt compelled to cull the whole livestock in 1965. In July 1965, after having cleared out and disinfected the cowhouses, animal husbandry was being started anew with 12 cows and heifers that had been bought at the Miesbach auction market.

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Alm (Alpine Pasture) Farming in Bavaria

G. Spatz*

General

"Almen" are farms which are utilized only seasonally during the summer months as grazing land.

Around 50,000, mostly young, cattle summer on around 1350 "Almen" in Bavaria.

The pastures of the "Almen" in Bavaria are located predominantly below the Alpine tree line, that is they have taken the place of the natural mountain forests. In this secondary vegetation principally flora elements are found which have their primary habitats in the natural grass biomes of the Alpine level. In this respect, the Alm pastures occupy a high land preservation position as habitats for rare and protected species as well as charming landscape elements in addition to the agricultural importance.

Utilization of the Almen

As a rule, the Almen are used extensively as pastures. The largest part of the areas is not fertilized either organically or minerally. Frequently, the grazing animals can move freely over the entire area, which can result in irregular grazing with under- and overgrazed sections. Large-area enclosures on well-managed Almen enable grazing rotation. Many Almen have several "echelons" (lower, middle, upper layers), which are grazed in succession and technically this system is comparable with grazing rotation.

Necessary maintenance measures include "Schwenden" (removal of woody growths as they arise), stoning (occasional collection of stones) and mechanical or chemical weed control.

*Prof.Dr. G. Spatz, Chair for Grassland and Fodder Cultivation of the Technical University Munich in 8050 Freising-Weihenstephan

Only easily accessible subsections, usually in the immediate vicinity of the Alm cabins are intensively utilized and also fertilized regularly. They provide considerably more and better fodder than the major part of the grazing areas. Occasionally, fenced areas also are found near the cabin, which are mowed once a year for hay to provide a small reserve for emergencies.

Grazing animal and soil erosion

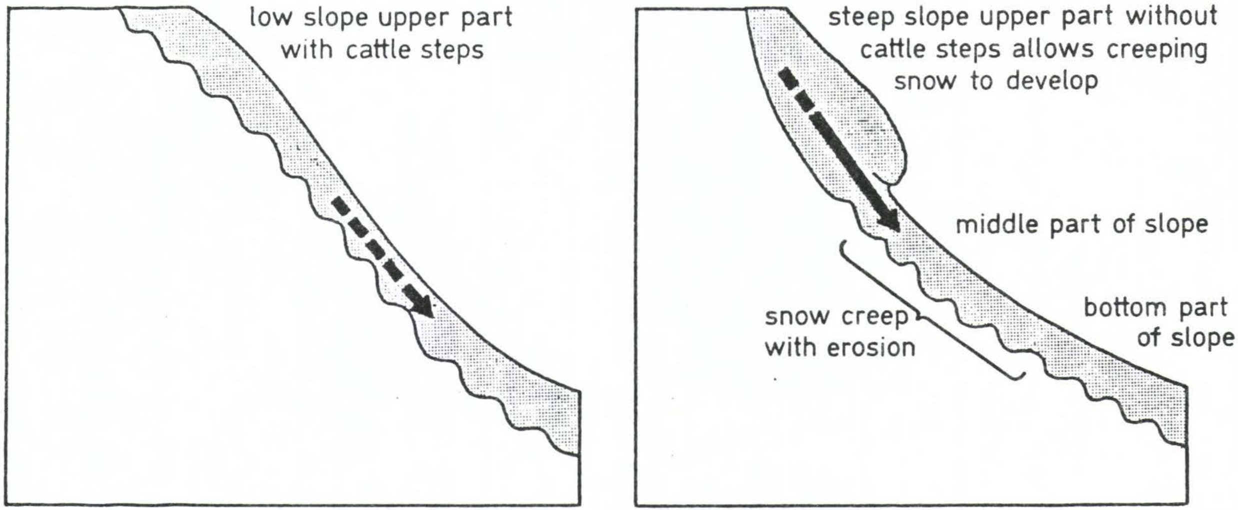
The grazing animal through its tread and bite exercises a direct effect on the vegetating cover protecting the soil.

The tread of the grazing animals

In steep terrain, cattle habitually always graze horizontally to the slope. This habit leads to the formation of lines running parallel to the slope, the so-called "cattle steps". Basically, structures running parallel to the slope exercise a stabilizing effect, which is true also for "cattle steps", provided there is no overgrazing. With uninterrupted wetness and continuous grazing, considerable soil damages and sod displacement can occur because of the increased plasticity of the soil. In such situations, it is the responsibility of the pasture personnel to drive the animals from steep slope areas to level pasture sections.

Major erosion areas are formed on the grazed steep slopes less as the direct result of the animal tread, but rather more through snow erosion beginning at the edges of the cattle steps. This situation occurs particularly when snow masses sliding down from the upper slope abruptly hit the cattle steps on the middle slope (Figure 1).

At watering places, enclosure gates or stable entrances, where a concentration of animals inevitably takes place, local tread damages and soil compaction can occur. As a rule such areas lie on flat terrain and are proportionally insignificant.



a) cattle steps as a stabilizing factor

b) cattle steps as erosion initiating obstacles for snow creep

Figure 1: cattle steps and soil erosion

The bite of grazing animals

The feeding on pasture plants could first of all be regarded as a basic damage to the vegetation and accordingly as promoting erosion. It has been proved on the other hand however that reasonable grazing does not damage the sod, but rather on the contrary leads to particularly regenerable and dense sods.

Water drainage and grazing

Erosion damages can of course occur not only through direct injuries to the ground; the increased runoff of surface water can secondarily promote erosion. Even though a measurable soil compaction on extensively grazed areas caused by animal tread could not be proved in our own studies, there is no doubt that the surface runoff during heavy rain is considerably greater on pasture areas than in a mountain mixed forest, for example. On the other hand even with a large surface runoff on intact mountain grassland there is no erosion of solids of any kind.

Pasture maintenance and soil erosion

Regular care of the pasture areas by the manager is a major contribution to the reduction of the erosion danger. Dividing the pasture area with enclosures to permit regulated rotation must be conceived as a minimum requirement in this respect and regarded as an adequate maintenance measure only with intensive grazing utilization. Particularly on extensive pasture areas with small cattle stocks, removal of the sporadically appearing tree growth ("Schwenden") is an important erosion-hindering action. As is also the removal of larger boulders on the terrain. At first glance, this requirement may come as a surprise. When the fact is realized however that most of the erosion damages on slope locations are caused by the winter creeping snow, this becomes understandable. Even with a relatively small slope inclination, the winter snow cover can start to move. If the snow slides only on a dense, smooth pasture sod, no damages can occur with slow sliding speeds, but as soon as obstacles are encountered in the form of boulders or young spruce trees, the snow drive develops tremendous forces. Boulders channel the topsoil like gigantic planes and young spruce can be levered along with their shallow root systems out of the ground (Figure 2).

Sudelfeld Alm District

The Alm district visited "Sudelfeld" is the largest coherent Alm district in Upper Bavaria. Large-scale cleared pasture areas permit spacious utilization and provide an adequate fodder basis.

The most common pasture plant communities are the Alchemillo-Cynosuretum in the lower locations and the Crepido-Cynosureteum and a secondary Seslerio-Caricetum sempivirentis in the higher elevations, which is modified depending on the degree of grazing. Small wet areas and patches of wild oats (mowing areas) are interspersed.

The following 6 vegetation examples convey an impression of the vegetation present.

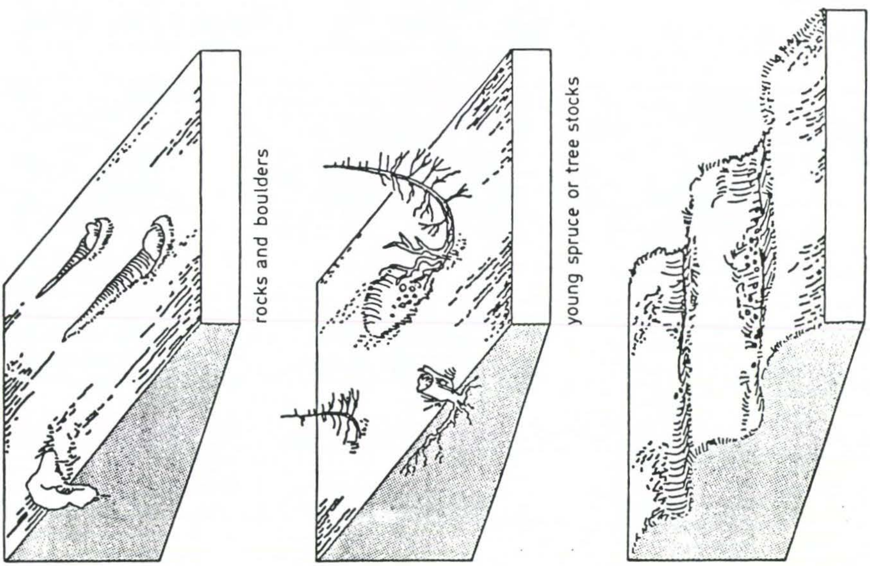


Figure 2: starting points of erosion on steep slopes

Example 1: Alchemillo - Cynosuretum, moist, high productiving, low SSE slope, deep rooting depth, good drainage, grazed, plant cover 98 %

Biomass (%) above soil

50 grasses

9 Agrostis tenuis
8 Festuca pratensis
8 Cynosurus cristatus
7 Festuca rubra
5 Dactylis glomerata
3 Deschampsia cespitosa
3 Poa supina
3 Phleum pratense
2 Briza media
1 Poa pratensis
1 Anthoxanthum odoratum

grassy plants

+ Carex flacca

30 herbage

3 Carum carvi
3 Leontodon autumnalis
3 Ranunculus acer
3 Mentha longifolia
3 Centaurea jacea
2 Leontodon hispidus typ.
2 Alchemilla vulgaris
2 Plantago media
2 Ranunculus montanus
1 Chrysanthemum leucanthemum
1 Leontodon hispidus hastilis
1 Galium mollugo
1 Prunella vulgaris
1 Ranunculus repens
1 Taraxacum officinale
+ Cirsium palustre
+ Myosotis palustris
+ Veronica chamaedris
+ Stellaria graminea
+ Rumex acetosa
+ Rhinanthus minor
+ Cerastium holosteoides
+ Cirsium arvense
+ Plantago lanceolata
+ Plantago major

20 legumes

11 Trifolium repens
7 Trifolium pratense
2 Lotus corniculatus

Example 3: Caricetum davallianae, disturbed, low NNE slope, moist by subsurface runoff, accessible, but rarely grazed

Biomass (%) above soil

35 grasses

23 Molinia caerulea
5 Briza media
5 Festuca rubra
2 Anthoxanthum odoratum
\+ Deschampsia cespitosa

40 grassy plants

11 Carex davalliana
8 Juncus alpino articulatus
6 Carex flava
5 Eriophorum latifolium
3 Carex paniculata
3 Carex panicea
2 Carex echinata
2 Carex flacca

22 herbage

2 Tofieldia calyculata
2 Leontodon hispidus hast.
2 Leontodon hispidus typ.
2 Equisetum palustre
1 Lychnis flos cuculi
1 Primula farinosa
1 Gentiana asclepiadea
1 Caltha palustris
1 Ranunculus nemorosus
1 Parnassia palustris
1 Aster belidiastrum
1 Trollius europaeus
1 Phyteuma orbiculare
1 Willemetia stapitata
1 Dyctylorchis maculata
1 Gymnadenia odorata
\+ Primula elatior
\+ Rhinanthus minor
\+ Ranunculus montanus
\+ Prunella vulgaris
\+ Potentilla erecta
\+ Galium palustre
\+ Pinquicula vulgaris
\+ Valeriana dioica
\+ Linum catharticum
\+ Veratrum album
\+ Plantago lanceolata
\+ Selaginella helvetica

3 legumes

2 Trifolium pratense
1 Lotus corniculatus

Example 4: SteilerNO-Hang, steep NE slope, shallow, developed from desintegrated granular dolomite, intensively grazed, with cattle steps and damages by animal tread

Biomass (%) above soil

38 grasses

15 Festuca rubra
8 Agrostis tenuis
4 Cynosurus cristatus
3 Briza media
3 Anthoxanthum odoratum
3 Nardus stricta
2 Deschampsia cespitosa

5 legumes

4 Trifolium pratense
1 Lotus corniculatus

28 grassy plants

13 Carex montana
7 Carex flacca
6 Carex flava
2 Carex panicea

29 herbage

11 Leontodon hispidus typ.hast.
3 Ranunculus montanus
1 Plantago lanceolata
1 Galium verum
1 Willemetia stipitatus
1 Potentilla erecta
1 Alchemilla vulgaris
1 Hieracium pilosella
1 Centaurea jacea
1 Veratrum album
1 Prunella vulgaris
1 Plantago media
+ Gentiana verna
+ Linum catharticum
+ Gentiana asclepiadea
+ Chrysanthemum leucanthemum
+ Galium verum
+ Parnassia palustris
+ Primula farinosa
+ Primula elatior
+ Cirsium palustre
+ Lysimachia numularia
+ Carlina acaulis
+ Crocus albiflorus
+ Polygala vulgaris
+ Acer pseudoplatanus juv.
+ Selaginella helvetica

Example 5: sown in, leveled ski-run, steep NE slope, carefully grazed, without tread damages, curing damages of snow caterpillar

Biomass (%) above soil

45 grasses

11 Festuca rubra
8 Agrostis tenuis
6 Festuca pratensis
5 Poa trivialis
3 Cynosurus cristatus
3 Dactylis glomerata
2 Poa pratensis
2 Agrostis stolonifera
2 Phleum pratense
1 Festuca arundinacea
1 Anthoxanthum odoratum
1 Poa supina

grassy plants

\+ Carex flacca
\+ Carex montana

25 herbage

4 Leontodon autumnalis
4 Ranunculus acer
3 Leontodon hispidus typ.
3 Prunella vulgaris
2 Leontodon hispidus hast.
2 Alchemilla vulgaris
2 Taraxacum officinale
1 Plantago major
1 Bellis perennis
1 Carum carvi
1 Plantago media
1 Centaurea jacea
\+ Potentilla erecta
\+ Urtica dioica
\+ Cirsium palustre
\+ Cerasteum cespitosum
\+ Veronica chamaedris

30 legumes

20 Trifolium repens
8 Trifolium pratense
2 Lotus corniculatus

Example 6: open area in between planted young forest, steep E slope, directly above fence

surrounding young forest

Picea excelsior
Taxus bacata
Fagus sylvatica
Acer pseudoplatanus
Sorbus aucuparia
Sorbus aria

herbal cover

Biomass (%) above soil

grasses

\+ Dactylis glomerata
\+ Elymus europaeus

100 herbage

28 Chaerophyllum hirsutum
18 Adenostyles alliariae
8 Stachys sylvatica
8 Senecio fuchsii
5 Aposeris foetida
5 Hieracium sylvaticum
5 Lamium galeobdolon
5 Eupatorium cannabinum
3 Mercurialis perennis
3 Phyteuma spicatum
2 Polygonatum verticillatum
2 Gentiana asclepiadea
1 Sanicula europaea
1 Thalictrum aquilegifolium
1 Geranium pratense
\+ Lysimachia nemorum
\+ Geum urbanum
\+ Primula elatior
\+ Cypripedium calceolus

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THE INFLUENCE OF ANIMAL TREADING ON SOIL PHYSICAL PROPERTIES OF MOUNTAINOUS SOILS

von

R. Horn[+]

INTRODUCTION

Due to climatic, hydrological and geomorphological conditions mountainous soils are often very sensitive to compaction, e.g. by animals or man, which may finally result in an irreversible variation of soil properties. The process of such an alteration may take place as follows: The compression leads to a mechanical destruction of plants and an additional settlement of the soil surface including an increase of the bulk density, preconsolidation load and penetration resistance, and a decrease of the average pore sizes, and thereby a decrease of the saturated hydraulic conductivity. Consequently rainwater persists at the top or in the soil for a longer time period, including worse aeration too. Additional dynamic stresses of such wetter soils-e.g. by animals, finally may destruct the soil structure by puddling. Consequently the surface runoff may be intensified too.

The aim of the investigations is the demonstration of those different stages of soil compaction and the induced alteration of soil physical and mechanical properties.

SOILS

4.1) FAO: Rendzina under mixed forest (beech, fir)

Braunerde Rendzina aus Hauptdolomit unter Laubmischwald

US-Soil Taxonomy: Rendoll

That soil characterizes the natural site conditions under forest.

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Tab. 1: General physical and chemical characterisation of the soils

site	stage	horizon	depth (cm)	structure	bulk density (g/cm^3)	particle density (g/cm^3)	moisture content θ at pF				available water capacity (mm/dm) at pF 1.8 - 4.2		air capacity (mm/dm) at pF $-\infty$ - 1.8	penetration resistance (MPa), pF 2.5	sat. hydraulic conductivity (cm/d)	s	texture (% fine earth)			gravel %	pH	% org. matter	CaCO$_3$ %
							$-\infty$	1.8	2.5	4.2		2.5 - 4.2					clay	silt	sand				
forest	4.1	A_h	0- 3	crumbly	0.26	2.15	87.9	38.5	34.7	16.0	22.5	18.7	49.4	0.2	1205	126	9	80.5	10.5	4.7	6.9	21.0	6.9
			7-10	crumbly	0.37	2.16	82.9	45.8	35.7	25.2	20.6	10.5	37.1	0.09	1031	359	14	77.6	8.4	5.1	6.8	20.0	5.8
		B_wC_m	12-15	subangular blocky	1.01	2.51	59.8	56.3	50.9	32.3	24.0	18.6	3.5	n.b.	43	30	26	60.0	14.0	15.0	7.2	3.8	23.0
		C_m	> 20	koh-stony																			
undamaged pasture	4.2	A_h	0- 3	subangular blocky-platy	0.88	2.46	64.2	50.8	50.2	33.7	17.1	16.5	13.4	1.2	87.9	48	18	67.0	25.0	22.0	7.2	11.0	18.0
		A_hB_w	10-13	subangular blocky - platy	0.68	2.48	67.7	61.3	58.5	38.5	22.8	10.0	6.4	0.9	212	115	30	41.8	8.2	8.6	7.1	2.8	11.0
		C_m	14-17	sub.blocky	1.00	2.51	59.8	56.3	50.9	32.4	24.0	18.5	3.5	n.b.	30	8	28	59.0	13.0	18.0	7.4	1.0	12.0
damaged pasture	4.3	A_h	0- 3	subangular blocky - platy	0.98	2.43	59.7	59.4	57.9	37.7	21.7	20.2	0.3	1.6	1.0	0.4	30	59.3	10.7	20.5	7.2	11.0	18.0
		B_wC_m	12-15	platy	0.88	2.44	63.9	60.3	53.4	31.7	28.6	21.7	3.6	1.5	7.2	5.8	39	54.6	6.4	5.8	6.7	1.2	4.1
mud	4.4	A_hG_r	2- 5	koh.	0.62	2.44	74.6	56.5	49.7	28.2	28.3	21.5	18.1	<0.001	14	4	41	52.4	6.6	5.1	7.1	10.0	5.4

Profile Description

Horizon	Depth (cm)	Description
O	4 - 1	
Oh	1 - o	
Ah	o - 12	stony loamy silt, crumbly, intensively rooted, gradual wavy boundary
BwCm	12 - 2o	stony, loamy silt, subangular blocky, wavy boundary
Cm	> 2o	

4.2) FAO: Calcaric Regosol
Rendzina Braunerde aus Hauptdolomit unter Almwiesennutzung
Soil Taxonomy: lithic Cryorthent
The pasture is visually undamaged by animal treading.

Profile Description

Horizon	Depth (cm)	Description
Ah	o - 1o	stony loamy silt, subangular blocky-platy, intensively rooted, abrupt boundary
AhBw	1o - 15	stony loamy silt, subangular blocky-platy, medium rooted, wavy to abrupt boundary
Cm	> 15	

4.3) FAO: Calcaric Regosol
Rendzina Braunerde unter Almwiesennutzung
Soil Taxonomy: lithic Cryorthent
The pasture is intensively damaged by trampling and shows an intensive soil movement.

Progile Description

Horizon	Depth	Description
Ah	o - 12	stony, loamy silt, subangular blocky-platy, few roots, abrupt boundary
BwCm	12 - 17	stony, loamy silt, platy, abrupt boundary
Cm	17	

4.4) FAO: Calcaric Gleysol

Naßgley unter Almwiesennutzung

Soil Taxonomy: Cryaquent

The wet pasture is absolutely destroyed by trampling, the soil surface is studded with deep holes due to that treading. That site is described as a "mud".

SOME REMARKS·

Bulk density $d_B (g/cm^3)$

Animal treading causes an increase of the bulk density from stage 1 to 3 (comparing the same soil depth), but decreasing with depth within the topsoil. At presence of additional free water, dynamic stresses result in a puddling toc, thus the bulk density decreases (stage 4).

Pore size distribution and saturated hydraulic conductivity

During stage 1 - 3 increasing compaction reduces the air capacity of the soil layers and the saturated hydraulic conductivity, while the available water capacity is increased. Puddling (stage 4) enhances the air capacity and the saturated hydraulic conductivity compared to 3.

Mechanical stability

The value of the preconsolidation load (calculated as a result of the confined compression test) increases from stage 1 to 3, while the mud is absolutely unstable. Increasing moisture suction results in higher values. That trend is verified by the vakues if the siuk cohesion too. On the other hand the angle of internal friction is highest in the intensively aggregated and rooted forest soil, but decreases with the intensified distruction of the natural soil structure (stage 1-41).

CONSEQUENCES OF ADDITIONAL COMPACTION for

a) root penetrability of the soils. Due to the additional decreases of coarse pores the penetration resistance increases but the intensity depends upon the preconsolidation load. Thus the plant growth in those soils is more difficult.

b) the infiltration behaviour. At all stages increasing load reduces the saturated hydraulic conductivity at which that reduction is highest after reaching the primary consolidation status. Thus the surface runoff gets more importance expecially in absolutely destructed soils at mountainous conditions.

Tab. 2: Preconsolidation load (N/cm^2) of differently prestressed soils (desiccation rate: 60, 300 mbar)

site	depth (cm)	preconsolidation load (N/cm^2) 60 mbar	300 mbar
forest	0 - 3	6.6	10.9
	7 - 10	5.8	10.8
	12 - 15	3.9	3.9
undamaged pasture	0 - 3	8.4	9.0
	6 - 9	7.8	8.2
	12 - 15	5.2	5.8
damaged pasture	0 - 3	17.8	18.9
	6 - 9	18.1	18.8
	10 - 13	9.3	10.1
intensively treaded area = mud	2 - 5	0.89	1.2

Tab. 3: Values of the cohesion (N/cm^2) and angle of internal friction (°) of differently prestressed top soils (A_h horizon) (desiccation rate: 60 mbar)

site	cohesion (N/cm^2)	angle of internal friction (°)	correlation coefficient
forest	0.05	47.5	0.994
undamaged pasture	3.1	37.4	0.997
damaged pastur	3.9	29.7	0.997
mud	0.01	8.0	0.991

Tab. 4: Stress dependent variation of the penetration resistance (MPa) (desiccation rate: 300 mbar)

site	depth (dm)	load (N/cm^2) 0	2	5	10	20	80
forest	0 - 3	0.2	0.5	0.79	2.1	3.2	11.8
	7 - 10	0.09	0.38	0.57	1.3	1.8	5.4
undamaged pasture	0 - 3	1.2	1.3	1.5	1.9	3.6	5.6
	6 - 9	0.9	1.2	1.4	2.0	2.9	5.9
damaged pasture	0 - 3	1.6	1.6	1.6	2.0	3.3	5.3
	6 - 9	1.5	1.6	1.8	1.9	3.5	6.8
mud	2 - 5	<0.001	0.9	1.5	2.1	3.0	6.0

Tab. 5: Load dependent variation of the saturated hydraulic conductivity (cm/d) (desiccation rate: 60 mbar)

site	depth (cm)	load (N/cm^2) 0	2	5	10	20	80
forest	0 - 3	1205	980	10.1	1.4	0.9	<0.001
	7 - 10	1031	860	216	100	9	1.4
	12 - 15	43	26	15	8	18	0.1
undamaged pasture	0 - 3	89	88	88	69	4.9	0.1
	12 - 15	212	160	112	89	51	2.1
damaged pasture	0 - 3	1.0	0.9	1.0	0.8	<0.1	<0.01
	10 - 13	7.2	6.0	5.8	1.0	0.6	<0.1
mud	2 - 5	14	0.9	0.6	0.03	0.01	<0.001

Mitteilungen Dtsch.Bodenkunl. Gesellschaft, 46, 7o - 71 , 1986

Excursion A, 2nd day

Soils, agriculture and forestry in the Bavarian lowlands ("Tertiärhügelland") and Hesselberg

by

Wittmann, O+ and Th.Diez, W.Vogl, K.Kreutzer, J.Bittersohl, R.Weihermann

Route map you find on page 7

Route description:

Munich: Northward on the gravel plain through increasingly more greatly groundwater-influenced regions and through the "Dachauer Moos" fen soil.

"Tertiärhügelland": Over a steep marginal range into the partially loess-loam covered Upper Bavarian "Tertiärhügelland" (Tertiary upland hills) through the flood plain of the Amper Valley (Alpine stream); the Autobahn then crosses the "Hallertau" hops growing district; in particular the north-south valleys with pronounced asymetry.

Pfaffenhofen an der Ilm: County seat, premium hops district; late Gothic church (15th century).

Kreutenbach: Excursion point 5, profile 5:"Braunerde" (brown earth) originated in loess-loam, nutritive potential experiment; during the further trip, the sandy part of the Tertiary upland hills not influenced by loess is touched.

Aichach: Castle Wittelsbach which gave its name to the Bavarian ducal family was located in the vicinity.

Höglwald: Excursion point 6, profile 6:"Parabraunerde" originated in a high silt covering layer over micaceous silt weathering of the Tertiary; soil acidification experiment.

Lower Lech Valley: High carbonate flood plain soils. Riss Ice Age terrace steps, loess covered with "Parabraunerden" und "Pararendzinen"; south of Augsburg, water supply for the City of Augsburg, primarily from

+Bayer.Geol.Landesamt D 8ooo München 4o, Heßstr. 128

shallow wells; relatively high nitrate infestation of the groundwater through agriculture; nitrate contents of the groundwater decrease considerably along the downstream cours of the Lech River.

Danube Valley ("Donauried") flood plain soils, partly strongly humic in great depth; flood plain sediments with lower carbonate content than in the Lech Valley.

Donauwörth was formerly a Free Imperial City.

"Riesalb": Soils originated in limes and dolomites of the Upper Jurassic, locally from coverings of clayey, sandy or calcareous Ries eruptive masses, scattered loess-loam influence, in particular near the Danube.

Ries: The circular depression of the Ries with a diameter of 25 km originated from the impact of a huge meteorite during the Neocene. It formed a crater extending to a depth of 5oo m, which today is filled with marly-clayey lacustrine deposits. The eruptive masses (mainly south and east of the depression) consist of rocks of the Mesozoic and the Pre-Neocene Tertiary stratigraphic sequences, more rarely of the material of the crystalline basement. Suevite is a crystalline breccia with alternating high but always present glass content (fusion resulting from high impact wave stress).

Oettingen is a former Residence City on the Wörnitz River.

Southern "Albvorland" (Alb forland): Soils: see description for Hesselberg excursion point.

Hesselberg: <u>Excursion point 7:</u> Soils originated rom Jurassic rocks (profiles 7.1-7.4), settlement history, agriculture farmland consolidation.

Dinkelsbühl: former Free Imperial City; old city distinguished by half-timbered buildings and with a very well preserved city wall, Georgskirche (St. George Church) with 3-naved Late Gothic hall (15th century).

Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 46, 72-82 (1986)

Excursion area Upper Bavarian "Tertiärhügelland"

by B. Hofmann +)

Geographical-geomorphological survey

The excursion points No. 5 Kreutenbach and No. 6 Höglwald are located in the Upper Bavarian "Tertiärhügelland" (Tertiary upland hills) (Region 12.8) extending from the Munich gravel plain and the "Altmoränen"-regions in the south up to the Danube Valley in the north. The Upper Bavarian "Tertiärhügelland" slopes from the southwest (approx. 560 m m.s.l.) to the northeast to the Danube (approx. 360 m m.s.l.) and to the east to the Isar (approx. 410 m m.s.l.). The largely autochthonous stream systems of the Paar and the Ilm drain to the Danube, those of the Glonn and Amper to the Isar. The Paar and the Amper themselves originate in the moraine region of the Alpine foothills. The "Tertiärhügelland" is divided by a closely meshed, finely ramified valley network into numerous hills and crests rising sometimes slightly and sometimes steeply 30-60 m above the bottoms of the valleys on the average. Kreutenbach (463 m m.s.l.) lies in the high loess-loam part of the Upper Bavarian "Tertiärhügelland" (12.8.3) and Höglwald in the loess-loam-influenced part. These two subregions have a more pronounced relief than the lower-lying, undulating sandy Tertiary upland hills (12.8.1) which change over into the wash-away region of the "Donaumoos".

+)Bayer. Geologisches Landesamt, Heßstr. 128, D-8000 München 40

Geological survey

The Upper Bavarian "Tertiärhügelland" (region 12.8) lies in the area of the South German molasses basin, a sedimentary trough, which as fore deep accommodated during the Tertiary the debris of the rising peripheral areas, in particular of the emerging Alpine chains. The surface is formed in the deposits of the Upper Freshwater Molasse . All those coarse and fine sediments of the foreland are described by this term, which were formed under mainland conditions after the ocean had retreated from the molasses basin, that is fluviately and limnetically. The sedimentation of the Upper Freshwater Molasses occurred during the Upper Miocene, around 15 to 10 million years ago. Its thickness is around 150-250 m.

The deposits of the Upper Freshwater Molasse form an alternating sequence of gravelly sands, sands, silts, marls and clays. These sediments were filled into the Molasse basin from the eastern limestone and central Alps by means of a far-reaching stream system from the east (Landshut area) to the west (Augsburg area). With increasing distance from the delivery area, ever more finely grained sediments were deposited. A great reduction of the shingle sizes and a depletion of the petrographic constituents through transport screening can already be recognized in the Upper Bavarian upland hills.

Grain size distribution:

- sandy gravels: maxima in the fine gravel and medium sand fraction
- sands: maximum in the medium sand fine sand fraction
- clays: clay content only rarely above 50 % clay ($< 2\ \mu$).

Petrographic constituents:

- gravels: 90 % quartzes, 10 % crystalline and sedimentary rocks.

Clay mineral constituents:

- clays:predominantly montmorillonite; kaolinite 0 - 2 %.

After the depositing in the Upper Fresh Water Molasse, the sedimentation area, tectonically removed, became the erosion area. The present upland hills were last formed during the Pleistocene in the periglacial zone. The valley asymmetry with preferred western steep slope exposure characteristic for the relief of the Tertiary upland hills is also of periglacial origin. The preferred eastern exposed slight slopes are for the most part covered with loess-loam and in the vicinity of the blow-off areas with loess. Potential blow-off areas of the loess were the gravel flats of the Lech, Amper and Isar valleys.

Climate

(shortened afterJ. van EIMERN 1975)

The climate of the Upper Bavarian "Tertiärhügelland" is characterized by an annual average precipitation from 700 to 850 mm (measured between 1931 and 1960). The average annual temperature is 7-8° C.

The higher lying regions have markedly higher precipitation amounts than the lower lying ones on both sides of the lower Paar, Ilm and Amper valleys. The broad valleys of the Ilm and the Glonn have somewhat less rain than the surrounding heights. The large amount of precipitation in the summer is notable, almost three times as much in July as in March, in the summer half year, almost twice as much as in the winter half year.

The Tertiary upland hills with their heights are a rain barrier area, even though not so pronouncedly as with a highland area. It is notable that summer thunderstorm rains and also hail are not infrequent.

Great terrain climatological contrasts exist with respect to the temperature. The broad valleys of the Ilm, Glonn, Amper, etc. may be regarded as being endangered by late and early frost, to a certain extent also the numerous asymmetrical valleys.

The soils

The formation, distribution and association of the soils in the Upper Bavarian "Tertiärhügelland" (region 12.8) are closely related to the parent material (coarse- and fine-grained deposits of the Molasse on the one hand, and loess and loess-loam as wind-formed covering sheets on the other), the (moderately moist) climate, the hilly undulating relief characterized by valley asymmetry and the water relationships determined particularly by the change between water-permeable and water-retaining deposits. Water permeability:

- gravelly sands, sands: very great to great
- silts, clays: medium to small and very small respectively
- loess: medium to small
- loess-loam, loess-loam solifluction layer: small and very small respectively.

Kreutenbach, excursion point 5. The distribution pattern of the soils in the rich loess-loam Upper Bavarian "Tertiärhügelland" (12.8.3) is characterized by the large-scale occurrence of the "Braunerde" originated from loess-loam (2b)* on the mostly eastern exposed slight slopes of the asymmetric valleys. Under agricultural use, the 3-4 dm thick high-silt cover layer is ± eroded or incorporated into the Ap horizon. The loamy colluvium (6a)* represents the accumulation form. "Pseudovergleyte Braunerden" of loess-loam (5)* are encountered in locations with more water (initial valley basins, lower parts of the slopes), "Gleye" (30b, 31b)* and "Auengleye" (32b) of loamy valley sediments in lateral valleys influenced by groundwater. On the mostly western exposed steeper slopes, the "Braunerden" of (gravelly-) sandy to loamy-sandy molasses material (9,10,11,12)* developed variously depending on the degree of erosion appearance. On moderately steep slopes "Braunerden" of sandy molasses material with loess-loam layer (13)* or "Braunerden" of loess-loam with intermixed (gravelly-) sandy molasses material (3)* change over to soils of loess-loam.

"Braunerden" (17b) originated from silty-clayey molasses sediments, which in various elevated locations extend on the surface, in

* Numbers in brackets marked with * refer to the numbers of the Soil Legend of Fig. 1 and Fig. respectively.

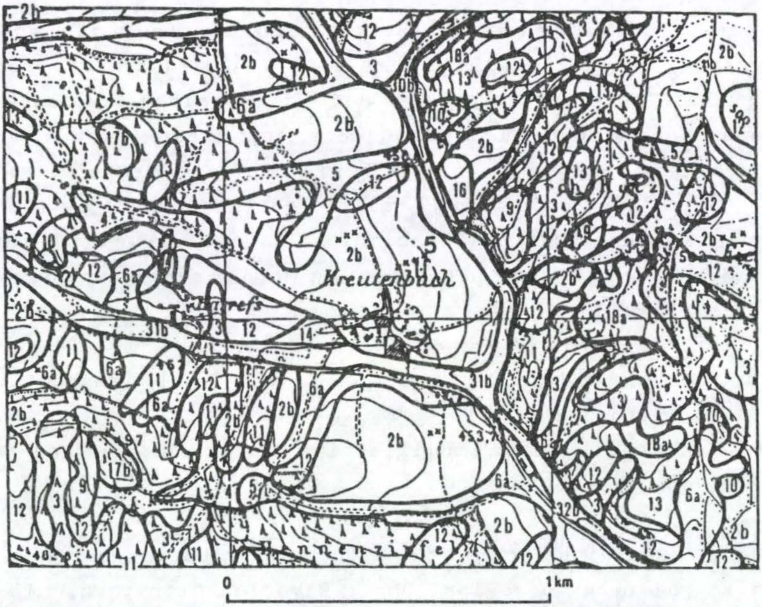

Fig. 1: Excursion-point No. 5, "Kreutenbach"
Sector of "Standortkundliche Bodenkarte von Bayern 1:25 000 Bl.7434 Hohenwart"

2b	"Braunerde" (Cambisol) originated from loess loam
3	"Braunerde" (Cambisol) originated from loess loam interfered with sandy Molasse material
4	"Braunerde", weak indications of damming wetness, originated from loess loam above loess solifluction layer
5	"Pseudogley-Braunerde" (Planosol-Cambisol) originated from loess loam
6a	"Kolluvium" (colluvium) of loamy erosional masses
9,10,11	"Braunerde" originated from gravelly- sandy, respectively sandy and slight loamy-sandy Molasse material
12,13	"Braunerde" originated from loamy-sandy, respectively loamy above loamy-sandy Molasse material
14	"Kolluvium" of Sandy erosional masses
17b	"Braunerde" originated from loamy cover layer above loamy-clayey Molasse material
18a	"Pelosol-Braunerde" (Pelosol -Cambisol) originated from loamy cover layer above loamy-clayey Molasse material
30b,31b	"Braunerde-Gley" (Cambisol-Gleysol), respectively "Gley" (Gleysol) originated in loamy valley sediments
32b	"Anmoorgley" (Humic Gleysol) originated in loamy valley sediments

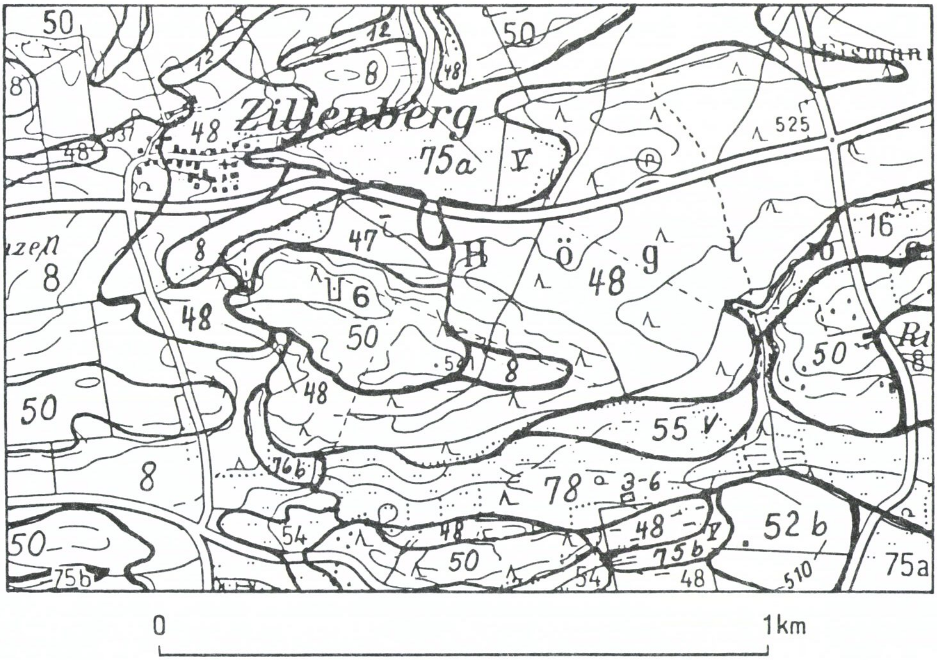

Fig. 2: Excursion point Nr. 6, "Höglwald"

Sector of "Standortkundliche Bodenkarte von Bayern 1:50 000, Bl.7732"

8	"Braunerde" (Cambisol) originated from loess loam interfered with sandy Molasse material
12	"Kolluvium" (Colluvium) of loamy erosional masses
16	"Pseudogley" (Planosol) originated from loess loam
48	"Braunerde" originated from loamy-sandy Molasse material
50	"(Para-) Braunerde" originated from loamy Molasse material and heavy silt cover layer
52b	"Braunerde" originated from loamy cover layer above loamy-clayey Molasse material
54	"Pseudogley-Braunerde" originated from loamy cover layer above clayey-loamy Molasse material
55	"Pseudogley" originated from loamy cover layer above clayey-loamy Molasse material
75a	"Gley" (Gleysol) originated in sandy valley sediments
75b,76b	"Gley" originated in loamy valley sediments
78	"Niedermoor" (fen peat)

erosion locations also "Pelosol-Braunerden" (18a) as layer profiles of 3 to 6 and less than 3 dm thick silty-loamy cover layer over loamy-clayey Molasse material.

Höglwald, <u>excursion point 6:</u> Soils of loess-loam (5)* recede in their distribution in favor of soils of Molasse material in the Upper Bavarian "Tertiärhügelland" (12.8.2) that are influenced by loess-loam. Locally occurring loess-loam coverings are usually only 3 - 6 dm thick or mixed with Molasse material (8)*. The alternating interbedding of permeable and water-retaining sediments on the undulating plateau locations is important here for the soil water regime. With good natural drainage, large-scale "Braunerden" or loamy-sandy (48)* and silty Molasse material (50)*, in water surplus situations "Pseudogley-Braunerden" (54)* and "Pseudogleye" (45)* as layer profiles of silty-loamy covering layer above loamy-clayey Molasse material, locally also "Pseudogleye"of loess-loam (16)* are distributed. Layer water escapes produced on slight slopes and in depressions led to formation of "Gleye" of sandy (75a)* or loamy (75b, 76b)* elutriation masses or formation of "Niedermoor" (fen soil) (78)*.

Vegetation
(shortened after W. BRAUN 1975)

The vegetative cover of the Upper Bavarian "Tertiärhügelland" is characterized essentially by growth areas of five potential natural wooded communities:

- lower locations
  - on strongly basic soils: Labkraut-Eichen-Hainbuchenwald (bedstraw-oak-hornbeam woods)
  - on weakly basic soils: hainsimsenreicher Labkraut-Eichen-Heinbuchenwald (abundant wood rush bedstraw-oak-hornbeam woods)
- higher locations
  - on strongly basic soils: Waldmeister-Tannen-Rotbuchenwald (sweet woodruff-fir-red beech woods)
  - on acidic soils: Hainbuchen-Rotbuchenwald (hornbeam-red beech woods)
- moist depressions and valley bottoms: Traubenkirschen-Erlen-Eschenwald (bird cherry-alder-ash woods)

Except for insignificant relics, mixed forests close to nature have scarcely been preserved. On the contrary, the landscape appearances in lower locations are characterized by pine and pine-spruce forests, in higher locations by pure spruce forests.

Forestry

The "Tertiärhügelland" is an old farming country. The farmer's forest is closely related with his fields, the proportion of the state forest is small. In the 19th century spruce was planted on the forest areas that had become deteriorated through forest grazing and dispersed utilization on the fresher, high-fine loam locations, on the drier, sandy-gravelly, mostly steeply slope locations pine or spruce with pine.

The forestry goal is to stabilize unstable spruce stands on locations with changing moisture with fir and red alder wherever precipitation conditions are appropriate, and on the locations with changing dryness with oak, hornbeam and also pine. Dry locations can be enriched with Douglas fir.

Hop Cultivation

(shortened after G. ROSSBAUER & F. GMELCH, 1981)

The Hallertau, the world's largest coherent hop cultivation district is located between Munich and Ingolstadt around the towns Pfaffenhofen, Wolnzach and Mainburg. The Hallertau encompasses the central territory of the loess-loam rich "Tertiärhügelland" (12.8.3 and 12.9.2) and the sandy "Tertiärhügelland" adjoining to the north (12.8.1). In 1985 it had a cultivated area of 16,681 hectares (166.81 Km^2) and the average size of the area devoted to hop growing was 4.41 hectares (44,100 m^2) per farm. The 10-year average yield was 1,760 kg per hectare (10,000 m^2). 60% of the hop harvest of 35,561 tons was exported in 1984 to over a hundred countries. The Purity Decree of 1516 (brewing only with hops, malt and water) and the Hop Origin Act of 1919 established the world fame of Hallertau hops.

The hop requires a great deal of sunshine for good aroma and sufficient rainfall particularly in June, July and August for a high yield and a high content of bitter substances. Such conditions exist in the Hallertau, both on the loamy and on sandy soils (the latter with appropriate fertilization).

The hop is a deep-rooted plant with root depths down to 4 m and more. Within a short time, it forms large plant masses. Its root system reacts sensitively to soil compaction. Accordingly, the following requirements result for the soil:

- deep and readily rootable down to 2 m if possible
- soil structure with small to medium compaction without hardpans
- balanced water economy without stagnation
- adequate resupply of nutrients.

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PROFILE No. 5 - BRAUNERDE

Site description:

Location	Kreutenbach
Grid Ref.	Top. Map 7434 Hohenwart R 55 660 H 77 030
Parent Material	loessloam and Upper Freshwater Molasse
Topography	hill, middle part of a slope, inclination 4^{o} ENE
Elevation	468 m m.s.l.
Land use	agriculture

Ecological moisture degree:
moderatly moist with dry periods (Vt)

Soil classification:

Braunerde (DBG) of very large development depth, subsoil weakly "pseudovergleyt" (weak clay illuvation possible), originated in cover layers: loessloam, from 65 cm down increasing influence of silty and fine sandy material of the Upper Freshwater Molasse

Alfic Umbrept (Soil Taxonomy)
Cambisol (FAO)

BRD	FAO	Depth	Description
Ap	Ap	0-25 cm	dark graybrown (10YR 4/3), humic, very silty loam, cohesive structure, many roots
IIB_{v1}	Bw	25-37 cm	light yellowishbrown (10YR6/4), very weakly humic, silty loam, weak prismatic structure breaking to fine to medium subpolyeders, some roots
$(S)B_{v2}$	Bw	37-65 cm	Yellowish gray brown (10YR5/6), silty loam with single concretions, subpolyedric to polyedric structure, prismatic, scarcely roots
$III(S)B_{v3}$	Bw	65-120 cm	light yellowish brown (10YR6/6), silty loam with single concretions, subpolyedric structure, prismatic, locally scarcely roots
B_{v4}	Bw	120-160 cm	yellowishbrown (10YR5/8), weakly silty, weakly clayey loam
$IVB_{v}5$	Bw	160-240 cm	yellowishbrown (10YR5/6), weakly clayey loam
B_{v6}	Bw	240-300 cm	yellowishbrown (10YR5/8), weakly clayey loam

6

Profile No. 5 Kreutenbach (Braunerde)

No	hor.	depth cm	sto. %	texture in % of humus-/~~carb.~~ free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ap	0-25	-	1.6	3.2	8.8	13.6	37.4	19.7	9.3	66.4	20.0		
2	IIBv1	-37	-	0.2	0.6	7.4	8.2	35.1	20.1	8.5	63.7	28.1		
3	(S)Bv2	-65	-	0.0	0.7	6.6	7.3	36.0	21.9	7.9	65.8	26.9		
4	III(S)Bv3	-120	-	0.1	1.8	9.5	11.4	20.0	36.4	7.1	63.5	25.1		
5	Bv4	-160	-	0.6	5.6	12.0	18.2	13.4	32.7	8.0	54.1	27.7		
6	IVBv5	-240	-	0.6	7.5	18.8	26.9	10.7	25.9	7.9	44.5	28.6		
7	Bv6	-300	-	0.4	6.2	21.3	27.9	10.8	25.6	7.7	44.1	28.0		

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	Ap	1.41	46.1		37.3	34.7	16.5		6.6	9.1	3.2	0.35	800	
2	IIBv1	1.46	44.7		39.6	37.1	27.4		6.0	12.9	2.6	0.20	500	
3	(S)Bv2	1.53	42.1		38.5	35.9	23.9		5.9	14.3	1.9	0.13	530	
4	III(S)Bv3	1.53	42.2		39.1	36.3	21.4		5.6	13.6	1.7	0.13	470	
5	Bv4								5.5	14.4	1.5	0.10	580	
6	IVBv5								5.3					
7	Bv6								5.1					

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	car-bon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ap	1.38	12.9	10.7	-	164		100	7	13	0	44		73.2
2	IIBv1	0.55	5.5	10.0	-	189		120	3	25	1	40		78.8
3	(S)Bv2		3.6		-	189		111	3	32	1	42		77.8
4	III(S)Bv3				-	191		104	2	44	1	40		79.1
5	Bv4				-	191		105	3	36	1	46		75.9
6	IVBv5				-	206		106	2	51	1	46		77.7
7	Bv6				-	197		91	1	47	1	57		71.1

Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 46, 83 - 85 (1986)

Soil physics and hydrological description

by

W. Vogl*

The soil at "Kreutenbach" has a density of between 1.4 and 1.7 g/cm^3 as shown in Fig. 1. A small increase in bulk density occurs in the plough layer. From 90 to 160cm depth the values are extremely high (1.6 to 1.7 g/cm^3). These high values and the low saturated water conductivity (Fig.1) in the subsoil are properties of the parent material and show that nearly no pedogenetic pore system was developed. In contrast in the upper part of the profile more secondary coarse pores and therefore a higher water conductivity were measured. In the Ap horizon and the plough layer water conductivity is influenced by soil management.

Soil water tension was measured during the growing seasons of 1978 - 1980 using Hg tensiometers. The values are classified (<0; 0-6; 6-30; 30-60 >60 kPa) and the classes were plotted versus time and soil depth (fig. 2). The high frequency of free water in >90cm depth is closely related to water conductivity and bulk density shown above. In comparison with 3 neighboured soils (sand; loamy sand and clay, respectively) this soil had the most extreme hydrology - during rainfall periods it was the wettest soil, during drought it had the driest top soil. This hydrology is typical of a pseudogley, which, however is not reflected by the profile morphology (e.g. mottling) The high available water capacity (177mm/m depth between pF 1.8 and 4.2 and 66mm between pF 1.8 to 2.9) supplies sufficient water for high yields in dry years. In wet years stagnant water limits deep rooting and the yields.

The concentrations of P, K and Ca in the soil solution were also measured during the growing seasons in 1979 and 1980 in the plots of 0P/0K and 66P/166K (see table 1). P concentrations did not vary significantly with soil depth and fertilization. K concentrations were influenced significantly by fertilizer application and soil depth. Even at no P and K fertilization their solution concentrations are not yield limiting.

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Table 1:
Mean values of P- K and Ca concentrations in the soil soulution (mg/cm^3) in the seasons 1979 and 1980. The soil solution was obtained by the centrifuge method.

Year 1979	P			K			Ca		
total mean	0.22			3.5			47		
mean of plot 0P/0K	0.24			2.5			29		
mean of plot 66P/166K	0.20			4.6			68		
Depth (cm)	mean	0/0	66/166	mean	0/0	66/166	mean	0/0	66/166
10	0.20	0.19	0.20	5.3	2.5	8.2	64	34	94
25	0.24	0.18	0.31	2.9	2.7	3.3	43	31	57
35	0.27	0.36	0.14	2.2	2.4	2.0	39	26	58
50	0.19	0.23	0.13	2.8	2.5	3.2	35	24	49

Year 1980	P			K			Ca		
total mean	0.12			9.7			164		
mean of plot 0P/0K	0.11			5.1			128		
mean of plot 66P/166K	0.13			13.5			194		
Depth (cm)	mean	0/0	66/166	mean	0/0	66/166	mean	0/0	66/166
5	0.12	0.05	0.20	10.8	3.4	18.1	90	52	128
10	0.10	0.09	0.10	13.1	4.2	23.4	224	153	306
20	0.13	0.12	0.14	16.9	9.7	23.3	179	138	215
30	0.12	0.09	0.14	5.6	5.2	5.9	202	216	191
40	0.12	0.11	0.13	7.9	3.9	10.2	140	98	163
50	0.11	0.21	0.04	2.9	2.3	3.3	115	83	136
60	0.20	0.15	0.24	3.7	4.2	3.3	119	76	148

FIG. 1

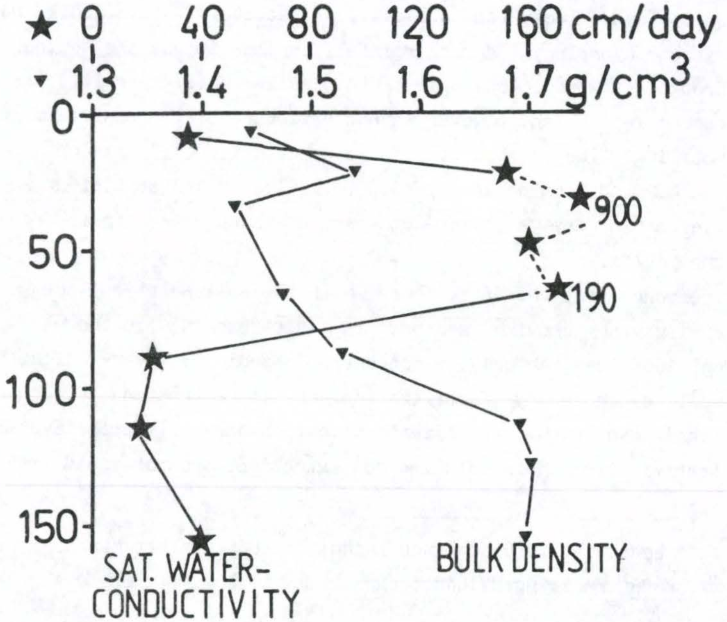
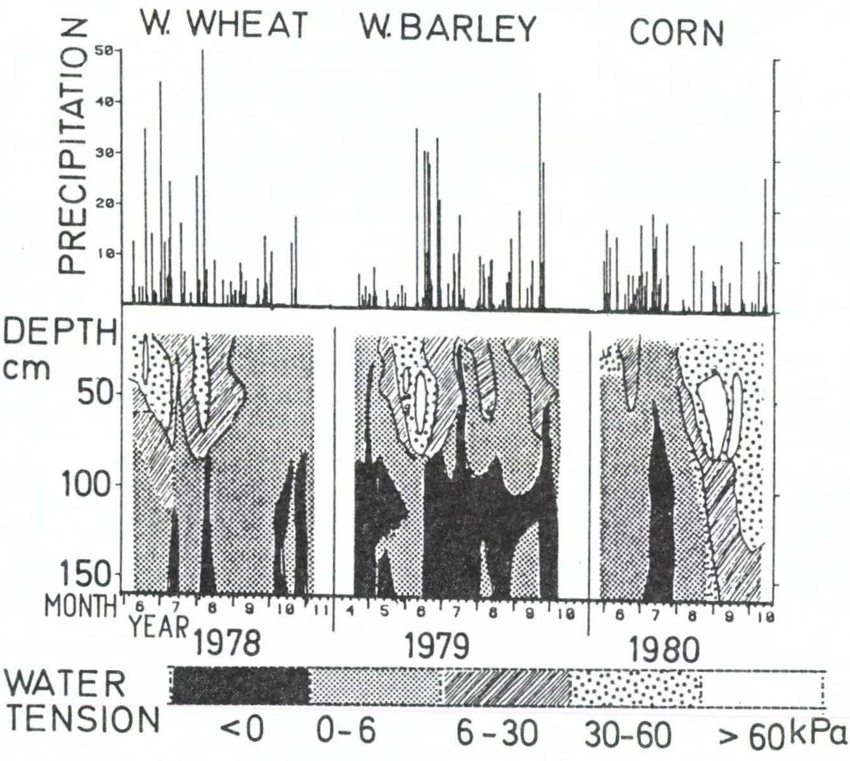


FIG. 2


W. WHEAT
W.BARLEY
CORN
PRECIPITATION
50
40
30
20
10
DEPTH
cm
50
100
150
MONTH
YEAR
6
7
8
9
10
11
4
5
6
7
8
9
10
6
7
8
9
10
1978
1979
1980
WATER
TENSION
<0
0-6
6-30
30-60
>60kPa

Mitteilungen Dtsch. Bodenkundl. Gesellsch. 46, 86 - 89, 1986

Optimal Phosphorus and Potassium Fertilization under Intensive Agriculture

demonstrated at the field experiment Kreutenbach

by

Th. Diez*

Fertilization with P and K in Germany is based on nutrient uptake by plants and the nutrient content of the soil usually extracted by Ca lactate pH 3.5. The concept is to establish a nutrient level in the soil which supplies sufficient nutrients even under unfavourable conditions (e.g. water stress). If below that level we recommend an amount of fertilizer above what is taken up by plants in order to reach the desired level. In contrast, if the nutrient content is above the desired level, a reduced fertilization is recommended.

The demonstrated field trial at Kreutenbach is one of many others in different areas and on other soils. It tries to find out the relation between yield and soil nutrient content. The outline of the experiment is given in table 1.

Results

P-Fertilization: Even at a very low soil-P of 5 mg/kg on average, an amount of fertilizer exceeding plant uptake (average 22 kg P/ha) produced only minimal, non significant yield increases (Fig. 1). The absolute increase in yield as against P_0 remained approximately constant over the 11 year period (Fig. 2).

With respect to the net return (gross yield minus costs of fertilizer), the application of P fertilizer was not justified. At this level of soil-P P total uptake by the crop is independent of the amount of fertilizer added. Only the check plot showed a lower uptake.

K-Fertilization: The initial K-content averaged 170 mg/kg and was within the target level. While the total yield could be slightly increased (about 3 %) with an application of up to 210 kg K/ha, the maximum economic yield was already reached at zero fertilization. Again, at this soil-K level no K-fertilizer can presently be recommended.

As with P the difference in yield between "K_0" and "K-fertilized" remained approximately the same during 11 years. However, the K-uptake by plants showed a remarkable increase ("luxury consumption").

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Table 1:

PK-field trial Kreutenbach 1974 - 1985

Fertilization, (kg/ha·a)									
	P	0	0	22	66	44	44	44	22[1]
	K	0	166	166	166	0	83	249	166
Yield, t/ha [2]	absol.	5.98	6.09	6.25	6.36	6.24	6.40	6.47	6.37
Average of 11 years [3]	rel.	100	102	105	106	104	107	108	106
Yield 1985, t/ha	absol.	6.09	6.42	6.76	6.49	6.04	6.57	6.57	6.72
Winterwheat	rel.	100	105	111	107	99	108	108	110
Plant uptake	P	261	267	286	283	278	300	280	296
in 11 years (kg/ha)	K	1095	1696	1632	1637	1180	1588	1713	1668
Available Soil-P[4] (mg/kg)	at beginning	40	44	44	57	57	48	40	44
	after 8 years	26	22	35	53	44	40	44	35
	after 11 years (after liming)	31	31	40	75	53	57	57	44
Available Soil-K[4] (mg/kg)	at beginning	149	191	191	183	158	141	174	149
	after 8 years	100	166	174	183	91	125	241	166
	after 11 years (after liming)	141	207	183	224	133	108	232	183

1) + 5 t CaO at beginning of field trial

2) grain crop units

3) rotation: corn (silage), winterwheat, winterbarley

4) extraction with calcium ammonium lactate (CAL)

Liming: In spite of a pH level of 5.7 there was no significant increase in yield through application of lime at the beginning of the trial on one plot.

Changes in the nutrient content of soil (Fig. 3)

P: In the early years of the trial the available soil-P decreased - independent of the amount of P applications - paralell to a decrease in pH. After repeated lime applications on all plots beginning in 1982 available soil-P increased in all plots, notably in those fertilized above the amount taken up by the plant. The results of 1984 show clearly the enrichment caused by fertilization above plant requirement (P_{44}, P_{66}) and the decrease at zero-fertilization (P_0).

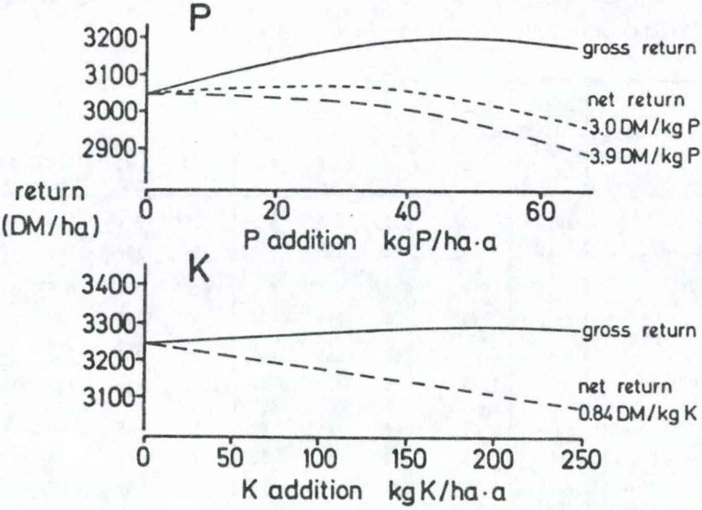

Fig. 1: Gross and net return in relation to P (upper) and K fertilization over a period of 11 years.

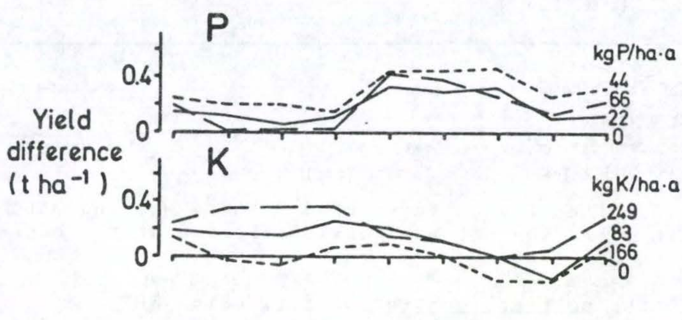

Fig. 2: Yield changes due to P (upper) and K (lower) fertilization over a period of 11 years (3 years-smoothed averages).

Fertilizer recommendation

The results of this field experiment together with many others in the state form the basis for establishing threshold soil values on which fertilizer recommendations are being based. The recent results have led to a lowering of these threshold values although not as low as suggested by the results from the Kreutenbach site.

The upper part of table 2 shows the presently used threshold values for P and K (expressed as mg P_2O_5 and K_2O per 100 g of soil respectively). In the lower part of the table the amount of fertilizer is indicated (kg/ha) which takes to amount of P and K taken up by the crop into account.

Tab. 2: PK-level in arable soils (mg P_2O_5 and K_2O per 100 g soil)

nutrient level	----P---- all soils	sands	-----K----- loams	clays
A low	8	8	8	10
B medium	8-14	8-14	8-14	10-19
C high	15-25	15-20	15-30	20-35
D very high	26-40	21-30	31-45	36-50
E extremely high	40	30	45	50

K: Available soil-K shows similar tendencies as the soil-P: Soil-K increased when pH was raised by liming particularly when more K was fertilized than the plants take up.

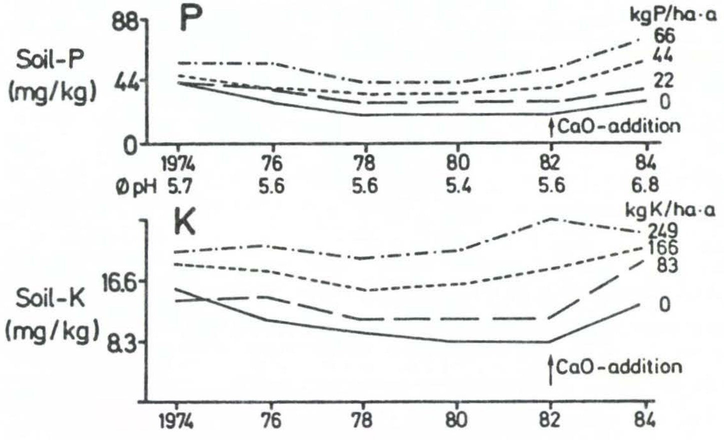

Fig. 3: Change of plant available (CAL extractable) soil P and K with time as a function of fertilizer level

A low	E + 90	E + 50	E + 100
B medium	E + 40	E + 25	E + 50
C high	E	E	E
D very high	1/2 E	1/2 E	1/2 E
E extremely high	0	0	0

Replacement of nutrients removed with the crop is recommended for level C for adequate maintenance of nutrients, even if there is no increase in yield. Maintenance of optimal pH is of paramount importance.

The aim of our future work is to establish threshold values better related to soil conditions and it may well be that this may lead to a further reduction of threshold values and in turn of fertilizer addition.

Mitteilungen Dtsch. Bodenkundl. Gesellschaft, 46, 9o - 95, 1986

Höglwald near Augsburg - Parabrownearth under Norway Spruce

by

K.Kreutzer, J.Bittersohl+

Excursion Profile 6: Site Description

Growth region:	South German tertiary
Growth district:	Upper Bavarian tertiary
Location:	State forest district Aichach, Höglwald
Elevation:	540 m above sea level
Topography:	Plateau, slightly sloped toward SW
Climate:	Mean annual precipitation: 800 mm (May - July 290 mm, April - November 610 mm); mean annual temperature: 7,3 °C (May - July 14 °C)
Parent material:	Fine sediments from Upper Miocene (Molasse) covered by a thin layer of quaternary sediments
Natural vegetation:	Beech-oak-forest with pine and fir
Ground vegetation:	Oxalis acetosella dominant in herb layer; Picea abies juv.; Mosses: Thuidium tamariscinum, Eurhynchium striatum, Hypnum cupressiforme, Mnium affine, Polytrichum formosum, Lophocolea heterophylla
Land use:	Forestry; nearly pure Norway spruce, some beeches, 80 years old
Soil classification:	German: Acidified Parabrownearth (resp. layered Brownearth), weak spodic, weak pseudogleyic in deeper layers FAO: Orthic acrisol US-Soil Taxonomy: Hapludult

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Profile Description

Horizon (German)	Depth cm	Description
		Humus form; Moder, 5 cm thick
L	5-4	Fresh litter of Norway spruce (< 10 % fine humus), loose
Of 1	4-2	Partially decomposed litter, very little matted, loose, few roots
Of 2	2-1	Partially decomposed litter residue; non-compact, moderate matted structure; loose, common roots, diffuse boundary
Oh	1-0	Very dark brown to black, well humified organic material (fine humus >70 % by volume), loose, crumb structure, plentiful roots, gradual smooth boundary
		Mineral soil
Aeh	0-5	dark reddish brown (5 YR 3/3) medium content of humus; weak sandy loam; crumb to subangular blocky, very weak thin platy structure; moderate loose; partial cloudy distribution of humus; very much roots; diffuse boundary
Alh	5-10	brown (10 YR 5/3) low content of humus; weak sandy loam; subangular blocky structure; moderate loose; much roots; diffuse boundary
Al	10-36 (40)	pale brown (10 YR 6/3) weak sandy loam; subangular blocky structure; moderate loose; common roots; clear boundary

Bt	36-50	yellowish brown (10 YR 5/4) weak clayey loam; subangular to angular blocky structure; moderate compact; clay skins on peds; iron-manganese nodules; weak, diffuse occurrence of iron-hydroxides, partly connected with pale zones around old root channels; few roots; diffuse boundary
II B(t)v	50-65 (70)	brown (10 YR 5/3) weak clayey to silty loam (without middle and coarse sand); other characteristics same as in Bt; diffuse boundary
Bv	65-95	brown (10 YR 5/3) sandy loamy silt; subangular to angular blocky structure, weak coarse prismatic; moderate loose; some clay skins; some iron-manganese nodules; little content of mica; very few roots
(Sw)Bv	95-130	yellowish brown (10 YR 5/6), olive gray (5 Y 5/2) weak gray mottles, more distinct around root channels, diffuse precipitation of ironhydroxid; sandy-loamy silt; coarse angular blocky - weak prismatic to coherent structure; moderate loose; little content of mica; few roots on prisms
Cv 1	130-170	yellowish brown (10 YR 5/6), olive (5 Y 5/3) olive gray mottles (colour of sediment); some dark brown spots; heavy silty fine sand; massif to slightly thin layered; concentration of mica on sedimentary layers; moderate loose
Cv 2	170-200	olive (5 Y 5/3) dark brown stripes; diffuse precipitation of ironhydroxides, decreasing downwards; heavy silty fine sand; massif to thin layered; high content of mica; moderate loose

Profil: "Höglwald"

No	hor.	depth	sto.	texture in % of humus-/carb. free fine soil									kf	
				sand				silt				clay		
		cm	%	c	m	f	Σ	c	m	f	Σ		cm/d	var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Of	4-1	0											
2	Oh	1-0	0											
3	Aeh	0-5	0	1	9	25	35	22	15	9	46	19		
4	Alh	5-10	0	1	10	25	36	21	15	7	43	21		
5	Al	10-20	0	0	10	26	36	22	14	10	46	18		
6	Al	20-30	0	0	11	22	33	21	15	9	45	22		
7	Al	30-40	0	0	7	21	29	20	14	17	51	20		
8	Bt	40-50	0	0	8	24	32	18	13	7	38	30		
9	IIB(t)v	50-70	0	0	1	25	26	27	13	8	48	26		
10	Bv	70-130	0	0	0	29	29	29	16	11	56	15		
11	Cv1	130-170	0	0	2	48	48	32	11	3	46	6		
12	Cv2	170-190	0	0	3	48	48	27	11	6	45	7		

No	hor.	bulk dens.	GPV	water content in % at pF				pH		Fe_d	Fe_o	Fe_o :	Mn_o	P_a
		g/cm^3	%	0.6	1.8	2.5	4.2	H_2O	$CaCl_2$	mg/g		Fe_d	mg/kg	
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	Of							3,95	3,20					
2	Oh							3,58	2,91					
3	Aeh	0,84	72	63,4	46,4	33,1	12,8	3,72	3,20	7,6	4,2	0,55	0,1	
4	Alh	1,22	55,3	53,6	38,2	29,4	15,0	3,96	3,62	6,7	3,4	0,50	0,7	
5	Al	1,18	55,0	54,0	36,2	26,6	15,5	4,21	3,96	6,0	3,4	0,56	1,1	
6	Al	1,40	48,7	44,0	36,1	28,9	22,9	4,20	3,95	7,6	3,4	0,45	1,2	
7	Al	1,41	41,8	39,8	35,8	31,6	23,5	4,18	3,83	10,0	2,9	0,29	0,6	
8	Bt	1,50	47,9	42,6	39,2	35,7	25,8	4,20	3,77	13,8	2,0	0,15	0,2	
9	IIB(t)v	1,54	44,6	41,3	38,6	35,5	26,1	4,65	3,92	14,2	1,6	0,11	0,3	
10	Bv	1,43	49,8	46,3	43,6	37,5	21,7	4,92	4,13	13,6	1,5	0,11	0,4	
11	Cv1	1,36	52,7	50,2	47,3	37,1	12,8	4,95	4,18	17,1	1,8	0,10	0,9	
12	Cv2	1,35	53,5	54,8	50,2	34,2	10,8	5,30	4,45	8,9	1,1	0,13	0,5	

No	hor.	$C_{org.}$	N_t	C:N	car-bon	CEC		exchang. cations in meq/kg						V	
						p	a								
		%	mg/g		%	meq/kg		Ca	K	Mg	Na	H	Al	%	Fe
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41	
1	Of	49,0	17,6	28	0		190	134,9	7,9	13,9	n.d.	26,2	7,3	82	n.d.
2	Oh	40,0	15,5	26	0	973	131	22,1	4,6	3,8	n.d.	28,9	70,9	23	0,35
3	Aeh	2,8	1,8	15	0	180	87	3,0	0,5	1,4	n.d.	9,4	68,7	6	3,5
4	Alh	1,3	0,9	14	0	97	55	0,9	n.d.	0,8	0,4	3,4	49,3	4	n.d.
5	Al	0,9	0,7	13	0	69	41	0,4	1,0	0,5	0,4	1,1	37,1	6	n.d.
6	Al	0,5	0,6	9	0	67	49	0,6	n.d.	0,5	n.d.	1,1	46,6	2	n.d.
7	Al	0,3	0,5	6	0	100	69	0,8	0,5	0,8	n.d.	2,0	64,3	3	n.d.
8	Bt	0,3	0,4	7	0	152	125	2,1	n.d.	1,9	n.d.	1,7	118,5	3	n.d.
9	IIB(t)v	0,2	0,4	6	0	150	124	14,1	n.d.	15,4	n.d.	1,9	91,5	24	n.d.
10	Bv	0,1	0,3	5	0	145	120	37,6	0,5	25,8	0,3	3,4	51,5	54	n.d.
11	Cv1	0,1	0,2	4	0	52	43	17,5	n.d.	9,2	n.d.	2,0	14,7	62	n.d.
12	Cv2	0,1	0,2	4	0	60	50	26,6	n.d.	12,3	n.d.	1,9	8,7	78	n.d.

Höglwald - Profil 0

	Fe_p mg/g	Mn_d mg/g	Al_d mg/g
1			
2			
3	3,6	0,2	1,6
4	1,9	0,9	2,0
5	1,1	1,2	2,2
6	0,7	1,3	2,2
7	0,4	0,7	2,2
8	0,3	0,4	2,9
9	0,3	0,4	2,6
10	0,2	0,5	1,9
11	0,2	1,1	1,9
12	0,1	0,6	0,8

p = soluble in $Na_4P_2O_7$
d = " " $Na_2S_2O_4$
n =

<u>Soil association</u>

Fine sediments of Upper Miocene age are dominant as parent material for the soils in the Höglwald-region. Upper soil horizons are influenced by quaternary sediments. The materials have been more or less displaced by periglacial processes. The changes to deeper non-dislocated materials are gradual. Tertiary sediments formerly including lime are decalcificated to a depth of 2 m or more.

From these layered deposites brownearths and parabrownearths are derived.

<u>Soil development</u>

Weathering of silicates and forming of clay minerals and pedogenous iron oxides; vertical transport of clay, formation of an argillic horizon; acidification with strong decreasing of base saturation and strong increasing of exchangeable aluminium; formation of acid humus layer (Moder) after 215 years cultivation of pure spruce.

<u>Soil ecology</u>

Good potential root growth, high amount of plant available water (circa 80 mm in 0 - 40 cm depth); big C/N-ratio (27) in humus layer, but high amount of mineralized nitrogen; good supply of bases only in humus layer and below main root zone.

Contents of the nutrients in the soil

Nährelementgehalte der Bodenproben "Höglwald":

Profil: 1 Datum der Probenahme: 5.10.82

No	Tiefe cm	C mg/g	N mg/g	C/N	P mg/g	K mg/g	Ca mg/g	Mg mg/g	Mn mg/g	Fe mg/g	Al mg/g	Cu µg/g	Zn µg/g
3	0-5	27,8	1,82	15	0,41	14,9	3,16	4,45	0,73	21,23	52,60	19	49
4	5-10	13,0	0,92	14	0,34	15,2	2,54	5,19	1,06	22,36	55,02	16	48
5	10-20	8,7	0,69	13	0,29	15,6	1,98	5,31	1,37	21,30	41,78	20	45
6	20-30	5,3	0,62	9	0,51	18,0	2,22	6,78	1,24	27,69	64,70	26	75
7	30-40	2,8	0,49	6	0,84	21,7	1,70	9.77	0,69	40,21	78,66	36	111
8	40-50	2,8	0,42	7	1,03	22,0	3,56	10,85	0,75	29,77	79,42	38	113
9	50-70	2,0	0,36	6	0,73	23,7	3,48	12,17	0,65	48,17	84,96	40	118
10	70-90	1,3	0,30	5	1,34	24,0	2,86	13,05	0,62	49,27	85,70	37	117
10	90-110	1,3	0,29	5	0,79	23,1	3,26	12,73	0,85	51,31	84,15	28	119
10	110-130	1,3	0,31	4	0,87	25,5	4,06	15,56	0,93	48,45	84,92	31	126
11	130-150	1,0	0,25	4	0,74	24,5	3,24	12,76	0,78	43,97	90,84	24	127
11	150-170	0,8	0,23	3	1,09	21,6	6,27	10,29	0,78	37,50	81,96	22	92
12	170-190	0,8	0,20	4	0,90	23,0	4,33	11,03	1,00	42,02	83,92	21	101

Mitteilungen Dtsch. Bodenkundl. Gesellschaft, 46, 96 - 1o2, 1986

Field Station Höglwald near Augsburg: Interdisciplinary Acid Rain experiments in Norway spruce stands

by

K.Kreutzer, J.Bittersohl, W.Grimmeisen, H.Reiter[+]

Objectives

The experiments shall inform about the influence of artificial acid rain and of compensative liming on the stand, the soil and the seepage water under controlled conditions. Two experiments are set up. They will be connected with a number of comparing studies on sites with different immission charges and bufferings.

In particular the experimental investigations are concerned with the following points:

a) Stand
- the occurrence of damage symptoms,
  (Forstliche Versuchs- und Forschungsanstalt, München)
- the state of nutrition (including uptake and enrichment of noxious elements in the trees),
- the growth,
  (Lehrstuhl für Waldwachstumskunde, München)
- the formation of fine roots,
  (Lehrstuhl für Bodenkunde, Göttingen)
- the occurrence of infections,
  (Lehrstuhl für Forstbotanik, München)
- the quantity and quality of mykorrhiza, including fine root morphology,
  (Lehrstuhl für Forstbotanik, München)
- the ground vegetation.

*) Lehrstuhl für Bodenkunde der Universität München, Amalienstr. 52, D-8000 München 40

b) Soil
   - the mobilisation, translocation and complexation of aluminium and heavy metals,
   - the mobilisation and translocation of macronutrients, including the formation and translocation of nitrate and the dynamic of sulphur and chloride,
   - the pH, the ion exchange capacity and the acid neutralizing capacity down to 2 m,
   - the microbiological activity and biomass, (together with Institut für Ökologische Chemie der GSF, München)
   - the soil fauna,
   - the budget of cations and anions inclusive changes in the storage.

c) Seepage water
   - the water movement within the root zone,
   - the quality and quantity of seepage water, which is leaving the main root zone.

Stands

a) Old Spruce Stand
Nearly pure Norway spruce, some beeches, 80 years, normally stocked, good yield class.
Second conifer generation after beech-oak-stands, which were substituted by conifers after clearcutting in the second half of the 18th century.

b) Young Spruce Stand
Nearly pure Norway spruce, some alders, 15 years, planted, normally stocked, good growth.
Third conifer generation.

Experimental Treatments

A 1	no irrigation, no liming
A 2	no irrigation, liming
B 1	irrigation with "acid" water, no liming
B 2	irrigation with "acid" water, liming
C 1	irrigation with "normal" water, no liming
C 2	irrigation with "normal" water, liming

Liming:

$CaCO_3$ (55 %), $MgCO_3$ (40 %); 4 x 10^3 kg ha^{-1}
(April 1984)

Irrigation with "acid" water (H_2SO_4):

170 l m^{-2} per season; 12 l m^{-2} per one action,
pH 2.7 to 2.8, i.e. 3,30 kmol H^+ ha^{-1} a^{-1}
(Start May 1984)

Irrigation with "normal" water:

The same amount as "acid" irrigation. About pH 5,
i.e. 0,02 kmol H^+ ha^{-1} a^{-1}
(Start May 1984)

Design

a) Old Spruce stand (soil irrigation)

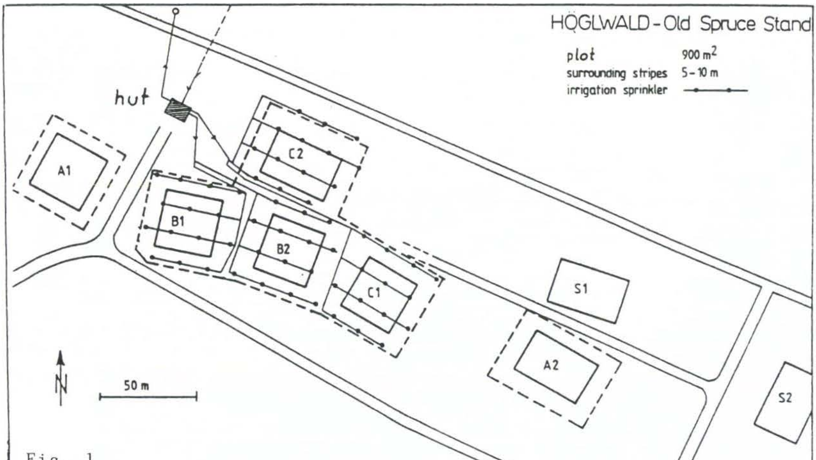


Fig. 1

b) Young Spruce stand (irrigation above canopy)

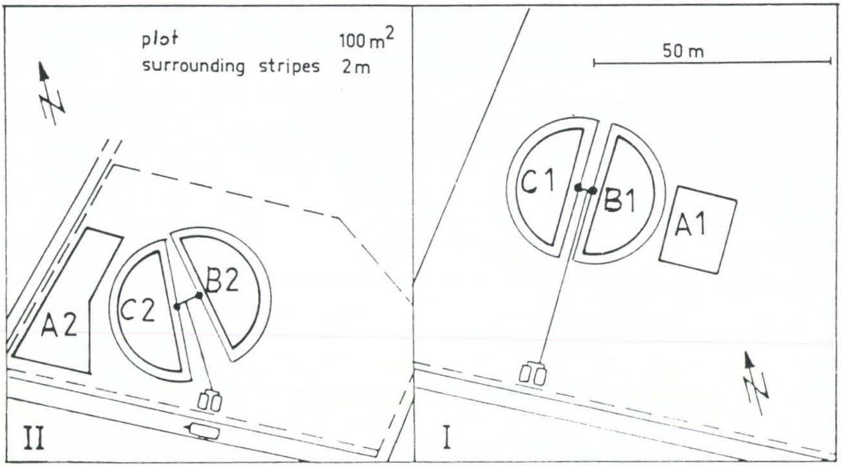


Fig.2

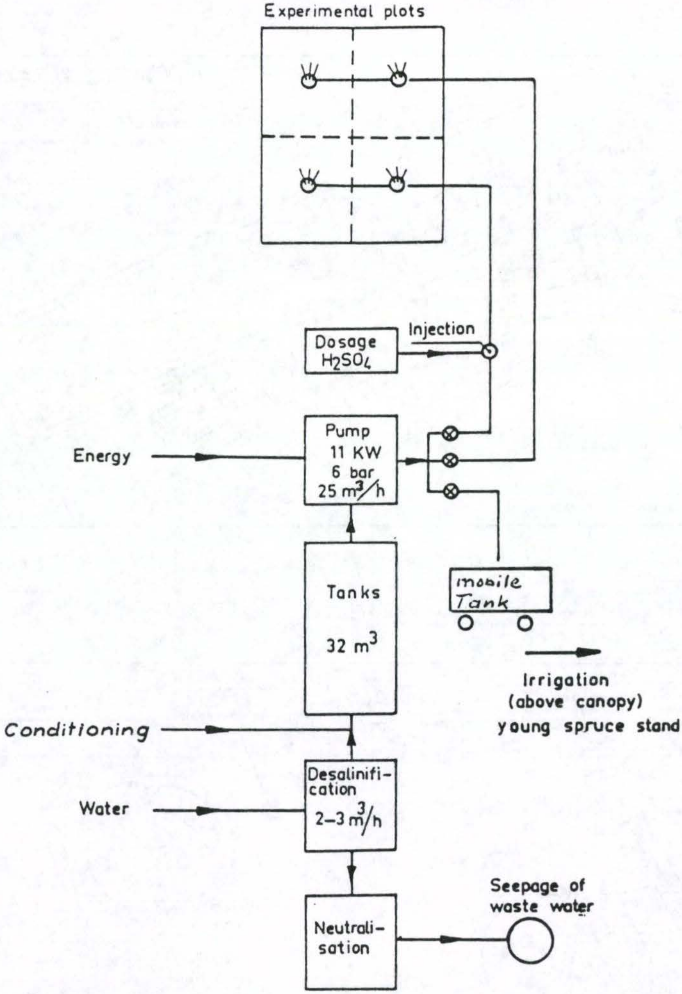
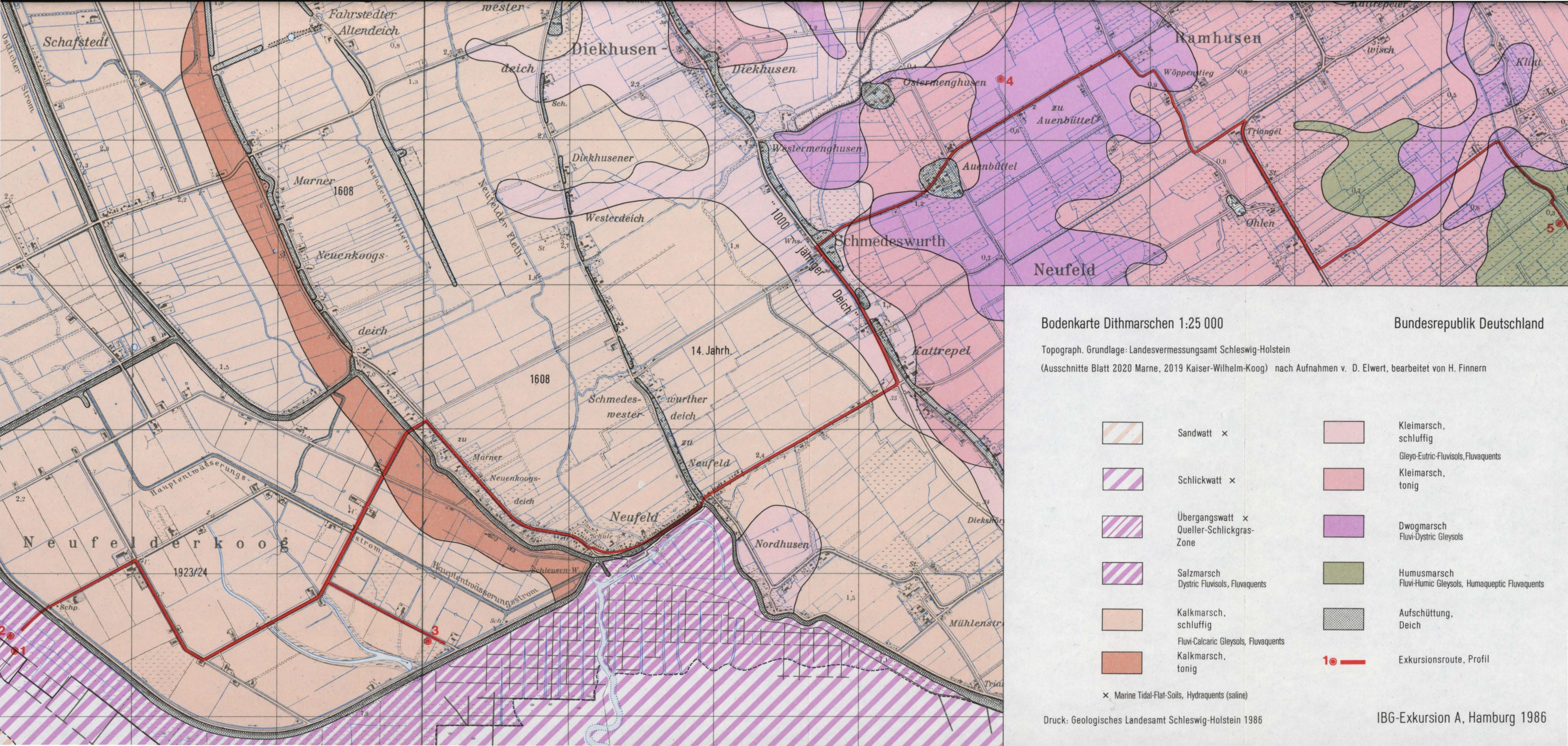


Fig.3: Irrigation technic


Bodenkarte Dithmarschen 1:25 000
Bundesrepublik Deutschland
Topograph. Grundlage: Landesvermessungsamt Schleswig-Holstein
(Ausschnitte Blatt 2020 Marne, 2019 Kaiser-Wilhelm-Koog) nach Aufnahmen v. D. Elwert, bearbeitet von H. Finnern
Sandwatt ×
Schlickwatt ×
Übergangswatt × Queller-Schlickgras-Zone
Salzmarsch
Dystric Fluvisols, Fluvaquents
Kalkmarsch, schluffig
Fluvi-Calcaric Gleysols, Fluvaquents
Kalkmarsch, tonig
Kleimarsch, schluffig
Gleyo-Eutric-Fluvisols, Fluvaquents
Kleimarsch, tonig
Dwogmarsch
Fluvi-Dystric Gleysols
Humusmarsch
Fluvi-Humic Gleysols, Humaqueptic Fluvaquents
Aufschüttung, Deich
Exkursionsroute, Profil
× Marine Tidal-Flat-Soils, Hydraquents (saline)
Druck: Geologisches Landesamt Schleswig-Holstein 1986
IBG-Exkursion A, Hamburg 1986
Schafstedt
Fahrstedter Altendeich
Diekhusen-deich
Diekhusen
Ramhusen
Ostermenghusen
zu Auenbüttel
Auenbüttel
Westermenghusen
Diekhusener Westerdeich
Marner Neuenkoogs-deich
1608
Schmedeswurth
"1000 jähriger Deich"
Neufeld
Kattrepel
14. Jahrh.
Schmedes-westerwurther deich zu Neufeld
zu Marner Neuenkoogs-deich
Neufelderkoog
1923/24
Hauptentwässerungsstrom
Nordhusen
Triangel
Ohlen
Klint
Mühlenstr.
1
2
3
4
5

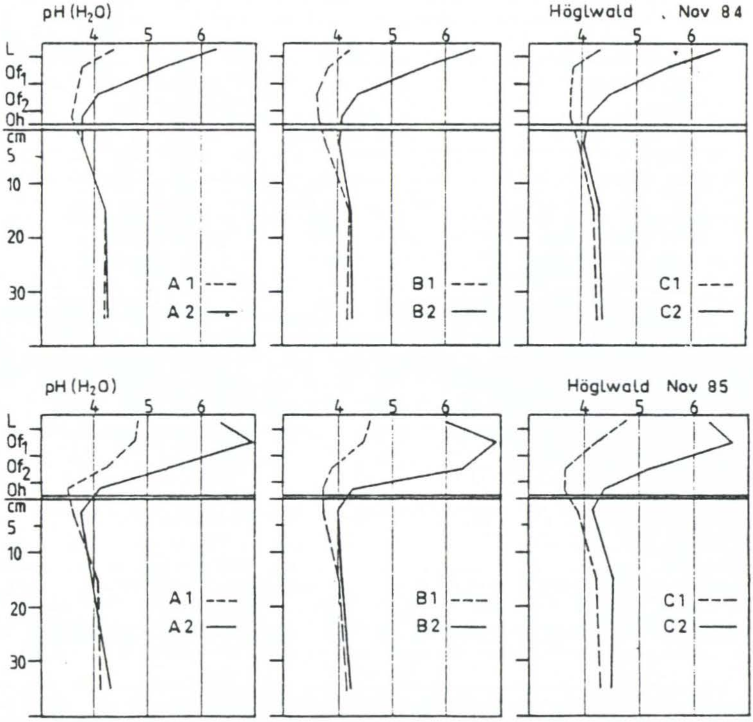


Fig.4: pH(H_2O) in the soil profile with (A2/B2/C2) and without (A1/B1/C1) liming on plot A (control), plot B (acid irrigated) and plot C (normal irrigated). Above: November 1984, below: November 1985

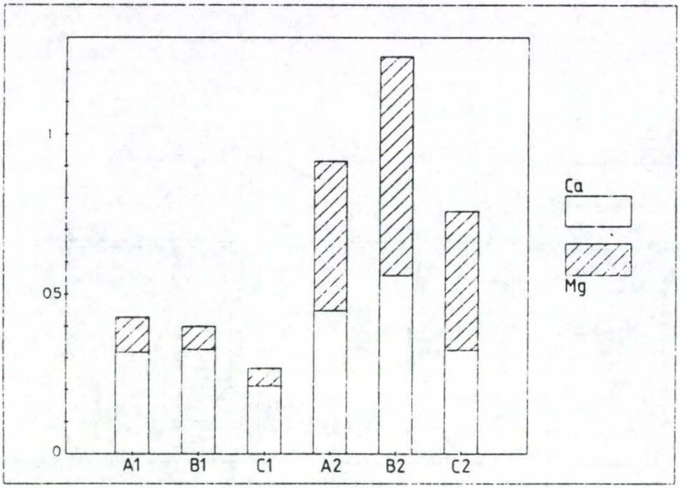


Fig. 5: Ca- and Mg concentrations (mmol IE/l) in water extracts of Oh-horizon on limed and unlimed plots (September 1985)

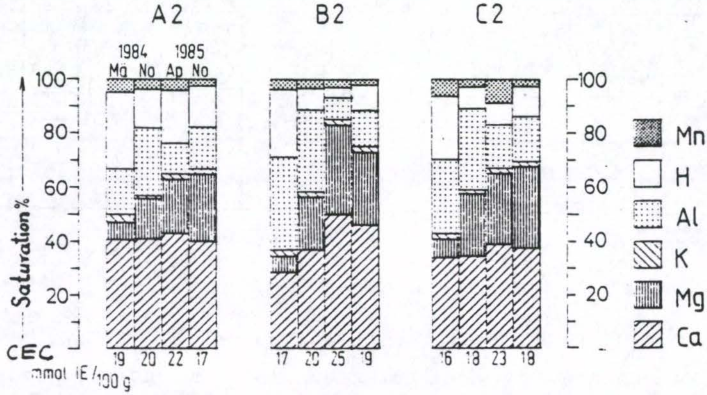


Fig. 6: Temporal development of equivalent portions (% saturation) and contents of NH_4Cl-extractable cations (CEC eff in mmol IE/100 g) in the Oh-layer of the limed plots.

After liming with calcium-magnesium-carbonate the saturation of exchangeable bases increased very strong within the humus layer. Magnesium, already increasing in the upper mineral soil, is being displaced with higher velocity and higher amounts than calcium. These processes are intensified by combination of liming and acid irrigation.

Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 46, 1o3 - 113, 1986

Excursion area "Südliches Albvorland" (Foreland of the Southern Franconian Alb) with excursion point Hesselberg

by O. Wittmann*

Geography

The excursion area lies in the "Südliches Albvorland" (5.8) between the Keuper slope in the north (5.6), the Ries Depression in the south (5.9) and the heights of the Southern Franconian Jura in the east (6.2). The landscape is dominated by the Hesselberg towering far above its surroundings, a 689 m (2260 ft) high Upper Jurassic outlier, from which the broad valley plain of the Wörnitz River can be seen.

Climate

The excursion area has an annual average precipitation measured for many years of 700 mm. The mean annual temperature is around 7.5° C.

Geology, geomorphology and soils

A stratigraphic sequence composed of deposits from the Middle Keuper, the Jurassic, the Tertiary (protrusion masses of the Ries Depression) and the Quaternary (cover sheets, valley deposits) forms the surface.

Characteristic is the multiple but regular soil association. It is caused mainly by the regular stratification made up of alternating sandstones, claystones, marl and limestones. The terraced relief that is typical for the scenery plays an additional role in the differentiated soil development. In this respect, it is significant that the actual origination material of the soil consists almost solely of cover sheets, which are due to the periglacial disintegration and depositing processes, and of which loess loam is also a part, partly as mixture component.

*) Bayer. Geologisches Landesamt, Heßstr. 128, D-8000 München 40

Corresponding to the sequence of geological strata, rocks, relief forms and soils are individually described (see also geological survey sketches):

"Burgsandstein" (Middle Keuper)

Parent material: medium to coarse grained sandstones with clay partings

Landscape: flat crests and waves with slightly to moderately inclined, partly terraced gradients.

Soils: low in nutrient and base, heavily acidic sandy "Braunerden" (Cambisols), under forest frequently "Podsol-Braunerden" (Podzol-Cambisols); on lower part of slopes mostly deeply developed loamy-sandy and sandy-loamy "Braunerden"; in the area of outcropping clay strata, sheet profiles, often spring or stagnant wet.

Land use: arable land, forest.

"Feuerletten" (Middle Keuper)

Parent Material: clay-stone, partly calcareous

Landscape: mostly moderately to strongly inclined terrain-ascents

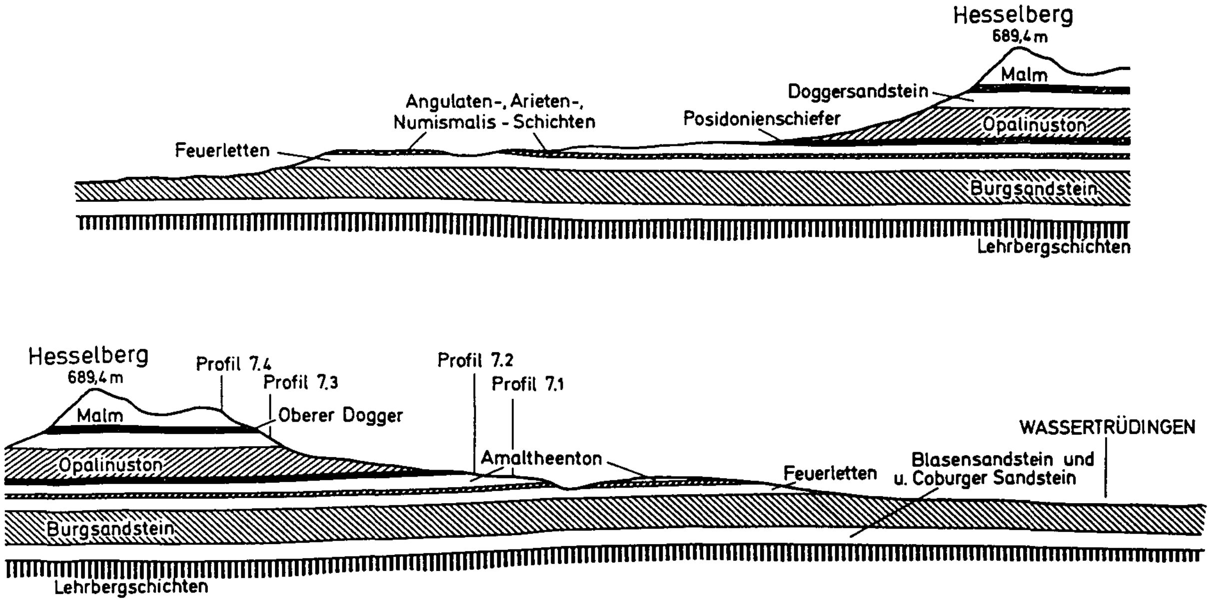
Soils: "Pelosole", calcareous "Pelosole" and "Pelosol-Braunerden" (clay-content of P-horizons 50-70%); frequently also "Braunerden" originated from loamy-sandy or sandy-loamy cover layers above clay-stone

Land use: forest, meadows (arable land).

"Angulaten-, Arietensandstein, Numismalis-Schichten (Hettang- bis Untere Pliensbach-Schichten)"

Parent Material: fine-grained sandstones ("Angulatensandstein") coarse calcareous sandstones ("Arietensandstein"), marl and marlaceous limestones, rich in fossils, partly with bituminous rocks ("Numismalis-Schichten")

Landscape: escarpments ("Angulaten-" and "Arietensandstein") with following stepped upland plains and high plateaus ("Numismalis-Schichten")



Geological profile through the "Südliches Albvorland"
(Foreland of the Southern Franconian Alb)
after H. Haunschild 1963 an H. Haunschild and Th. Weiser 1977

Soils: "Angulatensandstein": loamy-fine sandy "Braunerden"; "Arietensandstein": loamy-sandy to sandy-loamy "Braunerden" of high base saturation with conspicuous amounts of coarse sand, frequently also "Parabraunerden" with clayey-sandy argillic horizons; at the edges of scarps "Ackerrendzinen", 2-3 dm in depth, if this area is used as arable land; "Numismalis-Schichten": at high plateaus preponderant clayey-loamy, partly impermeable wet "Braunerden" under forest land-use, frequently with silty cover layer, also locally with higher clay contents ("Pelosol-Braunerden"); frequently even deeper horizons have characteristic dark colors produced by organic matter, partly originated from bituminous parent material; besides soils are relatively rich in heavy metals (Ni, Cr, Pb)

Landuse: arable land (forest).

"Amaltheenton (Obere Pliensbach-Schichten)"

Parent Material: shaly, often calcareous mudstone containing pyrite

Landscape: slightly inclined slopes divided by depressions and crests looking like flat upland areas

Soils: at slopes and crests "Pelosol-Braunerden" originated from loamy cover layers (1,5-3 dm in depth) above loamy-clayey mudstone-decomposition (50-55% clay-, 40-45% siltcontent); at deforested areas "Pelosole" also (cover layers $<$ 1,5 dm); at the lower parts of slopes and at upland plains also "Pseudogley-Braunerden" and "Pseudogleye"

Land use: arable land, meadows.

"Posidonienschiefer" and "Jurensismergel (Toare-Schichten)"

Parent Material: fine-shaly marl with beds of marlaceous lime, bituminous (-9% ascertained), "Jurensismergel" with phosphorite contents

Landscape: erosion plains

Soils: at the edges of the erosion plains to the valleys deeply developed (until 50 cm) "Rendzinen", otherwise deeply humic, clayey-loamy "Braunerden" of high base saturation and procee-

ding soils to Chernozem-like appearance (cf. "Numismalis-Schichten"); sometimes indications of damming wetness which are partly hidden because of the humus-rich rock;
at the lower part of the next rising step-slope frequently "Pelosole" and "Pelosol-Braunerden" originated from solifluction masses of the "Opalinuston"

Land use: arable land.

"Opalinuston (Untere Aalen-Schichten)"

Parent Material: shaly, marly clay-stones

Landscape: slightly to medium inclined slopes divided by depressions

Soils: "Pelosol-Braunerden" and "Pelosole" (P-horizons with 45-55% clay-, 40-50% silt-content); at "Hesselberg" also "Braunerden" originated from talus- and solifluction-covers derived from hanging "Doggersandstein"; stratum water at the boarder "Doggersandstein-Opalinuston" cause wetness at many places there ("Quellengleye, Pseudogleye" at slopes)

Preferred land use: arable land, meadows.

"Doggersandstein (Obere Aalen-Schichten)"

Parent Material: chiefly fine-grained sandstones

Landscape: strong inclined to steep slopes

Soils: fine-sandy to loamy-fine-sandy, also fine-sandy-loamy "Braunerden"; sandy soils are very acid and mostly weakly podzolized

Land use: forest, extensive pasture.

"Oberer Dogger (Bajoc-" to "Callov-Schichten)"

Parent Material: clay marl, marly limestones, limestones

Landscape: erosion plains, slope-flattenings

Soils: "Rendzinen", chiefly originated from solifluction layers of Upper Jurassic material; at the western part of the "Hesselberg" clay-marl-Rendzinas, "Pelosole" and calcareous "Pelosole"

Land use: forest, extensive pasture

Malm (Oxford and Lower Kimmeridge Strata)

Parent material:	bedded limestone, marl-limestones, marl inclusions.
Landscape:	steep rises, ridges.
Soils:	"Rendzinen" (rendzinas) (predominantly mull rendzinas)
Land use:	extensive pastures, forest.

Ries detrital masses

These are rocks from the present Ries Depression which were sprung out during the meteorite impact almost 15 million years ago and scattered on the foreland. Corresponding to the various rocks "Rendzinen" originated from malm limestone, "Braunerden" (brown soils) in sandstone masses (Dogger) as well as pelosols in marls and claystones of the Jurassic and the Keuper are found in the vicinity of the Hesselberg.

Loess-loam

Loess-loams are found primarily on the flat east and northeast slopes of the Lias clays and marl. Predominantly "Parabraunerden" and "pseudovergleyte Parabraunerden" of medium development depth with silty-loamy topsoil and silty-clayey-loamy subsoils originated from them. Not infrequently they lie above an older, compact loess-loam solifluction layer, whose water-retaining action also influences the primary root space.

In the higher-lying areas of the slopes, the loess-loam and loam covers usually thin out. In many cases, the claystone weathering from the Lias or Dogger then characterizes the subsoil ("Pelosol-Braunerden").

Land use: arable land

Valleys

"Auengley-Pelosole" and "Auenpelosol-Gleye" are characteristic for the flood plain area of the Wörnitz Valley. They are composed in some cases of deep humic, loamy-clayey sediments, which are usually silty-loamy in the upper 2-3 dm. The peripheral depressions of this valley are occupied by "Gley " and "Braunerde-Gley " of greatly varying textures (sands, loams, clays).

The lateral valleys likewise contain "Gley" and their transitional forms. In the wooded "Sandsteinkeuper","Naß-"and "Auengleye" are frequently formed. In the agriculturally utilized areas, the small lateral valleys and slope depressions are filled with ± gleyed colluviums. In some cases, the soils of this situation are only pseudogleyed.

Preferred land use: flood plains and lateral valleys, meadows; other valley situations largely also arable land.

PROFILE No. 7.1 - PELOSOL - PSEUDOGLEY

Soil classification: Pelosol - Pseudogley (DBG) originated from clayey solifluction material of "Amaltheenton" - weathering (Lower Jurassic), subsoil influenced by interflow
Haplaquept (Soil Taxonomy)
Eutric Gleyic Regosol (FAO)

SwAh 0-6 cm dark graybrown (10YR3/2), strongly iron mottled, very humic clayey loam; fine subpolyedric structure, many roots abundant

AhSw 6-21 cm dark graybrown (2.5YR3/2),strongly iron mottled, very humic clay; prismatic-subpolyedric structure, many roots abundant

PSwd 21-51 cm dark gray (10YR4/2),iron mottled, humic clay, from 40 cm down manganese mottled, coarse prismatic-polyedric structure; some roots

PSd 51-77 cm blue gray (5Y4/1), iron mottled, humic, sandy, loamy clay with some concentration of Mn-Fe-concretions; coarse polyedric structure; scarely roots

Sd1 77-115 cm light blue gray (5Y4/1), iron mottled, weakly humic, loamy clay with Mn-Fe-concretions; coarse polyedric structure; scarcely roots

Sd2 115-130 cm blue gray (2.5Y5/0) and ochre (10YR5/6), iron mottled, very weakly calcareous, very weakly humic, weakly stony (marl-limestones of Lias Gamma), loamy clay with Mn-Fe-concretions, cohesive structure

Hesselberg; Profiles 7.1 Pelosol - Pseudogley and 7.2 Pelosol

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Profile 7.1: Pelosol - Pseudogley														
1	SwAh	0- 6												
2	AhSw	-21	-	1.8	4.2	1.8		2.5	9.5	13.4		66.8		
3	PSwd	-51	-	1.5	4.7	2.2		2.8	7.7	12.7		68.4		
4	PSd	-77	-	6.4	15.0	5.6		5.7	9.5	8.7		49.1		
5	Sd1	-115	-	3.6	10.1	4.0		3.6	11.6	10.4		56.7		
6	Sd2	-130	-	4.7	4.3	3.2		7.1	13.2	13.2		54.3		
Profile 7.2: Pelosol														
1	Ap	0-15	-	5.9	11.2	5.0	22.1	5.4	19.8	17.0	42.2	35.7		
2	P	-38	-	1.6	1.7	0.7	4.0	0.7	16.1	17.0	33.8	62.2		
3	PCv	-50	-	3.6	1.5	1.0	6.1	4.7	19.3	17.7	41.7	52.2		

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
Profile 7.1: Pelosol - Pseudogley														
1	SwAh							6.5	6.2					
2	AhSw	0.83	66.6		55.1	52.2	25.3	6.3	6.0					
3	PSwd	1.29	50.2		48.1	46.2	27.0	6.5	6.1					
4	PSd	1.52	42.4		41.9	40.6	32.1	6.9	6.3					
5	Sd1	1.53	42.1		41.9	41.2	32.1	7.0	6.5					
6	Sd2							7.6	7.1					
Profile 7.2: Pelosol														
1	Ap							7.0	6.7					
2	P	1.41	46.6		43.6	41.2	32.7	6.6	6.4					
3	PCv	1.40	47.2		44.3	41.4	33.2	5.3	4.9					

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
Profile 7.1: Pelosol - Pseudogley														
1	SwAh	9.50	0.927	10.2		542		482	5	49	1	5		99.2
2	AhSw	6.68	0.700	9.5		482		421	4	37	3	17		96.4
3	PSwd	2.53	0.284	8.9		391		339	3	31	0	18		95.3
4	PSd	1.19			-	266		221	3	17	0	25		90.6
5	Sd1	0.78			-									
6	Sd2	0.39			0.2									
Profile 7.2: Pelosol														
1	Ap	2.35	2.35	10.0		217		139	15	13	0	50		77.0
2	P					247		151	7	21	11	57		76.9
3	PCv					236		113	6	21	10	86		63.5

Hesselberg: Profiles 7.3 and 7.4

No	hor.	depth cm	sto. %	texture in % of humus-/ sand c	m	f	Σ	free fine soil silt c	m	f	Σ	clay	kf cm/d	pH CaCl2 var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Profile 7.3: Podsol-Braunerde														
1	Of	5												3.0
2	Aeh	0- 1												2.9
3	Ahe	- 6	7	3.3	22.3	63.2	88.8	2.2	3.4	2.3	7.9	3.3		3.2
4	Bsv	-11	0	2.5	19.5	66.4	88.4	2.0	2.4	2.0	6.4	5.2		3.4
5	Bv11	-45	4	2.4	20.4	66.2	89.2	1.7	2.4	1.6	5.7	5.2		4.3
6	Bv12	-70	4	2.2	17.4	68.4	88.0	1.6	2.2	1.1	4.9	7.2		4.2
7	SwBv	-90	0	0.4	12.8	63.5	76.7	1.5	2.2	2.6	6.3	17.1		3.9
8	SdCv	-200	3	1.1	11.0	63.6	75.7	1.3	1.6	3.0	5.9	18.4		3.9
Profile 7.4: Mullrendzina														
1	Ah	0-12												6.7
2	AhCv	-25	61	8.8	3.7	7.2	19.7	7.1	18.0	18.6	43.7	36.6		7.3
3	Cv	-150												

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	a	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
Profile 7.3: Podsol-Braunerde														
1	Of	46.0	14.1	32.6										
2	Aeh	4.55	1.7	26.8		127		3	1	0	1	122		3.9
3	Ahe	1.47	0.4			80		0	0	0	0	80		0
4	Bsv	0.92				78		2	0	0	0	76		2.6
5	Bv11					49		0	0	0	0	49		0
6	Bv12					51		1	0	0	0	50		2.0
7	SwBv					66		0	1	0	0	65		1.5
8	SdCv					62		2	1	0	0	59		4.8
Profile 7.4: Mullrendzina														
1	Ah	5.9	3.3	17.8		491		473	3	9	1	5		99.0
2	AhCv	2.5	1.7	14.7	36.7	349		341	3	4	1	0		100
3	Cv				98.7									

PROFILE No. 7.2 - PELOSOL

Soil classification: Pelosol (DBG) of medium development depth originated form Amaltheenton (Lower Jurassic)
Udorthent (Soil Taxonomy)
Eudric Regosol (FAO)

Ap 0-15 cm	dark gray brown (2.5Y4/4), very humic, weakly clayey to clayey loam; friable, many roots abundant
P 15-38 cm	gray (5Y5/2) and gray brown (2.5Y5/6), loamy clay; coarse polyedric structure, many roots
PCv 38-50 cm	gray (5Y4/2) and ochre brown (10YR4/4), slate-gritty, loamy clay; coarse polyedric structure, partly platty primary structure, mans roots
Cvn 50-85 cm	dark gray (5Y5/1) and ochre brown (10YR3/3) slateclay; scarcely roots

PROFILE No. 7.3 - PODSOL-BRAUNERDE

Soil classification: Podsol-Braunerde (DBG), subsoil "pseudovergleyt", originated from Doggersandstein (Middle Jurassic)
Spodic Udipsammept (Soil Taxonomy)
Dystric Cambisol (FAO)

O 5 cm	decomposed litter and felt of roots (analysed:Of)
Aeh 0- 1 cm	dark gray brown (7.5 YR 3/3), very humic fine sand, single grain structure, many roots abundant
Ahe 1- 6 cm	dark brown gray (7.5 YR 3/2), humic fine sand, single grain structure, many roots abundant
Bsv 6- 11 cm	dark reddigh brown (5 YR 4/6), weakly humic, weakly stony, weakly loamy fine sand, single grain structure, many roots
Bv_1 11-70 cm	reddigh brown (5 YR 5/8), stony fine sand, single grain structrue, many roots
SwBv 70-90 cm	light brown (7.5 YR 6/8) and reddish brown (5 YR 5/8), pale and reddish (iron) mottled, weakly clayey fine sand, single grain structure
SdCv 90-200 cm	reddish brown (5 YR 5/8) and light gray (2.5 GY 7/1), strong pale and reddish (iron) mottled, clayey fine sand, kohésive structure, scarcely roots

PROFILE No. 7.4 - MULLRENDZINA

Soil classification: Mullrendzina (DBG) originated from limestone congelifracts of the Malm (Upper Jurassic)
Rendoll (Soil Taxonomy)
Rendzina (FAO)

Ah 0-12 cm dark gray brown (10YR3/4), very humic, stony, clayey loam, friable, many roots abundant

AhCv 12-25 cm dark yellowish brown (10YR4/6), humic, highly calcareous, very stony, clayey loam, friable to subpolyedric structure, many roots abundant

Cv 25-150 cm light gray (2.5 8/4) limestone congelifracts in marly matrix, scarcely roots

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8

Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 46, 114 - 116, 1986

Farmland Consolidation (Flurbereinigung) as exemplified in the "Group Land Consolidation" of the Hesselberg Area

by R. Weihermann +)

I. Why Farmland Consolidation?

Due to historical developments most farms in Germany have their acreage scattered with inconveniently shaped small lots and poor roads. The cause for this situation is on the one hand the old ancient custom of real estate division (i. e. a given farm was divided up between the sons of the owner as an inheritance; thus the individual lots were getting smaller and smaller in the course of centuries).

There were areas in Germany where farmers had their land in more than a hundred different lots, all scattered and some down to the size of a few hundred square meters.

Today the basic requirements for farming are high productivity of labour and fields which can easily be managed by machines (the lengthening of a field from 100 m to 400 m reduces labour by 25 %).
The construction of suitable field roads adds to savings of travelling time. Further requirements are soil improvement, soil drainage, erosion control, landscape management and renovation of the villages.

II. Land Consolidation in the Hesselberg Area

The group land consolidation at the Hesselberg comprised an area of 20.600 ha of which 13.400 ha are farm land. It is 22 km in length (east-west) and 10 km in depth. It consists of 31 participating communities (Teilnehmergemeinschaften) of an average size of 660 ha, 10 ha per individual farm. 60 % of the farmland are arable, 40 % are pasture.

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A participating community represents generally a village and comprises approximately 50 individual farms. The farmers elect a board consisting of about 10 members from their number; the government through its Land Consolidation Head Office appoints an engineer who acts as chairman. This board, in cooperation with other government offices, draws up all the plans for the consolidation and carries them out - generally with sizeable contributions (in labour etc.) by the participating members.

Supervising authority is the Land Consolidation Head Office. The whole process takes roughly 10 years. In addition to the land consolidation which concerns itself with farmland there is also a village consolidation, the so-called village renovation.

1. The following measures were carried out in a participating community of an average size of 660 ha.

   a) Consolidation of property

      If a farm, for example, consisted of 40 different lots in different locations, now after land consolidation it only consists of 3 lots.

   b) Construction of field roads

      12 km of field roads were built, of which 5.3 km were paved roads (concrete or asphalt) and 6.8 km gravel roads.

   c) Soil improvement

      Drainage measures were carried out in an area of 96 ha (almost exclusively arable land). 60 ha were improved in a 3-step amelioration scheme, i. e. first by way of extensive drainage (with pipes 40 m apart), then by loosening of the subsoil (80 cm in depth, 75 cm apart) and finally by application of 6 t of lime (CaO) per ha. About 12 ha were graded.
      All areas were surveyed before soil improvements began. Special attention was given to erosion problems. The endangered areas are identified by the universal soil loss equation (Wischmeier) and suitable steps are taken such as the construction or maintainig of terraces, changes from arable land into pasture, contour cultivation etc.

d) Landscape Management and Conservation Measures

The following plantations were carried out: a wind barrier in 3 rows over 1.8 km; 2.5 km of roadside plants, 0.7 ha of shrubs, 2 biotopes (one new, one preserved).
2.1 ha of dry pasture land were protected including sheep-farming in order to preserve the rare and interesting flora of this area. Villages, barns and machine sheds were surrounded with shrubs. A total of 10.000 trees and shrubs were planted in each community.

2. In the interest of preserving historical sites, ancient monuments or remnants of buildings (such as fragments of the Roman Wall or medieval buildings) were clearly marked and partly restored. An "instruction trail" communicating geological data of the area, was established.

3. Hydrological measures comprised the construction of 2 water retention ponds with a surface of 37 ha, protective measures against inundation and extention of drainage ditches.

4. In the course of village renovation the following steps were taken:
   - creating possibilities for expansion and development of farms;
   - providing every farm as far as possible with an access from the backyard;
   - improvement of traffic conditions in the villages;
   - construction of public areas and facilities such as machine pools, playgrounds, soccer fields, squares, village ponds, fountains, sewage disposal plants, enlargements of the cemetery, designation and development of residential and industrial sites.

5. Cost and financing (excluding village renovation):
   The cost of land consolidation for 1 ha is between 3.000 and 4.000 DM. This does not include expenses for personnel and surveying. The farmer contributes a basic fee pro ha according to his average income, in our case ca. DM 1.000/ha. The difference to the total cost is made up by the government. Extra expenses (e.g. drainage and soil improvements) are shared on an even basis (50 % each) by owner and government. The three-step soil amelioration amounted to ca. DM 3.000 per ha.

Used laboratory methods	Profile, No.								
	1.1	1.2	2.1	2.2	6	7.1	7.2	7.3	7.4
Particle-size analyses (<2mm): a) Combined sieving and burette method			X	X	X				
b) Combined sieving and pipette method						X	X	X	X
Clay minerals: X-ray diffraction			X	X	X				
pH (soil suspensions): a) Water dilution	X	X	X	X	X	X	X	X	X
b) $CaCl_2$	X	X	X	X	X	X	X	X	X
Carbonate: a) Dry combustion, gasanalytical measurement of Carbonate-Carbon after combustion of organic Carbon at 500°C	X	X						X	X
b) Carmhomat			X	X	X				
c) HCl treatment, gas volumetric						X	X	X	X
Carbon: Total Carbon; Dry combustion, gasanalytical measurement	X	X							
–: Organic Carbon; a) Total Carbon minus Carbonate Carbon	X	X							
b) Carmhomat					X				
c) Acid dichromate digestion,colorimetry			X	X		X	X		
–: Oxalate extraction, colorimetry	X	X							
Nitrogen: a) Kjeldahl digestion	X	X	X	X	X	X	X		
b) Dry combustion, gasanalytical measurement								X	X

Used laboratory methods	Profile, No. 1.1	1.2	2.1	2.2	6	7.1	7.2	7.3	7.4
Cation-exchange capacity: NH_4Cl a) at current soil pH	X	X	X	X	X				
b) at pH 7	X	X							
–: NH_4OAc			X	X	X				
–: $BaCl_2$, pH 8.2, flame photometry						X	X	X	X
Extractable bases: NH_4OAc extraction, a) Atomic adsorption of Al, Na, K, Ca, Mg	X	X							
b) Atomic adsorption of Al, Fe, Ca, Mg; flame photometry of K, Na			X	X	X				
–: $BaCl_2$, pH 8.2, a) Flame photometry						X	X		
b) Flame photometry of Ca, K, Na; atomic adsorbtion of Mg								X	X
Phosphorus: Total Phosphorus a) HF digestion, colorimetry	X	X							
b) $HF/HClO_4$ digestion, atomic adsorbtion			X	X	X				
c) H_2O_2 treatment, $HClO_4$ digestion, colorimetry						X	X	X	X
–: Citric acid extraction after Soil Conservation Service (1972)	X	X	X	X	X				
Potassium: $HF/HClO_4$ digestion, flame photometry			X	X	X				

Used laboratory methods	Profile, No.								
	1.1	1.2	2.1	2.2	6	7.1	7.2	7.3	7.4
Calcium: HF/$HClO_4$ digestion, atomic adsorption			X	X	X				
Magnesium: HF/$HClO_4$ digestion, atomic adsorption			X	X	X				
Iron: a) Oxalate extraction, atomic adsorption	X	X	X	X	X	X	X	X	X
b) Dithionite extraction, atomic adsorption	X	X	X	X	X	X	X	X	X
c) HF/$HClO_4$ digestion, atomic adsorption			X	X	X				
d) Na-pyrophosphate extraction, atomic adsorption			X	X	X				
Aluminium: a) Oxalate extraction, atomic adsorption	X	X	X	X	X				
b) Dithionite extraction, atomic adsorption	X	X	X	X	X				
c) HF/$HClO_4$ digestion, atomic adsorption			X	X	X				
d) Na-pyrophosphate extraction, atomic adsorption			X	X	X				
Manganese: a) Oxalate extraction, atomic adsorption			X	X	X	X	X	X	X
b) Dithionite extraction, atomic adsorption			X	X	X				
c) HF/$HClO_4$ digestion, atomic adsorption			X	X	X				
d) Na-pyrophophate extraction, atomic adsorption			X	X	X				
Trace metals: HF, $HClO_4$, HNO_3 digestion, atomic adsorption	X	X	X	X					

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Excursion A, 3rd day

Podsols and Pseudogleys of Baden-Württemberg

by

K.E. Bleich, K.H. Hauffe and E. Schlichting+

Route description

Crailsheim is situated in the flat valley of the Jagst river. Here the cuesta of Middle Triassic rocks forms a bay which widens to the north. - From Blaufelden westward to

Raboldshausen, where two profiles are shown. A few kilometers from here is the next profile in the forest near Brüchlingen. West of here, in Langenburg, we reach again the Jagst valley which now shows steep slopes of Middle Triassic rocks (stone walls for terracing indicate former vineyards).

Langenburg with its 13th century fortress which has been turned into a castle in the 15th and 16th centuries (with museum for weapons, porcellaine, veteran cars in the Marstall) still is the residence of the Fürst von Hohenlohe-Langenburg. The small town has kept its medieval character with walls and some frame-work houses. - We cross the Jagst valley in southerly direction on the plain "Haller Ebene". After Hörlebach with medieval tower (now Youth Hostel) to the Autobahn; a bridge (height 185 m / length 1128 m) crosses the Kocher valley. The large plain with smooth hilly relief extending towards the west is called "Hohenloher Ebene", bordered by the cuesta of Upper Triassic rocks called "Waldenburger Berge" (the castle and small town of Waldenburg can be seen from the road). - Near

Öhringen we leave the Autobahn and see, to the north of Westernbach, the profile of the Roman Wall "Limes" (constructed behind a palisade in the middle of the 2nd and destroyed in the middle of the 3rd century A.D. as eastern border against "Obergermanien"). - Returning to the Autobahn and continuing in westerly direction we pass a partly forested small ridge and enter the basin "Heilbronner Becken" with vineyards on the slopes and forest on the plateau. Behind the crossing of the Autobahn are the ruins of the fortress "Weibertreu" near Weinsberg. North of Heilbronn we pass the large Neckar valley

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and proceed to the "Kraichgau" district. Due to intensive farming, problems of soil erosion are widespread. At Sinzheim (with "Technik-Museum" to the right) we leave the Autobahn and see steeper slopes with hilly relief in the higher parts of the landscape. In the valley of the Elsenz creek which was part of the Neckar valley in the lower pleistocene (as a meander) lies Mauer, where the lower jaw of Pithecanthropus (called "Homo Heidelbergensis", approximately 500.000 years old) was found. More and more, the Middle Triassic rocks form the plateaus and ridges of the landscape; the loess cover extends as far as the Neckar valley and its terraces near Neckargemünd, where the slopes of the valley are dominated by lower triassic sandstones and debris (under mixed conifer. forest, plateaus with farming due to soils of loess). This landscape is the southern part of the Odenwald which we enter at Neckarsteinach (with several medieval fortresses) and pass through to Heiligkreuzsteinach where a profile sequence is demonstrated next day.

After returning to the Neckar valley we continue to Heidelberg with its famous castle ruin.

Heidelberg got its well-known features in the 16th and 17th century. Its University, founded in 1386 by the Pfalzgrafen of Wittelsbach, is now the oldest in Germany (the library has 1.2 million books; the old Aula, dating from 1711, is well worth seeing). The old part of the city was mainly built between 1544 and 1632 (Hotel "Ritter" from 1592) with additions in the 18th century (Karlstor Bridge 1786-88). The fortress from the 13th century was turned into a castle 1530 to 1618 (the Ottheinrichsbau was the first palace of the Renaissance in Germany; the Friedrichsbau is famous for its figurine decoration; the Englische Bau was built for the wife of Friedrich V, the "Winterkönig" whose election to King of Bohemia lead to the 30 Years War. The famous "Heidelberger Faß" with its capacity of 220.000 liters was concipated for the wine taxes which had to be delivered to the Pfalzgraf each year).

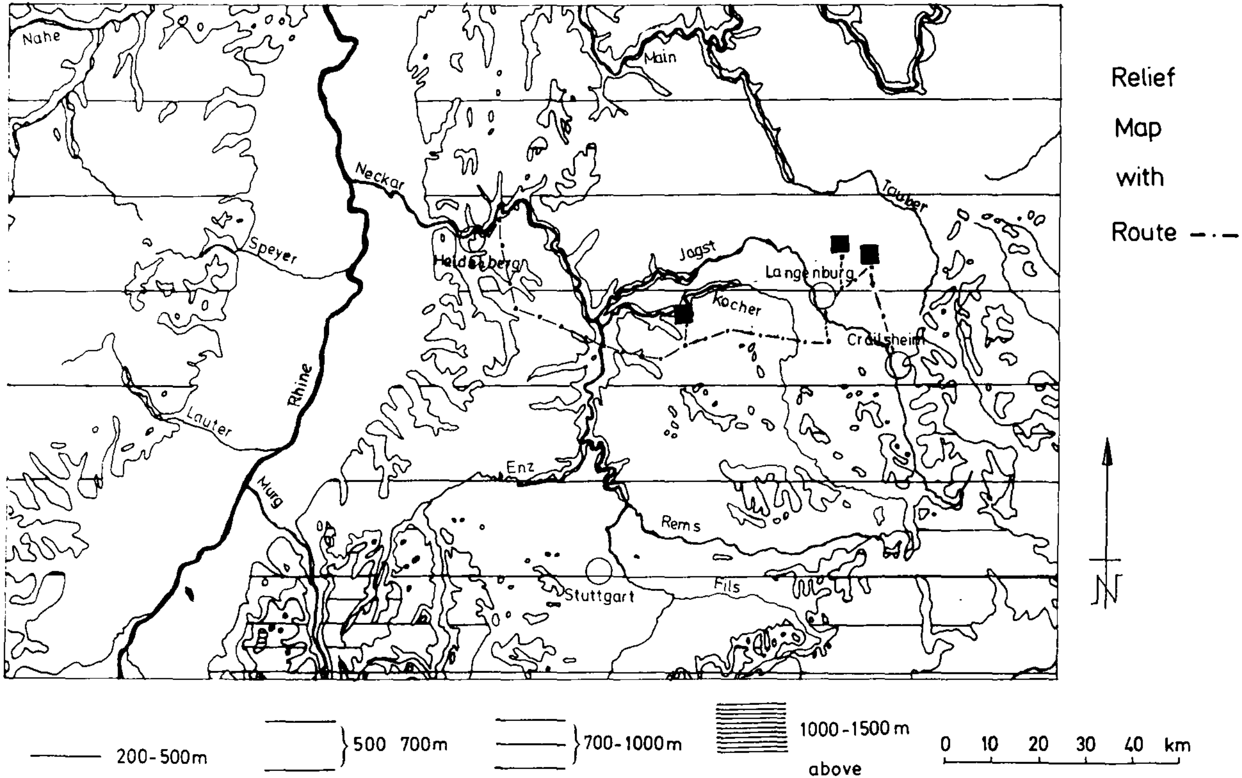


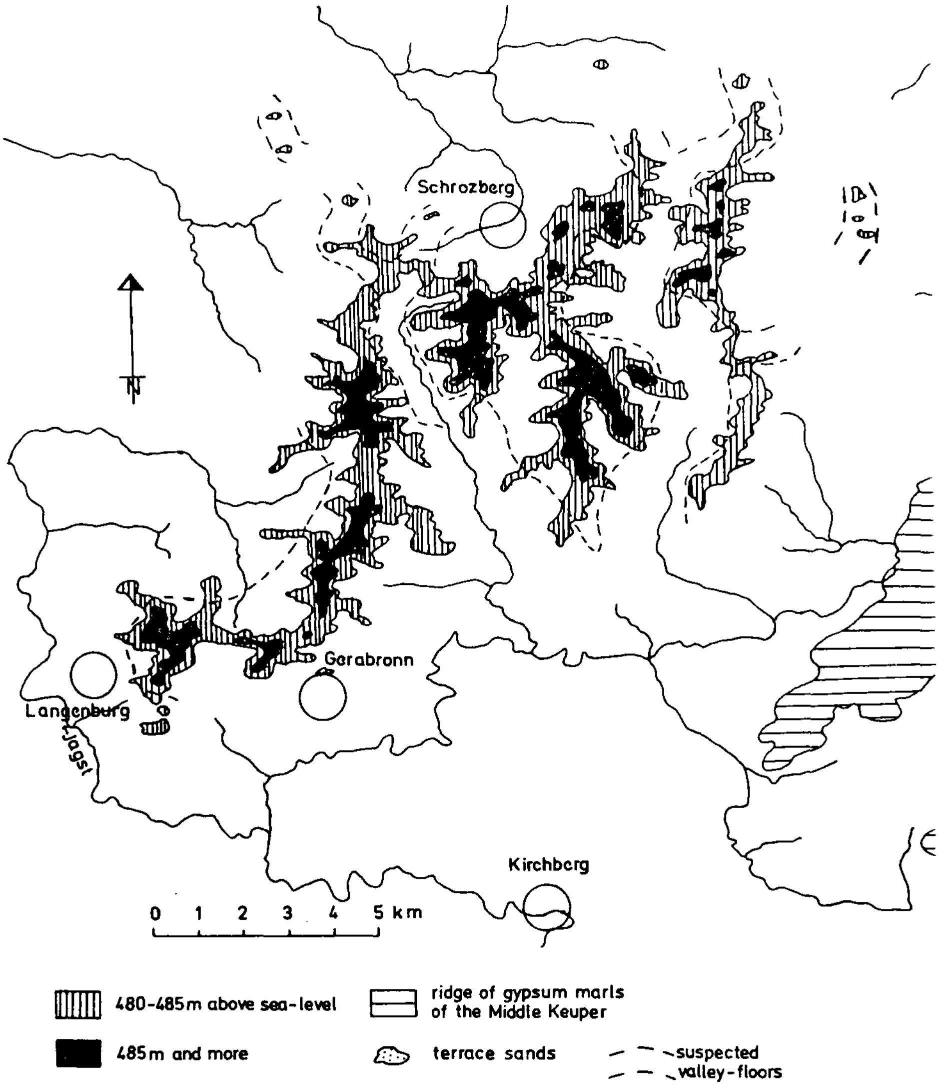
Fig. 1: Top map of Northern-Württemberg with excursion route of Excursion A

Environment and Land Use

Physiography and Geology

For the route in Baden-Württemberg, only the sequence of triassic sediments with pleistocene cover of loess, solifluidal material and debris is important, but older (granite, Permian) and younger (Jurassic) parts are exposed not far from Heidelberg. The sequence will be traversed from the top to the base. The area belongs to a large basin extending in northeastern direction at the end of the Paleozoic era; the Zechstein transgression stopped near Heilbronn. The Triassic started with fluvial red quartz sands; the Buntsandstein is subdivided by two poorly developed conglomerates. The Middle Buntsandstein forms a dominant cuesta and attains a thickness of 300 to 400 m in the southern Odenwald. At the top, peneplains from the Late Tertiary and maeanders of the Neckar river are recognizable; the Upper Buntsandstein which consisted of platy layers (partly clayey) is mostly eroded. Marine transgression began at that time but reached its greatest extension in the Muschelkalk. The lower part of it formed marls and limestone banks, whereas the middle part shows dolomites and clay schists with sulfate and salt beds. The Upper Muschelkalk (with 70 to 90 m of limestones) forms a cuesta, the border of which is diminished in height by salt solution and karstification. Towards the end, dolomite formation is spreading which lasts until the Lower Keuper, interrupted by brackish sediments (clay and marl, sand and even coal seams); this changing sequence forms the roof of the cuesta and is widespread in the plain of Hohenlohe. Rocks of fluvial sediments (sandstones, alternating with clayey marls, dominate the Mittle Keuper of the marginal cuesta. The sedimentation is continued until the Upper Jurassic period, but all has been removed here by erosion except for a lowered block of Lias and Dogger sediments in the western Kraichgau area. Ruins of volcanoes from the Tertiary are preserved in the Kraichgau (Steinsberg) and Odenwald (Katzenbuckel, with clods of claystones from the Middle Jurassic in the tuff). North of Crailsheim, pebbles and frost debris of yellowish, grey and red flint (partly as moss agate and silicified wood) are scattered on various old terraces (mainly between 480 and 485 m above sea-level with increasing size and frequency to the east) and now concentrated in valley bottoms. They are residues of fluvial sediments in the former catchment area of the Brenz river, a tributary of the Danube. During the Pleistocene, most of the Kraichgau and a large part of Hohenlohe was repeatedly covered with loess (interrupted by soil formation at least three times), partly covering ice wedges and involution layers, while on the slopes solifluction and frost shattering took place. During the Holocene, colluvial and alluvial sediments spread with agricultural use.

Geomorphology



Climate and Hydrology

Whereas precipitation in the excursion area is decreasing from the east (800 mm annual means) to the west (700 mm in the western Kraichgau area), with more continental character slightly changing to oceanic, temperature is increasing markedly from 7.5 to over 9 °C (annual means). In the Odenwald the amount of precipitation is distributed more or less regularly all over the year; rains of ascent are important.

Apart from the southern Odenwald the area has a wide network of rivers with rather small karstic springs yielding hard to sulfatic water; salt brines are the reason for the foundation and development of Swabish Hall (to which they gave the name "hal" = salt in the Early Middle Ages). The southern Odenwald has a narrow network of rivers and abundant springs with soft water arising from the sandstone.

Vegetation

Originally the area had been wooded, most of it by broad-leafed trees whereas coniferous forest was restricted to mountainous areas rich in precipitation such as the Odenwald and the Keuper mountains. Now the forested area is dominated by fast-growing conifers all over the country. In the surroundings of Crailsheim, spruce forests with fir occur as well as beech forests with fir and pine or spruce. The eastern Keuper mountains are covered with coniferous forests (mainly spruce) with an important share of beech; the western border of this type is nearly coincident with the Roman fortification ("Limes"). The neighbouring part (with more precipitation) has more fir and birch trees. The plain of Hohenlohe has forests with broad-leafed trees (beech and oak) besides conifer (spruce) on the plateau and beech forest on the slope of the valleys together with dry pastures (with black thorn bushes, juniper and wild roses). The Kraichgau also has forests with broad-leafed trees (mostly oak, together with grove-beech and linden-tree). In the Odenwald, forests with beech and oak are typical on slopes and with birch-tree on the plateaus, but conifer is widespread. The moist valley bottoms originally had bogs with alder-tree and willow, which are now confined to the margin of the creek; most of the plain is meadow.

Soils

Soils from loess prevail along the route, besides those from solifluidal material on steeper slopes of valleys (mostly clayey, in the Odenwald stony) and from Upper Triassic layers (especially near Crailsheim and on the cuesta south of the Autobahn). Thus, strongly developed Pseudogleys occupy the center of the plateaus in the eastern part of the excursion area, associated with Parabraunerde-Pseudogleys, Pelosols and Brown earths, in the depressions with silty colluvia;

the slopes are dominated by Pseudogley-Pelosols together with Brown and Mergel-pelosols, in deeply incised valleys by Rendzinas and Brown earths, whereas the valley bottoms have Vegas and Gleys bordered by colluvial soils. On the cuesta south of the Autobahn the Pelosols are confined to the lower part, while the upper is dominated by Brown earths, more or less podzolized, and shallow developed Podzols. - Approaching the basin of Heilbronn, Rigosols are more and more occupying the steep southern slopes; Pseudogleysation is decreasing and Parabraunerde is widespread, together with Pararendzinas on top of hills and Vegas with colluvial soils in the valleys. Due to the increasing influence of erosion towards the western Kraichgau, Pararendzinas spread all over the landscape, in some places even into the valleys (from colluvium rich in lime). In the southern Odenwald, Brown earths prevail; Podzols and Stagnogleys are only moderately developed.

Agriculture and Forestry

Agriculture dominates the basin of Heilbronn and the Kraichgau area where it began more than 5000 years ago in the Early Neolithic. The main crops are cereals, maize and sweet turnip; intercropping is extensive and interspersed with special cultures (fruits, vine and tobacco). Especially in the western Kraichgau erosion problems are evident; with increasing colluviation, arable farming has been extended into the valley bottoms. In the plain of Hohenlohe agriculture still prevails but is mixed with grassland (partly dry pastures on steep slopes of the valleys) whereas meadows cover up to 50 % of the cultivated area in the surroundings of Crailsheim. Odenwald and Keuper mountains are predominantly forested areas, the former originally with broad-leafed trees (beech, oak), the latter with mixed forest (spruce, beech), but plantations of pine-trees have been extended in the 19th century everywhere. Today, forestry follows more ecological points of view.


Soil Map
of
Northern
Wuerttemberg
Heidelberg
Crailsheim
Stuttgart
N
0 5 10km

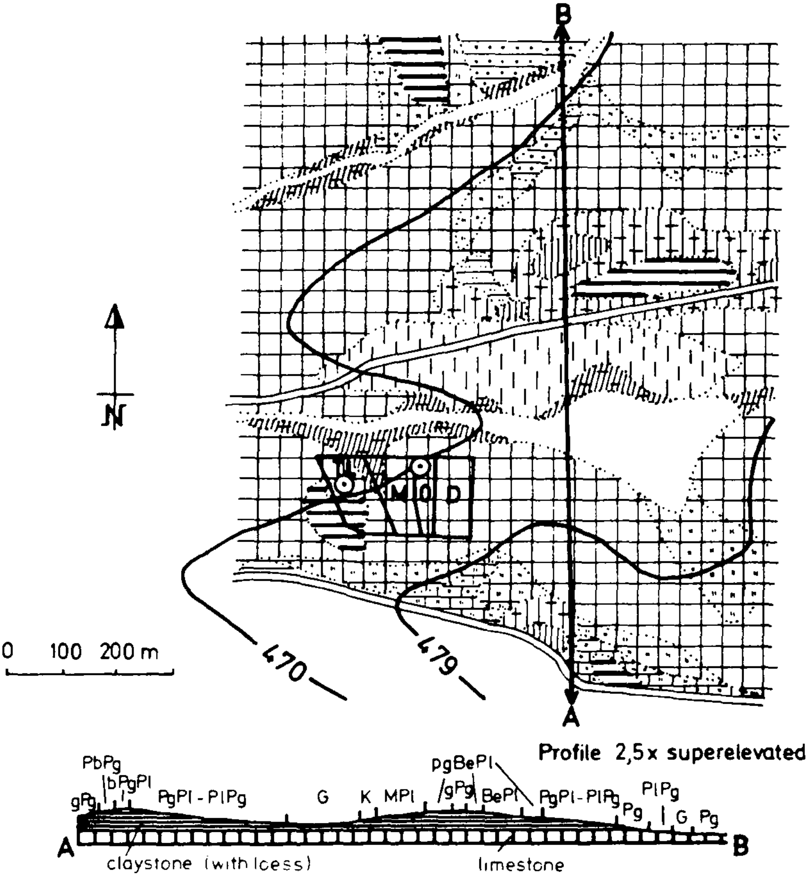
Legend:

Parent material	Relief	Soils
limestone (partly dolomitic) ± loess	dry valleys	Rendzina-Terra fusca-Braunerde (partly himic) with relics of Red Loam
clayey marl and limestone banks ± loess	plateaus, hills and gentle slopes	Mergelpelosol and -rendzina-Pseudogley-and Braunpelosol-Parabraunerde-Braunerde (± vlayey)-Vega with Rendzina, Braunerde-Terra fusca, Pseudogley-Parabraunerde and Pararendzina
clay-(silt-)stone and sandstone banks ± loess	plateaus, hills and gentle slopes	Pseudogley-and Braunerde-Pelosol-(Pelo)Pseudogley-Pelogley-Anmoor with Mergelpelosol, Pseudogley-Parabraunerde, Braunerde a. Lowmoor
sandstone (partly clayey)	ridges and gentle slopes	Braunerde-Stagnogley-Ockererde-Podsol-Gley with Ranker and Pseudogley
silt-(clay-)sandstone ± loess	ridges and gentle slopes	Braunerde-Pseudogley-Gley with Podsol Braunerde, Ranker a. Stagnogley
coarse sand (clay) and sandstone ± loess	plateaus, ridges and slopes	Pseudogley-Podsol-Braunerde-Gley with (Pseudogley-)Parabraunerde, Braunpelosol and Stagnogley
granite and porphyry	ridges and slopes	Ranker-Braunerde-Braunerde-Podsol-Gley with Syrosem, Gleyvega a. Anmoor
ejection of meteoritic crater	hills and gentle slopes	Rendzina-Braunerde-Pseudogley-Gley with Protorendzina
clay-with-flint colluvium ± loess	flat hills and slopes	Pseudogley-Parabraunerde-Braunerde with Rendzina, Terra fusca, Podsol, Stagnogley a. Highmoor, partly above large relics of Red Loam
(loamy) terrace sands ± loess	plateaus	Pseudogley-(Bänder-)Parabraunerde-(Podsol-)Braunerde-Pseudogley-Pelosol-Anmoor-Gley with Parabraunerde-Pseudogley
loess with flint	plateaus and ridges	Pseudogley-Parabraunerde-Pseudogley Braunpelosol-Braunerde-Pelogley with Mergelpelosol a. Sandbraunerde
loess	ridges and plateaus	Pararendzina-Chernosem-Parabraunerde-Parabraunerde-Braunerde-Vega with Mergel- and Braunpelosol
loess	ridges, hills a. gentle slopes	Parabraunerde-Pararendzina-Braunerde-Vega with Kalk-and Pseudogley-Braunerde, partly vineyards w. Rigosol
loess	ridges and plateaus	Parabraunerde-Pseudogley-Parabraunerde-Vegagley with Pseudogley, Braunerde and Anmoor
terrace sediments with loess	plateaus and hills	Parabraunerde-Braunerde-Vega-Gley-Anmoor with Podsol-Braunerde
alluvial sediments	hills and plains with ridges	Braunerde-Vega-Gley-Paternia with Mergelrendzina and Anmoor

Experimental Field Raboldsbausen

The experimental field for land improvement was layed out between 1967 and 1969 after fallowing of meadows with a zero plot, a plot with drainage (depth 0.85 m/distance 8 m), mole drainage (0.5/2.5 m) and deep-loosening (0.7/0.8 m); the latter two have a requirement drainage (24 meters distance). The owners of the area are Hans Renner (drainage plot) and Heinz-Friedrich Renner (remaining part), both are trained and professional farmers.

	Mixed farm H.-F. Renner:		Mixed farm H. Renner:	
	1975	1984	1975	1985
Farmland	60 ha	49 ha	24.6 ha	24.6 ha
Cereals	30 "	33.5 "	19.4 " *)	20.4 " *)
Fodder	10.5 "	6.0 "	root crops	0.6 "
Grassland	9.5 "	9.5 "	5.2 ha	3.6 "
Forest	5.7 "	5.7 "	8.6 "	8.6 "
	*) alternating after 2-4 years with grass seed			
Milch cows	13	13		
Calves (with mast)	52	50	12	-
Sows	25	27	22	30
Fattening pigs	80	130	40	40
Sheep	10	-		
Livestock units	64	68	22	20



Legend:

MPl		Mergelpelosol from marly claystone (Lower Keuper)	gPg		Grey Pseudogley from Loess
BePl		Braunerde-Pelosol from marly claystone (Lower Keuper)	"		30-60 cm over claystone
"		with pseudogleyed subsoil	Pg		Pseudogley from solifluidal (sandy) loam and sandstone debris
PgPl -PlPg		Pelosols with different Pseudogleysation	K		colluvium with pseudogleyed subsoil
b "		with brown (silty) topsoil	G		Pelogley
PbPg		Parabraunerde-Pseudogley from Loess			
"		30-60 cm over claystone			

Site Description

Location: East of Raboldshausen, Kreis Schwäbisch Hall

Elevation: 469 m

Landform: Flat mountain ridge

Slope: Lower part, northwest, 4%

Drainage: Pipe (since 5 years)

Vegetation: Crops

Use: Field

Soil Temperature: 8,5 °C

Parent material: Claystone (lower part of the Upper Triassic) with shallow loess cover, solifluction material

Soil classification; FAO: Gleyic Cambisol

German: Pelosol-Pseudogley, mittel ausgeprägt, Naßphase lang

US Soil Taxonomy: Vertic Haplaquept, fine, illitic, mesic

Profile Description

Horizon:		Depth: cm	Description:
Ap	Ap	0-16	dark brown (10 YR 3/4), silty loam (uL), granular, few roots, clear boundary
Sw	Bcg	-45	yellowish grey (10 Y 5/1) with few mottles, sandy clay loam (stL), polyhedric, many blackish concretions, clear boundary
SdP	Bwg	-65	light bluish grey (5 BG 6/1)/orange (7.5 YR 7/8) mottled, silty clay (uT), prismatic to coherent with weak slickensides, smooth transition
PSd	Bg	-80	light bluish grey (5 BG 6/1)/yellowish grey (2.5 GY 5/1)/orange (7.5 YR 7/8) mottled silty clay (uT), coherent, smooth transition
lCSd	Cg	-110	as before, but calcareous with pieces of limestone

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ap	0-16	3,2	6,0	3,2	15,9	25,1	28,5	18,1	13,6	60,2	14,7	1858,	
2	Sw	-45	6,7	5,7	2,0	5,8	13,5	10,5	15,0	14,7	40,2	46,3	23,9	
3	SdP	-65	4,5	2,8	1,6	6,7	11,1	8,5	15,1	14,5	38,1	50,9	0,5	
4	PSd	-80	1,3	2,1	1,3	4,9	8,3	6,6	15,5	16,6	38,7	53,0	0,5	
5	lCSd	-110		2,0	0,9	2,0	4,9	3,4	16,9	19,2	39,5	55,6	0	

No	hor.	bulk dens. g/cm³	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	Ap	1,29	51,1	49,7	46,0	43,3	26,0	6,3	5,9	10,1	8,02	0,79	333	61,0
2	Sw	1,46	45,2	39,2	37,9	37,3	23,7	6,4	6,0	14,0	9,70	0,69	295	2,2
3	SdP	1,52	43,9	44,2	43,2	42,1	31,2	7,0	6,1	16,7	0,65	0,04	165	24,0
4	PSd	1,56	42,5	44,7	43,9	42,6	31,5	7,4	5,8	11,1	1,58	0,14	160	15,3
5	lCSd	1,54	41,9	49,8	48,7	47,0	35,4	8,0	7,6	16,2	3,46	0,25	97	2,2

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	$CaCO_3$ %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	Mg	K	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ap	5,3	5,3	10	0	226	249	215	28	4.3	1,3	17		94
2	Sw	1,0	1,2	8	0	122	120	95	17	1,8	6,1	13		90
3	SdP	0,5	0,6	8	0	164	198	121	73	3,1	0,9	10		95
4	PSd	0,5	0,6	8	0	176	194	120	69	3,9	0,9	13		94
5	lCSd	0,5	0,6	8	16,9	200		278	57	3,9	1,4	0		100

Site Description

Location: East of Raboldshausen, Kreis Schwäbisch Hall

Elevation: 468 m

Landform: Flat mountain ridge

Slope: Lower part, northwest, 5%

Drainage: Pipe (with deep-loosening down to 0.7 meters)

Vegetation: Crops

Use: Field

Soil Temperature: 8,5 °C

Parent material: Claystone (lower part of the Upper Triassic) with flat Loess cover, solifluction material

Soil classification; FAO: Gleyic Cambisol

German: Pelosol-Pseudogley, mittel ausgeprägt, Naßphase lang

US Soil Taxonomy: Vertic Haplaquept, very fine, illitic, mesic

Profile Description

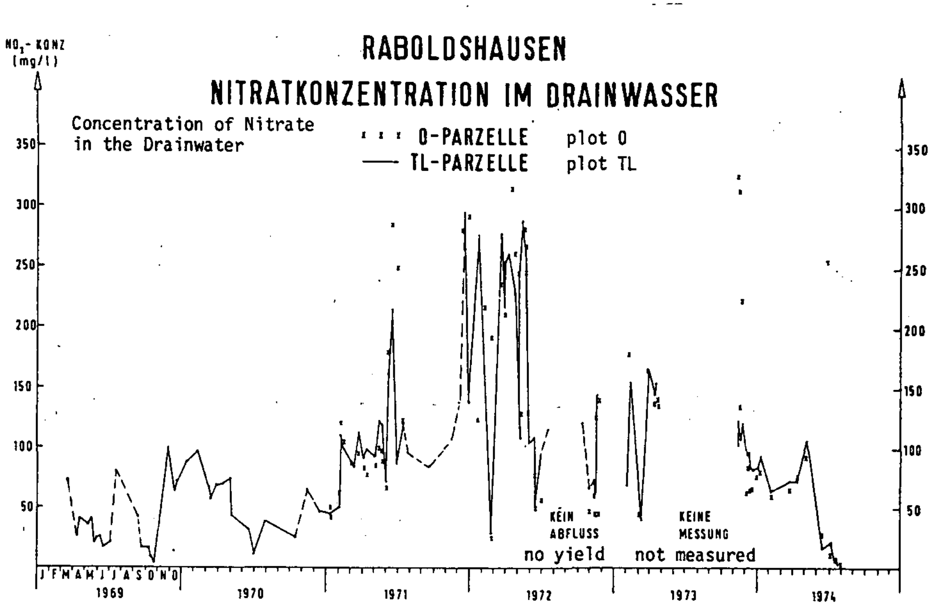
Horizon:		Depth: cm	Description:
Ap	Ap	0-20	dark brownish grey (10 YR 3/3), loamy clay (LT), granular to subpolyhedric, few roots, clear boundary
RSw	Bwgp	-40	yellowish grey-brown (10 YR 7/3), mottled orange (10 YR 6/6) and grey (2.5 Y 6/0), loamy clay (LT), (polyhedric to) coherent, smooth transition
RSdP	Bgp	-88	bluish grey (10 B 5/1) / orange (5 YR 7/8)/ reddish brown (5 YR 6/6) mottled clay (T), prismatic to coherent with weak slickensides, blackish concretions, smooth transition
lCSd	Cg	-100	as before, but coherent and calcareous with pieces of limestone

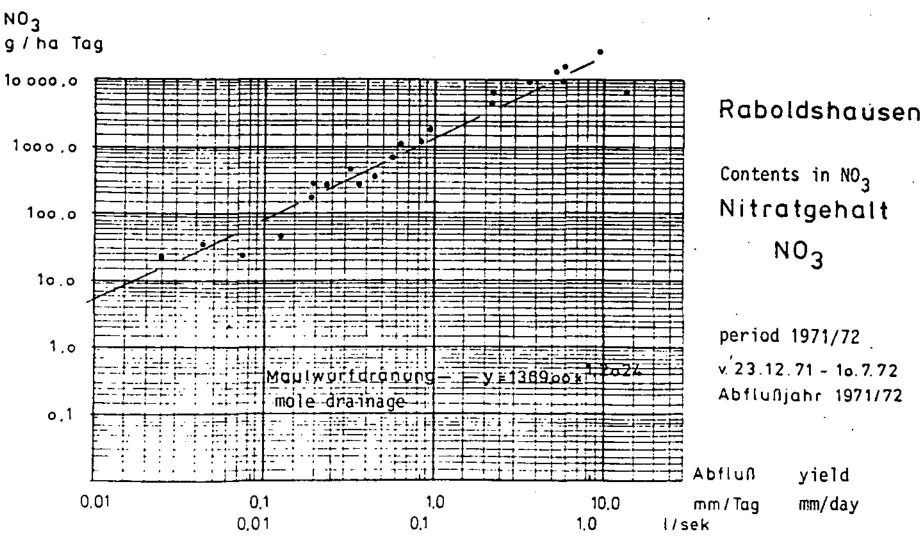
No	hor.	depth	sto.	texture in % of humus-/carb. free fine soil									kf	
				sand				silt				clay		
		cm	%	c	m	f	Σ	c	m	f	Σ		cm/d	var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ap	0-20	3				6,8	22,7	17,8	10,8	51,3	41,9	350,8	
2	RSw	-40	0				8,9	7,6	15,5	12,0	35,1	56,0	415,6	
3	RSdP	-83	0				3,0	12,0	6,0	12,0	30,0	67,0	1,7	
4	1CSd	-100	0				2,0	9,0	5,0	12,0	26,0	72,0		

No	hor.	bulk dens.	GPV	water content in % at pF				pH		Fe_d	Fe_o	Fe_o: Fe_d	Mn_o	P_a
		g/cm^3	%	0.6	1.8	2.5	4.2	H_2O	$CaCl_2$	mg/g			mg/kg	
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	Ap	1,00	61,1	60,8	45,3	41,8	32,1	6,7	6,1	19,7	6,90	0,350	450	97,0
2	RSw	1,45	46,1	49,4	45,0	44,5	35,1	7,0	6,2	22,5	3,00	0,133	475	1,4
3	RSdP	1,47	46,2	53,0	53,0	49,4	36,6	7,6	7,2	27,2	2,06	0,076	200	2,5
4	1CSd							8,0	8,5	18,1	2,35	0,13	82,5	3,0

No	hor.	$C_{org.}$	N_t	C:N	$CaCO_3$	CEC		exchang. cations in meq/kg						V
						p	a							
		%	mg/g		%	meq/kg		Ca	Mg	K	Na	H	Al	%
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ap	4,3	2,7	15,9	0	365	374	338	27	5.9	3,5		17	96
2	RSw	0,8	0,7	11,4	0	210	235	193	34	4,3	3,2		10	96
3	RSdP	0,7	0,4	17,5	0	240	277	197	72	5,2	3,1		4	99
4	1CSd	0,4	0,5	8,0	1,4	202		(348)	76	5,5	7,7	0	0	100

No.	hor.	Ti o/oo	Zr o/oo	Ti: Zr	in % of clay kao	ill	x	sme	chl
1	Ap	5.66	0.22	26	3	28	61	3	5
2	RSw	5.63	0.20	28	3	22	56	14	5
3	RSdP	4.06	0.11	37	3	31	46	16	4
4	CSd	5.56	0.12	38	2	44	54	2	2

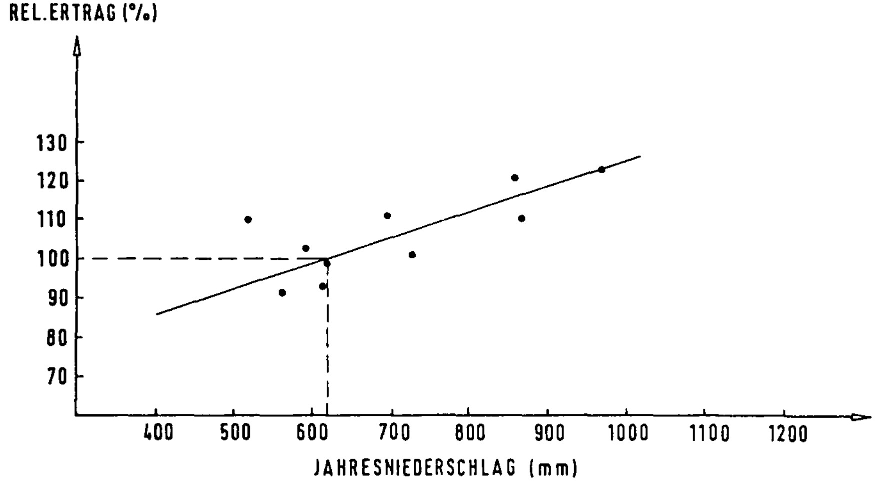

NO3 - KONZ (mg/l)
RABOLDSHAUSEN
NITRATKONZENTRATION IM DRAINWASSER
Concentration of Nitrate in the Drainwater
O-PARZELLE plot O
TL-PARZELLE plot TL
KEIN ABFLUSS
no yield
KEINE MESSUNG
not measured
J F M A M J J A S O N D
1969
1970
1971
1972
1973
1974


NO3
g / ha Tag
Maulwurfdränung
mole drainage
y = 1369,00 x
Abfluß yield
mm / Tag mm/day
l/sek
Raboldshausen
Contents in NO3
Nitratgehalt
NO3
period 1971/72
v. 23.12.71 - 10.7.72
Abflußjahr 1971/72

RABOLDSHAUSEN

REL.ERTRAG (D 24/0-PARZ) UND NIEDERSCHLAG

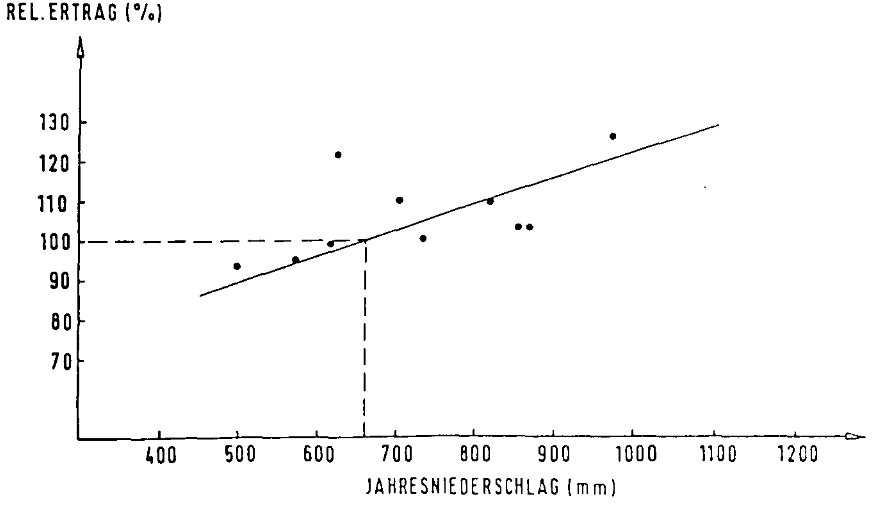
Relative yield (plot D 24/0) and precipitation



RABOLDSHAUSEN

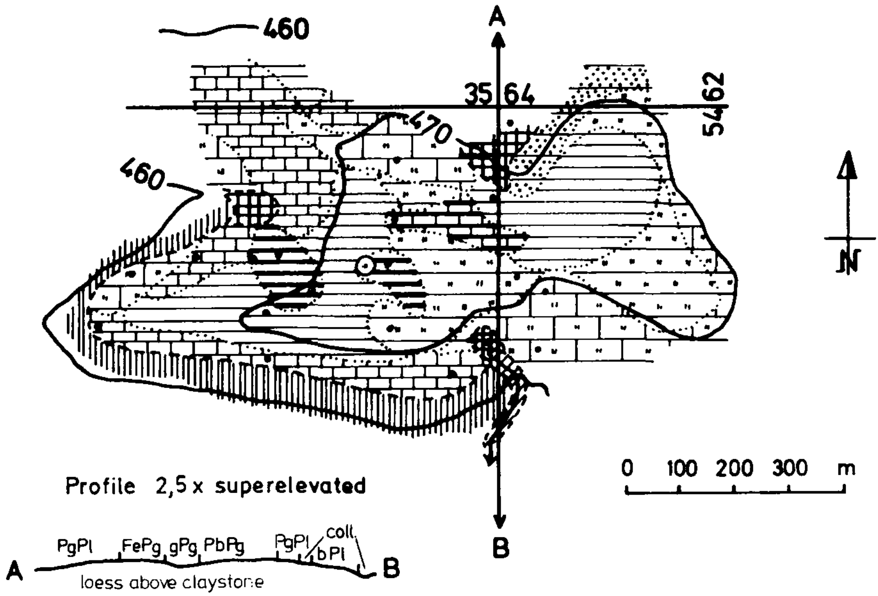
REL.ERTRAG (D8/0-PARZ) UND NIEDERSCHLAG

Relative yield (plot D8/0) and precipitation



Interpretation Raboldshausen

Parent material dense, partly stony, calcitic-marly, illitic-clayey (ameliorated profile very clayey) solifluidal material, possibly - see silt content and Ti:Zr - with a loess blanket. Certainly loss of carbonates and gain in iron oxides; depletion of bases probably decreased by liming; at most weak clay trans-formation and translocation, but in the stratified material quantification difficult; horizontal translocation of iron not shown in data. - Accumulation of 34.3 kg organic matter/m² (versus 29.6 kg/m²) of mull-type, with average C:N of 9.2 (versus 15.4). -
Structural transformation of the dense material with a high swelling capacity - see field capacity >pore volume in subsoils - and low hydraulic conductivity by weakening and segretation; by aggregation leading to moderate permeability only in the topsoil. Effect of amelioration on pore volume (until 80 cm 399 versus 363 l/m²) and coarse pores (33.8 versus 30.7 l/m²) only low, but subsoil permeability increased, perhaps due to better microstructure. But much higher clay content and amelioration under unfavourable weather conditions must be considered.
Rooting depth 20-40 cm; air capacity see coarse pores; available field capacity 116 (112) l/m² - thus moderately dry, but frequently surface water stagnation and poor aeration of the soil. Reserves of N with 1846 g/m² very high (in the ameliorated profile - due to mobilization? - only 962 g/m², but still high); reserves of P (nearly 0.6 kg/my) and K (43 kg/m²) very high with low availability. But trophic character of both soils good. Improvement of structure by appropriate crop rotation and possibly application of gypsum should be tried.



Langenburg

Soil map on the plateau between Langenburg and Brüchlingen, NE Württemberg

Legend:

gPg	Grey Pseudogley from Loess
"	30-60 cm above claystone
FePg	Fahlerde-Pseudogley from Loess
"	30-60 cm above claystone
PbPg	Parabraunerde-Pseudogley from Loess
"	30-60 cm above claystone
PgPl	Pseudogley-Pelosol from claystone (Lower Keuper) (with silty topsoil)
bPl	Braunpelosol from marly claystone
Pg	Pseudogley from solifluidal (sandy) loam
K	silty colluvium
• •	abundant oxide concretions

Langenburg

Site Description

Location:	Northeast of Langenburg, Kreis Schwäbisch Hall
Elevation:	472 m
Landform:	Flat mountain ridge
Slope:	No
Drainage:	Strongly impeded
Vegetation:	Spruce forest
Use:	Forest
Soil Temperature:	8,5 °C
Parent material:	Loess

Soil classification; FAO: Eutric Planosol

German: Grauer Pseudogley, mittel ausgeprägt, Naßphase lang

US Soil Taxonomy: Aeric Fragiaqualf, fine, illitic, mesic

Profile Description

Horizon:		Depth: cm	Description:
L/Of	O	1-0	moss and needles, partially decomposed
Ah	Ah	0-2	blackish brown (5 YR 2/1, sandy loam (SL), granular to sponge-like, many roots, clear boundary
AhSw	AhE	-14	greyish brown (10 YR 4/3), sandy loam (SL-sL), subpolyhedric, some roots, clear boundary
Sew	Ecg	-28	light grey (10 YR 7/3) with little mottles, sandy loam (sL), subpolyhedric, few blackish brown concretions, clear boundary
Skw	Bcg	-60	brown (7.5 YR 5/8)/light bluish grey (2.5 Y 7/2) mottled, small ferruginous mottles, loam to loamy clay (L-LT), polyhedric to platy, many blackish brown concretions, smooth transition
Sd1	Bwg1	-90	brown (7.5-10 YR 5/8)/light bluish grey (2.5 Y 7/1) mottled, loamy clay (LT), fragipan,platy small concretions, smooth transition
Sd2	Bwg2	-120	as before, but coarse prismatic
IISd3,4	IIBwg3,4	-200	as before, but clay (T), prismatic to coherent
IIISd5	IIIBwg5	-250	yellowish brown (10YR 5/4)/greenish grey (7,5GY6/1) mottled, clay (T), coherent

Micromorphological Description

Ah: Fine granular, lower part subangular blocky to laminar with many irregular pores within the peds, passages rare, faecal material visible (widespread in the upper part) together with organic matter, some roots, matrix abundant dark brown to light greyish brown with darker zones, some large irregular oxide concretions (iron/manganese) which are cellular in the center and show few concentric rings at the outside.

Sew: Weak laminar with small cracks and some irregular fine pores, no passages, mostly large roots, matrix yellowish to greyish brown, abundant small and some large oxide concretions with cellular core and interrupted concentric crusts.

Skw (transition to Sd): Incomplete subangular blocky with few cracks and lenticular pores, roots rare, matrix light greyish brown with segregations of iron oxides (partly along root channels), in some cases transition to cellular concretions with distinct boundaries, some small and large oxide concretions (massive, cellular), the small ones with distinct concentric shape, the larger ones irregular or spheroidal (with few concentric rings).

Sd: Weak angular blocky to prismatic with few cracks and lenticular pores, root channels rare, matrix yellowish brown with large light greyish mottles (mostly along larger cracks), sometimes with cellular oxide concretions (bulbous boundaries) and thin impregnations along root channels, transition to oxide segregations visible.

Iron balls, Ah horizon

SEM photo: R. Wurster

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	L/Of	1-0	0				-	-	-	-	-	-	-	
2	Ah	0-2	0				3,4	29,4	31,5	14,7	75,6	21,0	-	
3	AhSw	-14	0				3,2	33,2	28,4	13,3	74,9	21,9	285,1	
4	Sew	-28	0				3,3	32,7	33,0	11,5	77,2	19,5	155,5	
5	Skw	-60	0				1,6	27,2	29,8	5,4	62,4	36,0	2,5	
6	Sd1	-90	0				1,8	27,1	26,3	8,9	62,3	35,9	0,4	
7	Sd2	-120	0		0,7	8,1	8,8	24,3	15,7	10,2	50,2	41,0		
8	II Sd3	-150	0		0,6	7,8	8,4	15,3	9,9	9,9	35,1	56,5		
9	Sd4	-200	0		0,5	8,4	8,9	11,7	12,5	11,2	35,4	55,3		
10	IIISd5	-250	0		0,1	0,2	0,3	1,0	10,3	6,7	18,0	81,7		

No	hor.	bulk dens. g/cm³	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o: Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	L/Of							4,5	4,2					195,3
2	Ah							3,8	3,1	6,1	2,88	0,47	1300	57,3
3	AhSw	1,07	59,6	50,0	36,8	28,3	13,3	4,3	4,0	18,5	3,80	0,21	1800	< 1,0
4	Sew	1,26	53,0	42,9	34,1	25,8	14,6	4,3	4,2	15,8	3,40	0,22	1675	"
5	Skw	1,49	45,3	41,5	36,0	31,1	24,9	4,5	4,2	12,5	3,35	0,27	1500	"
6	Sd1	1,54	43,5	38,2	36,1	31,5	28,4	5,1	4,4	17,3	2,25	0,13	235	"
7	Sd2							5,1	4,4	14,4	1,88	0,13	180	"
8	IISd3													
9	Sd4													
10	IIISd5													

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	$CaCO_3$ %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	Mg	K	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	L/Of	47,07	13,4	35,1	0	455	177	76	11	13,7	12,6	424		21
2	Ah	24,65	9,1	27,1	0	436	100	42	8	4,5	4,7	560		10
3	AhSw	1,44	0,9	16,0	0	92	29	3	2	0,8	1,2	98		7
4	Sew	0,58	0,5	12,6	0	56	35	2	1	0,7	1,3	68		7
5	Skw				0	122	72	11	8	1,9	1,2	90		20
6	Sd1				0	132	115	46	31	2,6	1,1	73		53
7	Sd2				0									
8	IISd3				0									
9	Sd4				0									
10	IIISd5				0									

Interpretation Langenburg

Parent material dense (marly?), illitic-loamy silt (loess), underlain by and cryoturbated with illitic clay (age: Lower Keuper) and "contaminated" by some volcanic material (clinopyroxene belonging to the Laacher See-Tuff 1-4 of Alleröd age), possibly mixed in by bioturbation, and by recent industrial dust (see picture with iron oxide balls detected in the fine sand), both leading to more mica and illite and less stable minerals (especially Zrc) near the surface.

Deep leaching of carbonates (if originally present) and strong depletion of bases, especially in horizons 3 and 4 (in 2 and 3 "H+Al" > CECp), in horizons 1 and 2 reverted by bioaccumulation and/or dust. Pronounced formation of iron oxides ("silicate"-Fe decreasing from over 60 to below 10% of total, "oxide"-Fe increasing from 30 to 75% towards surface, except for horizon 1); bleaching and mottling or formation of concretions not shown in data. Due to gradual decrease of "loess character" downwards, quantitative statements about clay formation and translocation difficult, but obviously strong alteration of clay minerals towards chlorite in the acid topsoil. - Accumulation of only 18.1 kg org. matter/m² of moder-type, with average C:N of 21.8; recent bioturbation low. - Presumably dense parent material altered into coarse platy and very dense fragipan (and argillic horizon?) with few coarse pores and low hydraulic conductivity, only in topsoil loosening with high porosity and permeability.

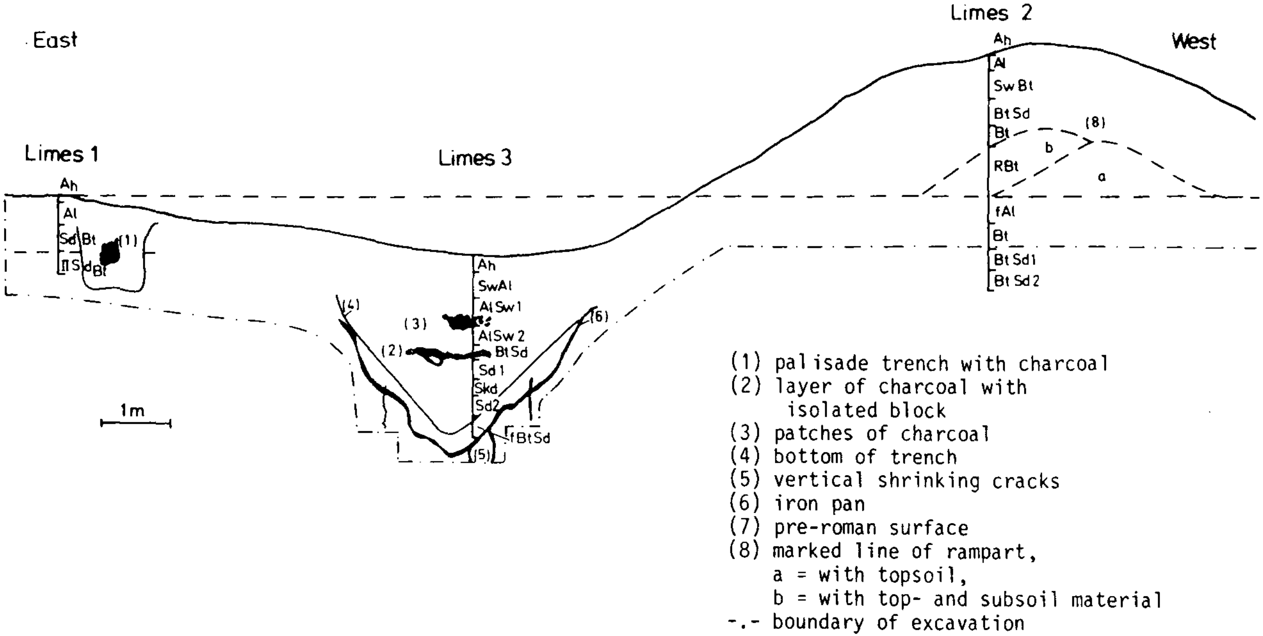
Rooting depth 30 (to 60 in dry periods) cm; air capacity until 80 cm 103 l/m²; available field capacity 111 l/m² - thus moderately dry, but most time of the year topsoil saturated with water and scarcely aerated. Reserves of N with 416 g/m² moderate with presumably low availability. The same applies probably to P and K, thus trophic character poor with exchangeable Al exceeding Ca in the subsoil. Liming may be advisable already for good timber production, would be necessary along with deep-loosening and uptopping of P, K-reserves for farming.

Langenburg: Supplementary data

No	hor.	depth cm	minerals in % sand fsp	qu	gl		c silt fsp	qu	gl	qu:fsp	clay Kao	Ill	X	Mont	Chl
1	2	3	4	5	6	7	8	9	10	11	12	13		14	15
1	L/Of	1-0													
2	Ah	0-2					21,7	69,8	8,5	3,2	5	30	40	10	15
3	AhSw	-14					23,3	73,6	3,1	3,2	5	15	20	5	55
4	Sew	-28					25,0	68,2	6,8	2,7	5	20	20	5	50
5	Skw	-60					25,1	68,1	6,8	2,7	5	30	30	10	25
6	Sd1	-90					25,7	68,1	6,2	2,7	5	30	35	10	20
7	Sd2	-120					24,5	69,8	5,7	2,8	5	30	40	10	15
8	IISd3	-150													
9	Sd4	-200													
10	IIISd5	-250									0	65	35	0	0

No	hor.	Ti ‰	Zr ‰	Ti: Zr	heavy minerals in % Ap	Zrc	Tur	Rut	Gar	Hbl				volc.
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	L/Of													
2	Ah	5,02	0,43	11,7	47,0	29,1	8,5	5,8	0,5					7,1
3	AhSw	4,91	0,48	10,2	}45,1	36,2	4,2	5,3	1,1					6,3
4	Sew	5,37	0,47	11,3										
5	Skw	4,97	0,39	12,8	}49,2	28,0	2,4	11,5	2,4	0,5				4,6
6	Sd1	4,78	0,37	13,0										
7	Sd2	4,77	0,34	13,9	56,8	19,7	6,2	13,5	1,1					0,8
8	IISd3	4,45	0,29	15,6	}60,0	19,9	5,1	9,9	1,7					
9	Sd4	4,81	0,21	22,8										
10	IIISd5	3,63	0,11	31,7	74,8	15,7	2,0	5,2	1,0	0,5				

No	hor.	K_t ‰	Mg_t %	P_t %	Fe_t ‰	Mn_t %						NH_4Cl me/kg H	Al	%
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	L/Of											58	6	
2	Ah	14,2			22,3							22	19	
3	AhSw	13,7			19,6							0	24	
4	Sew	15,2			21,8							1	29	
5	Skw	16,2			39,7							3	47	
6	Sd1	15,4			39,5							10	24	
7	Sd2	14,9			39,3									
8	IISd3	13,1			38,8									
9	Sd4	27,3			29,2									
10	IIISd5	30,5			67,8									



Cross section through archeological site of roman fortification"Limes near Westernbach"with profiles "Limes 1-3"

Limes North of Westernbach

Site Description

Location: North of Westernbach, Kreis Hohenlohe; area outside the fortification ("Limes1")

Elevation: 322 m

Landform: Flat mountain ridge

Vegetation: Beech forest

Slope: No

Use: Forest

Drainage: Impeded

Soil Temperature: 9,5 °C

Parent material: Younger and older Loess

Soil classification; FAO: Dystric Podzoluvisol

German: Parabraunerde-Pseudogley, mäßig entwikkelt, Naßphase kurz

US Soil Taxonomy: Aquic Hapludalf, fine-silty, mixed, mesic

Profile Description

Horizon:		Depth: cm	Description:
Ah	Ah	0-5	dark brownish grey (10 YR 3/4), loamy silt (lU), granular to subpolyhedric, many roots, clear boundary
Al	E	-35	light greyish brown (10 YR 7/4), loamy silt (lU), subpolyhedric, some roods, wedged boundary
SdBt	B(g)t	-70	brown (10 YR 4/6), light greyish brown (10 YR 7/3) in wedges, loam to loamy clay (L-LT), polyhedric to prismatic, clay coatings on aggregates, many small blackish brown concretions, smooth transition
IIBtSd	Bgt	-100	brown (10 YR 5/6), few cracks grey (10 YR 7/3) with ferruginous border, loam to loamy clay (L-LT), coarse prismatic, clay coatings, many small blackish brown concretions

No	hor.	depth cm	minerals in % sand fsp	qu	gl		c silt fsp	qu	gl	qu:fsp	clay Kao	Ill	X	Mont	X	Chl
1	2	3	4	5	6	7	8	9	10	11	12	13		14		15
1	Ah	0-5									17	23	26		17	17
2	Al	-35									17	25	25	4	17	12
3	SdBt	-70									17	25	25	8	17	8
4	IIBtSd	-100									17	25	25	8	17	8

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ah	0-5	0				3,2	39,2	29,7	9,9	78,8	18,0	1633,0	
2	Al	-35	0				1,9	38,8	36,0	8,3	83,1	15,0	2082,2	
3	SdBt	-70	0				0,7	29,8	23,9	8,1	61,8	37,5	812,2	
4	IIBtSd	-100	0				0,7	33,1	26,6	7,2	66,9	32,4	135,6	

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	Ah	0,79	69,3	63,8	43,2	33,5	12,0	4,6	3,9	9,0	2,8	0,31	650	20,2
2	Al	1,09	59,2	47,7	36,1	28,8	10,0	4,6	3,7	9,0	2,5	0,28	380	< 1
3	SdBt	1,09	59,9	47,4	39,2	32,8	13,5	4,9	3,9	12,5	4,0	0,32	350	2,9
4	IIBtSd	1,44	47,3	44,4	40,3	35,6	15,7	5,2	4,1	16,0	8,3	0,52	405	5,7

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	$CaCO_3$ %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg Ca	Mg	K	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ah	6,56	3,78	17,4	0	186	80	54	8	4,5	0,9	118		36
2	Al	0,76	0,58	13,1	0	90	41	6	2	1,3	0,8	70		13
3	SdBt	0,17	0,29	5,9	0	164	102	39	25	2,6	1,2	90		43
4	IIBtSd	0,14	0,22	6,4	0	156	118	63	34	2,0	1,9	64		61

No.	hor.	Ti o/oo c silt	Zr o/oo c silt	Ti: Zr	% fsp	c qu	silt mi	qu: fsp	H me/kg*)	Al me/kg*)
1	Ah	2.3	.44	4.4	9.1	87	4.3	9.6	7	6
2	Al	2.1	.43	4.9	10.7	84	5.0	8.0	2	29
3	SdBt	2.0	.37	5.5	10.2	86	3.9	8.5	2	33
4	IIBtSd	1.9	.35	5.5	8.7	89	2.3	10	6	11

*) NH_4Cl-extr.

Micromorphological Description

SdBt: Incomplete angular blocky with some cracks and irregular pores, small round passages frequent, some fine roots, matrix brown with large dark brown and light grey mottles (diffuse boundary), abundant laminated clay coatings, partly alternating with blackish brown oxide segregations (transition to irregular concretions with sharp boundaries).

IIBtSd(Riss-loess): Incomplete prismatic fine irregular to round pores rare, some passages (partly refilled with silt and clay coatings), fine roots rare, matrix brown to light brown with dark greyish patches around large cracks, abundant laminar clay coatings in pores, channels and cracks, partly alternating with bleached silt laminae, in some cracks alternating with blackish brown oxide segregations, those also as small patches with crenellated boundary (partly with root channels in the center).

Distribution of clay coatings:

L1, 40 cm:	matrix 85%; coatings 16%, of which	59% in round pores (22 thin)
		26% in long pores (22 thin)
	without relation to pores	15%
" 85 " :	matrix 91%; coatings 9%, of which	58% in round pores (19 thin)
		20% in long pores (7 thin)
	without relation to pores	22 %
L2, 10 cm:	grains of laminated clay skins without relation to pores, rare	
" 45 " :	matrix 86%; coatings 14%, of which	51% in round pores (17 thin),
		32% in long pores (9 thin)
	without relation to pores	17%
" 90 " :	matrix 80%; coatings 20%, of which	27% in round pores (11 thin)
		20% in long pores (13 thin)
	without relation to pores	53%
L3, 115cm:	matrix 88%; coatings 12%, of which	17% in round pores (all thin)
		41% in long pores (17 thin)
	without relation to pores	42%
" 185 ":	matrix 87%; coatings 13%, of which	27% in round pores (7 thin)
		38% in long pores (11 thin)
	without relation to pores	35%

Site Description

Location: North of Westernbach, Kreis Hohenlohe: Roman fortification ("Limes 2")

Elevation: 324 m

Landform: Flat mountain ridge

Vegetation: Beech forest

Slope: No

Use: Forest

Drainage: Moderate

Soil Temperature: 9,5 °C

Parent material: Loam from Loess

Soil classification; FAO: Eutric Podzoluvisol

German: Pseudogley-Parabraunerde, mäßig entwickelt, Naßphase kurz

US Soil Taxonomy: Aquultic Hapludalf, fine-silty, mixed, mesic

Profile Description

Ah	Ah	0-5	brownish grey (10 YR 4/4), loamy silt (lU), granular to subpolyhedric, many roots, clear boundary
Al	E	-20	light greyish brown (10 YR 7/4), loamy silt (lU), subpolyhedric to polyhedric, some roots, wavy boundary
SwBt	B(g)t	-55	light brown (10 YR 5/6), grey (10 YR 7/2) mottles with ferruginous border, loam to loamy clay (L-LT), polyhedric to prismatic, clay coatings on aggregates, few large blackish-brown concretions, few roots, smooth transition
BtSd	Bgt	-90	as before, but more mottles, prismatic, mottled transition
Bkt	Bcst	-120	dark brown (10 YR 4/4-6)/brownish grey (10 YR 7/2-1) mottled, loamy clay (LT), coarse prismatic, many small blackish brown concretions, clay coatings on aggregates, sharp boundary
RBt	Bt	-180	pieces of dark brown (10 YR 4/4) and light grey (10 YR 7/1) loam (L) with less concretions, clay coatings, sharp boundary
fAl	E	180-215	light greyish brown (10 YR 7/3), loamy silt (lU), subpolyhedric to coherent, few blackish brown concretions, wavy boundary
Bt	Bt	-250	brown (10 YR 5/8), loamy clay (LT), prismatic, clay coatings, smooth transition
BtSd1	Bgt1	-280	brown (10 YR 5/6) with greyish brown (10 YR 7/3) cracks and fissures, loam to loamy clay (L-LT), prismatic, clay coatings, many small blackish brown concretions, smooth transition
BtSd2	Bgt2	-305	as before

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ah	0-5	0				2,5	33,7	27,2	9,0	69,9	27,6	924,5	
2	Al	-20	0				1,9	32,9	31,9	8,3	73,1	25,0	2393,0	
3	SwBt	-55	0				1,4	29,7	30,5	8,3	68,5	30,1	328,3	
4	BtSd	-90	0				0,8	30,4	23,3	7,8	61,5	37,7	276,5	
5	Bkt	-120	0				1,3	35,9	24,9	6,6	67,4	31,3	509,8	
6	RBt	-180	0				2,0	35,4	26,7	8,0	70,1	27,9		
7	fAl	-215	0				2,2	41,5	24,0	8,5	74,0	23,7		
8	Bt	-250	0				1,4	38,7	19,3	8,0	66,0	32,6		
9	BtSd1	-280	0				1,1	38,4	17,9	8,2	64,5	34,4		
10	BtSd2	-305	0				0,7	34,4	24,7	7,8	66,9	32,4		

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	Ah	1,24	53,2	52,7	43,0	34,8	11,8	4,4	3,9	11,5	2,7	0,23	255	3,4
2	Al	1,31	51,5	51,4	35,2	29,8	13,3	4,6	3,9	19,5	2,1	0,11	255	<1
3	SwBt	1,44	47,3	44,6	36,9	32,4	15,2	5,1	4,2	17,5	1,1	0,06	325	<1
4	BtSd	1,53	44,0	42,2	36,2	32,1	14,8	5,6	4,5	14,0	2,4	0,17	325	7,3
5	Bkt	1,45	46,7	46,7	41,3	36,2	17,2	5,7	4,5	16,5	3,0	0,18	370	15,1
6	RBt	1,40						5,5	4,4	16,0	2,7	0,17	420	2,1
7	fAl	1,45						5,6	4,3	9,0	2,8	0,31	550	2,8
8	Bt	1,45						5,8	4,5	17,0	2,7	0,16	390	13,2
9	BtSd1							5,7	4,8	18,0	3,1	0,17	425	16,0
10	BtSd2							6,1	5,0	19,5	3,3	0,17	400	13,8

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	$CaCO_3$ %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	Mg	K	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ah	2,01	1,49	13,5	0	133	86	14	4	3,0	1,7		106	18
2	Al	0,67	0,59	11,4	0	143	128	34	10	2,1	1,7		125	28
3	SwBt	0,17	0,29	5,9	0	184	115	56	33	2,3	1,8		76	55
4	BtSw	0,12	0,25	4,8	0	155	134	80	46	2,4	1,9		44	75
5	Bkt	0,13	0,24	5,4	0	161	145	88	46	3,8	2,1		60	70
6	RBt	0,13	0,23	5,7	0	126	79	38	28	2,9	2,6		64	54
7	fAl	0,15	0,19	7,9	0	85	57	24	13	1,1	2,9		44	48
8	Bt	0,12	0,23	5,2	0	163	122	74	34	2,8	4,2		53	69
9	BtSd1	0,11	0,24	4,6	0	146	144	95	40	2,4	3,9		35	57
10	BtSd2	0,11	0,24	4,6	0	137	148	95	46	2,3	3,7		31	83

No	hor.	depth cm	sand fsp	sand qu	sand gl	sand	c silt fsp	c silt qu	c silt gl	c silt qu:fsp	clay Kao	clay Ill X	clay Mont X	clay Chl
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ah	0-5									17	25 25		21 12
2	Al	-20									17	25 25		25 8
3	SwBt	-55									17	25 25	4	21 8
4	BtSd	-90									17	25 25	8	17 8
5	Bkt	-120									17	25 25	8	17 8
6	RBt	-180									17	26 26	5	17 9
7	fAl	-215									17	21 29		21 12
8	Bt	-250									17	25 25	8	17 8
9	BtSd1	-280									17	25 25	8	17 8
10	BtSd2	-305									17	25 25	8	17 8

No	hor.	depth cm	c silt fsp	qu	gl	qu:fsp	Ti c ‰	Zr silt ‰	Ti: Zr	NH4Cl me/kg H	Al
1	Ah	0-5	18,7	77,1	4,2	4,2	2,19	0,49	4,50	21	42
2	Al	-20	17,6	76,1	3,2	4,3	2,20	0,44	4,97	24	56
3	SwBt	-55	17,6	79,8	2,6	4,6	2,04	0,38	5,37	0	29
4	BtSd	-90	15,5	82,9	1,6	5,4	1,96	0,34	5,83	0	4
5	Bkt	-120	22,5	71,4	6,1	3,2	2,28	0,38	6,04	1	4
6	RBt	-180	20,0	77,9	2,1	3,9	2,24	0,41	5,45	1	6
7	fAl	-215	20,2	74,8	5,0	3,7	2,16	0,45	4,83	8	8
8	Bt	-250	18,9	73,1	8,0	3,9	2,31	0,37	6,17	0	8
9	BtSd1	-280	20,3	75,3	4,4	3,7	2,18	0,35	6,24	0	4
10	BtSd2	-305	23,2	71,4	5,4	3,1	2,16	0,35	6,09	0	2

Micromorphological Description

Al: Incomplete subangular blocky with fragments of clods due to Roman raising of rampart, with some irregular pores within the peds, passages rare, organic matter (sperical seed-grains) rare, some pieces of charcoal, rare roots, matrix greyish brown with dark grey and yellowish brown isolated patches, the latter including rare fragments of clay coatings (mostly laminar), some blackish brown cellular oxide concretions (iron/manganese) with light brown margin (diffuse to clear boundaries), some oxide segregations with crenellated boundaries.

SwBt (below 45 cm depth): Incomplete angular blocky with some fragments of clods, some irregular pores, passages (wormholes with fillings from the Ah) rare, rare roots but frequent round passages with smaller size, matrix brown with light brown patches, abundant laminated clay coatings (crescentic in pores and parallel along cracks and root channels), some of them obviously relictic (without relation to pores; see table before), some segregations of iron oxide with clear crenellated boundaries.

BtSd (90 cm): Incomplete angular blocky with large fragments of clods (with diffuse to clear boundaries), some cracks and few irregular pores, passages rare, rare pieces of charcoal, matrix greyish brown, in the fragments light bluish grey and brown mottled, abundant laminated clay coatings (as before), some small cellular oxide concretions and larger segregations (partly along cracks).

Site Description

Location: North of Westernbach, Kreis Hohenlohe; Roman fortification ("Limes 3")

Elevation: 321 m

Landform: Flat mountain ridge **Vegetation:** Beech forest with ash trees

Slope: No **Use:** Forest

Drainage: Strongly impeded **Soil Temperature:** 9,5 °C

Parent material: Colluvium from Loess

Soil classification; FAO: Eutric Planosol

German: Grauer Pseudogley, stark entwickelt, Naßphase lang

US Soil Taxonomy: Typic Ochraqualf, fine-silty, mixed, mesic

Ah	Ah	0-20	dark brownish grey (10 YR 3/4), loamy silt (lU), granular to subpolyhedric, many roots, smooth boundary
SwAl	E(g)	-55	light greyish brown (10 YR 7/2-3) with ferruginous mottles, loamy silt (lU), subpolyhedric, few roots, smooth transition
AlSw1	Eg1	-90	light grey (10 YR 7/2) brown (10 YR 5/6) mottled, loamy silt (lU), subpolyhedric, patches of charcoal, mottled transition
AlSw2	Eg2	-115	greyish brown (10 YR 5/4) with light grey (10 YR 7/2) and brown (10 YR 5/8) mottles, silty loam (uL), subpolyhedric, few blackish brown concretions, mottled transition
BtSd	Btg	-130	brown (10 YR 6/4) with darker (10 YR 5/8) mottles, loam to loamy clay (L-LT), subpolyhedric to polyhedric with clay coatings, few concretions, layer of charcoal at the base, sharp boundary
Sd1	Bg1	-160	brown (7.5 YR 5/8), grey (10 YR 7/2) mottles with ferruginous border, loam to loamy clay (L-LT), polyhedric to coherent, clay coatings on aggregates, few blackish brown concretions, clear boundary
Skd	Bcsg	-180	light brown (10 YR 6/8)/greyish brown (10 YR 6/4) mottled, with darker ferruginous border, loam to loamy clay (L-LT), coherent, clay/ferruginous coatings on cracks, many blackish brown concretions, clear boundary
Sd2	Bg2	-205	dark brown (7.5 YR 4/6), light grey (2.5 Y 7/1) inclined bands, loam to loamy clay (L-LT), coherent, few concretions, sharp boundary
fBtSd	Btg	-240	brown (7.5 YR 5/8), light grey (2.5 Y 7/1) vertical cracks with ferruginous border, loam to loamy clay (L-LT), coarse prismatic to coherent; the trench is marked by a ferruginous band (hardpan) at 20 to 40 cm distance from the border

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ah	0-20	0				3,3	37,4	30,9	10,0	78,3	18,4	1624,3	
2	SwAl	-55	0				1,2	40,4	30,3	7,2	77,9	22,9	198,7	
3	AlSw1	-90	0				2,1	40,4	28,5	7,0	75,9	21,9	121,0	
4	AlSw2	-115	0				1,2	31,4	29,9	9,2	70,5	28,4	146,9	
5	BtSd	-130	0				1,3	33,9	28,7	8,0	70,6	29,4	164,2	
6	Sd1	-160	0				1,4	35,9	24,5	8,3	68,7	28,9		
7	Skd	-180	0				1,4	29,9	26,2	8,3	64,4	34,2		
8	Sd2	-205	0				1,0	32,0	26,6	9,7	68,3	30,7		
9	fBtSd	-240	0				0,7	26,5	18,6	6,8	51,9	47,4		

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	Ah	0,91	65,1	57,0	43,0	37,0	17,4	6,1	5,9	12,5	3,9	0,31	925	7.6
2	SwAl	1,37	49,1	46,7	38,8	32,6	11,2	6,8	5,9	16,0	2,9	0,18	205	5,3
3	AlSw1	1,38	48,9	46,2	38,2	32,6	9,2	6,2	5,3	13,3	4,2	0,32	500	3,0
4	AlSw2	1,46	46,9	46,9	40,9	36,0	16,2	5,7	4,8	12,3	8,0	0,65	900	20,5
5	BtSd	1,50	45,1	44,8	39,6	35,3	16,6	5,5	4,6	14,0	13,0	0,93	275	
6	Sd1	1,52						5,5	4,5	17,5	7,0	0,40	250	
7	Skd	1,47						5,4	4,4	18,0	8,8	0,49	675	
8	Sd2	1,55						5,5	4,4	17,0	4,4	0,25	135	
9	fBtSd	1,54								17,8	8,0	0,45		

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	$CaCO_3$ %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	Mg	K	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ah	3,31	2,48	13,3	0	167	151	139	8	2,3	1,2	40		79
2	SwAl	0,45	0,50	9,0	0	97	77	67	8	1,1	1,3	17		82
3	AlSw1	0,34	0,34	10,0	0	93	86	80	4	1,0	1,3	24		78
4	AlSw2	0,30	0,44	6,8	0	83	94	76	15	1,8	1,4	42		69
5	BtSd				0	136								
6	Sd1				0	150								
7	Skd				0	162								
8	Sd2				0	182								
9	fBtSd				0									

No	hor.	depth cm	c silt fsp	c silt qu	c silt gl	c silt qu:fsp	Ti c silt ‰	Zr c silt ‰	Ti: Zr
1	Ah	0-5	22,0	73,2	4,0	3,3	2,11	0,46	4,62
2	SwAl	-55	21,1	73,5	2,1	3,5	1,94	0,40	4,79
3	AlSw1	-90	19,8	70,5	9,7	3,6	2,00	0,40	5,01
4	AlSw2	-115	18,9	73,6	7,5	3,9	1,99	0,43	4,65
5	BtSd	-130					2,10	0,44	4,80
6	Sd1	-160					2,03	0,42	4,84
7	Skd	-180					2,02	0,47	4,31
8	Sd2	-205					2,10	0,48	4,34
9	fBtSd	-240					2,25	0,47	4,82

Micromorphological Description

BtSd (below 115 cm depth): Incomplete subangular blocky to massive with some irregular pores and cracks, small leaf fragments and charcoal rare, matrix light (greyish) brown, marginal turning into dark greyish brown (mottles with diffuse boundary) and bluish grey with diffuse to clear boundaries, frequent laminar clay coatings (crescentic in pores and parallel along cracks and root channels, frequently alternating with silt laminae, some of them relictic (without relation to pores; see table before), some brown to blackish brown oxide segregations (partly on cracks).

Sd2 (185 cm): Complete angular and rounded subangular blocky with sharp boundaries, frequent cracks and irregular to round pores, matrix brown, light grey and (along cracks) bluish grey with diffuse boundary, turning to greyish brown (mottles), frequent laminated clay coatings (as before), on cracks together with brown to blackish brown oxide segregations (those also in small patches with crenellated boundaries).

Sd2 (200 cm): Incomplete angular blocky with some cracks, matrix brown (fragments of clods due to erosion of Roman rampart) and greyish brown, along cracks greyish brown and bluish grey with diffuse boundaries, less developed clay coatings and isolated fragments, some segregations and large cellular concretions of iron/manganese oxides.

Interpretation

Parent material in the ancient foreland and below the rampart moderately dense (probably marly and illitic) loamy silt (loess of Würmian age underlain by Riss-loess, probably with Eemian soil formation). Deep leaching of carbonates (if originally present); depletion of bases moderate in the actual and weak in the buried profile, possibly by addition from the overburden. Due to lack of C-horizons formation of iron oxides and clay uncertain (but probably the case, mottling and formation of concretions not shown in the data). Clay translocation more pronounced in the actual than in the buried profile. - Accumulation of only 11.9 kg org. matter/m^2 of mull-type with average C:N of 12.3 (humus scarcely preserved in the buried profile). - Presumably dense parent material segregated into prisms to polyhedra in the subsoil, leading to a moderate permeability (in horizon 3 to an unexpectedly high porisity), and aggregated to crumbs in the loose topsoil with a very high permeability. - Rooting depth in the actual profile 70 cm; available field capacity and air capacity until 80 cm 208 and 162 l/m^2 respectively, thus moist and - except for short periods - well aerated. Reserves of N with 483 g/m² moderate with presumably medium availability. The same applies probably to P and K, thus trophic character moderate to poor (exchangeable Al exceeding Ca in horizon 2). Liming and uptopping of P reserves may be advisable already for good timber production, would be necessary for farming.

Parent material of the rampart profile former soil material with ± upside down orientation of qu:fsp and mica contents, but not of base saturation. Contents of iron oxides and clay resemble those in the buried profile; concretions may be "lithogenic", as well as some mottles and argillans (especially in horizon 4 more than 50% without relation to pores); but obviously also mottling and clay translocation after deposition of the material occurred. - Accumulation of only 7.8 kg org. matter/m² of mull-type with average C:N of 8.7 - Presumably loose parent material (with some lump pieces still to be seen) condensed by settling, and segregated to prismatic structure with lower porosity and permeability than in the sedentary soil (surface horizon influenced by visitors). - Structure-bound site properties (especially air capacity, 85 l/m²) less favourable than in the sedentary soil, trophic properties similar (N, Al) or slightly better (P, K).

Parent paterial of the trench profile mainly material eroded from the rampart (demolition of fortification documented by charcoal 2 from palisade-oak, whereas charcoal 3 is not from oak). Profile does not exhibit a reverted upside down effect in the distribution of weatherable minerals or in the base saturation, has similar iron oxide, slightly higher silt and lower clay contents than the rampart. Decreasing clay contents in the deposits may correspond with increasing lessivation in the rampart, but some clay was translocated in situ. The same applies to the formation of mottles (whereas the concretions may be "lithogenic") and definitely to that of the iron-pan outside the trench. - Accumulation of 18.9 kg org. matter/m² of mull-type with average C:N of 11.6. - Presumably loose parent material (fragments of clods visible in thin-section) condensed by settling and only weakly segregated, even less permeable than the wall profile. - Structure-bound site properties similar to those in the sedentary soil, except for a lower air capacity (107 l/m²) and longer periods of poor aeration. Trophic properties better (818 g N/m², but availability presumably lower), especially more available P, less exchangeable Al (but also much less K).

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Roman fortification ("Limes 3")

No	hor.	depth cm	minerals in % sand fsp	qu	gl		c silt fsp	qu	gl	qu:fsp	clay Kao	Ill X	Mont X	Chl
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ah	0-20									17	25 25	4	12 17
2	SwAl	-55									17	25 25	4	12 17
3	AlSw1	-90									17	25 25	4	17 12
4	AlSw2	-115									17	25 25	8	17 8
5	BtSd	-130									17	25 25	8	17 8
6	Sd1	-160									17	25 25	8	17 8
7	Skd	-180									17	25 25	8	17 8
8	Sd2	-205									17	25 25	8	17 8

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Exkursion A, 4th day

Landscapes and Soils of the Odenwald and the Rhine Valley

by H.-P. Blume[1) and K. Stahr[2)

Route description:

Heidelberg: lies on the eastern margin of the Upper Rhine Rift Valley (Oberrhein-Graben). To the east the route follows the Neckar Valley which is cut into the southern Odenwald. The Odenwald is a mountainous landscape build up from crystalline rocks (granites and gneisses and some porphyres) covered by the lower triassic Buntsandstein. In medieval times numerous castles have been built on the sandstone ridges along the valley.

Neckarsteinach: To the north the small valley of Steinach is followed. The Odenwald is mainly used as a thermophilous broadleaf forest on the lower slopes and on the crystalline rocks (oak, beach, maple, wild cherry ..) Higher up coniferous forest especially on the sandstone slopes predominate (spruce, fir, scotch pine, with some beach). Only the narrow valley bottoms and some hill top plains are used as grassland.

Heiligenkreuzsteinach: Demonstration of soils 4.1-4.3 on the west-facing slope under mixed forest.

1) Institute of Plantnutrition and Soil Science, Olshausenstraße 4o, 23oo Kiel

2) Institute of Ecology- Soil Science, Salzufer 12, 1ooo Berlin 1o

Schriesheim: The winding road lead through the crystalline Odenwald back across the main fault of the Upper Rhine Rift Valley. The south-western foot slopes of the Odenwald are covered with vineyards. The historic road along the Odenwald "The Bergstraße" is famous for the marvellous aspect during the blossom of numerous fruit trees in spring (apples, pears, cherries, plums).

Heddesheim: The Rhine Terrace (upper Würmian) is covered by aeolian loess sediments with Braunerde and Parabraunerde development. Traditionally this area is used for intensive agriculture and horticulture.

Viernheim: The Rhine plain is partly covered by youngest pleistocene to holocene dune sands. Here the highways are bordered by pine forests.

Mannheim-Ludwigshafen: The sistertown is important as a main traffic junction and by it's industry, especially the big chemical plants of BASF.

Frankenthal: The floodplain of Rhine is crossed just north of the mouth of the Neckar. Here wet soil conditions predominate with Auenboden (Fluvisols), Gleyen (Gleysols) and Niedermooren (Eutric Histosols) as typical soils. These silty and clayey, peaty soils have been drained and ameliorated and now are used for intensive agriculture and horticulture.

Grünstadt: The western part of the Upper Rhine Graben is a undulating hilly lowland with regular west-east leading hill crests intersecting by small streamlets. Upon tertiary sands, gravels and marls thick loess covers are sedimented.

Bockenheim: The traditional vineyards are planted on Tschernosems mostly eroded to Pararendzinas or cultivated Rigosols. The eroded soils are colluviated in the valleys and from colluvial Tschermosems and Mollic Gleysols.

(lunchbreak) The area is relatively warm 1o^{o}C and dry 4oo-45o mm/a. The road continues along the western main fault which has no significant geomorphological feature here.

Monsheim Flörsheim: We leave the Upper Rhine Graben and enter the Mainzer Becken which was formed adjoint to the Rhine Graben as a sinking depression in the tertiary (oligocene-miocene).

Alzey: The climatically favoured area (9-1o^{o}C,~5oo mm carries soils from tertiary marls, limestones with a loess cover. The agricultural use is extremly intensive maize, sugar beat, potatoes, wheat and the vineyards are the typical landuse on the slopes (white: Riesling and Müller-Thurgau and red: Burgunder). Alzey is a important town in the central Mainzer Becken. Preroman Foundation 23oo years old since 1277 township. Medieval walls and gates, castle restored 19o4.

Gau-Bickelheim: The Wißberg to the north is formed by oligocene clayey marls and covered by a miocene limestone plateau. It is surrounded by traditional vinegrowing villages.

Wallertheim: The old part of Wallertheim west of the railway station allows to reconstruct the landscape history during the younger pleistocene with phases of fluvial activity, tectonics, soil formation and loess deposition. (Profile 4.4).

Worrstadt Oppenheim: Eastwards we cross the Mainzer Becken until its edge. The Galgenberg serves as a pit for the famous Dyckerhoff-Concrete (from tertiary marls and limestones, upper oligocene-miocene).

Nierstein: Rhine ferry: We enter the flood plain of the Rhine close to the main fault (Profile 4.5)

Hessenaue: Before canalisation of the Rhine a forest and peatland now in agricultural production with loamy, clayey, peaty and gravelly soils (relictic Gleysols, Fluvisols and Eutrophic Histosols).

Mainz: At the mouth of the Main river important roman foundation (Moguntia). Important city during Christianisation of Germans (Bonifatius archbishop of Mainz 748).
Dom and some other medieval churches in the old city center. Today capital of the federal state of Rheinland-Pfalz. (over night stay)

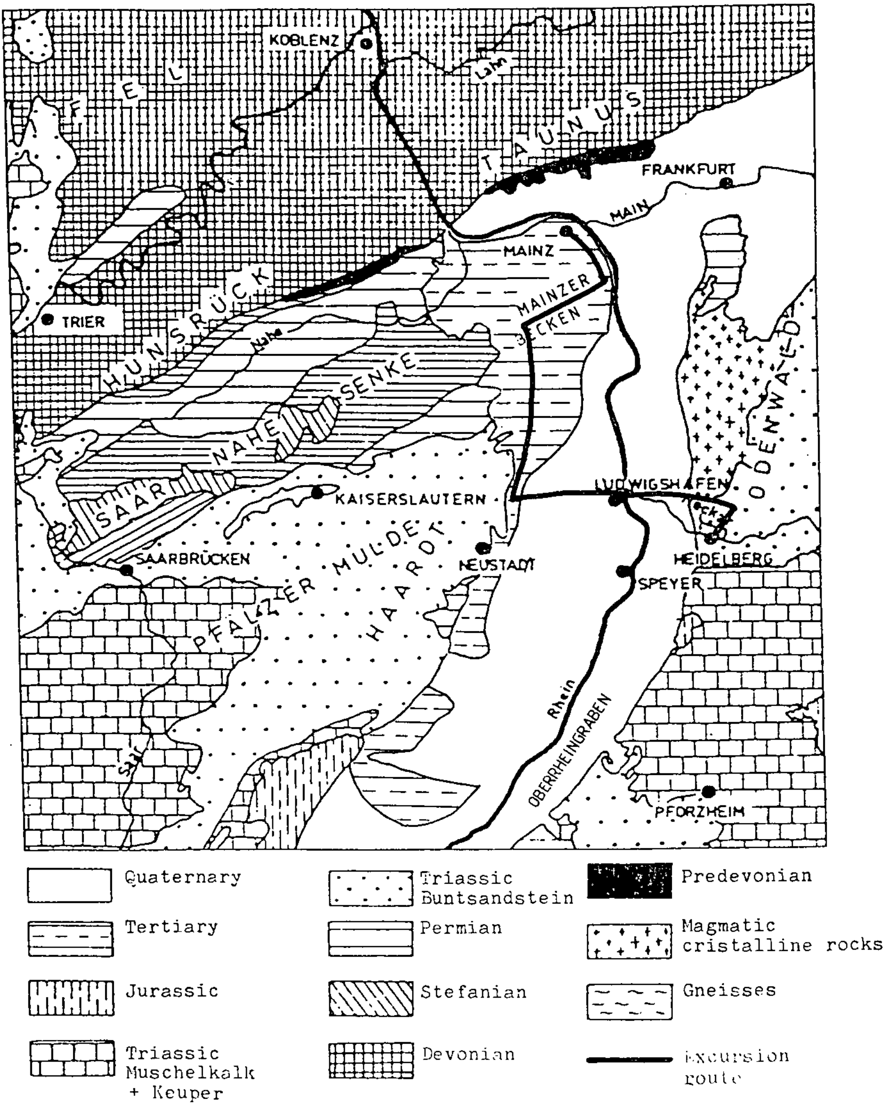

Fig. 1 Generalized geological map of the Upper Rhine Rift Valley and the surrounding areas (after ATZBACH 1970)

Soil near Heiligkreuzsteinach/Odenwald

by H.-P. Blume (Kiel)

The hilly Sandstone-Odenwald is characterized by Cambisols and Podzols. Figure A 4.1 shows a soil catena near Heiligkreuzsteinach. The selected profiles are part of a soil sequence at 300 m O.D. on a slope of 27^{o}, with 950 mm annual rainfall and 7.7^{o} C under conifers and beeches. The soils are formed in solifluction deposits, 2 to 3 m thick, of Young Pleistocene age, which are mixtures of loess and Mesozoic sandstone. They are well-drained, with Podzols on the slopes and Cambisols in shallow slope depressions (see position a - c in figure A 4.1). According to finds of volcanic glass particles by K. Bleich dated in other profiles, the C-horizon (Basisfolge) belongs to the Middle Pleistocene; the remaining part is younger than 60000 years (Würm).

a) Typic Podsol with lessivage (Ferro-Orthic Podzol, Alfic Haplorthod) from (loess)/sandstone-solifluction deposits (4.1)

Ofh	2- 0 cm	Greyish black leaves and litters
Aeh	0- 20 cm	Brownisch black (10YR3/1), bleached sand particles, fine crumb to single grained,loose,very stony sand, common roots, clear boundary
Ae	- 55 cm	Greyish yellow brown (10YR5/2), fine crumb to single grained, loose, very stony sand, few roots, clear boundary
Bh	- 60 cm	Dark reddish brown (5YR3/4), granular with organs, moderately, loose (somewhat cemented), gravelly loamy sand, few roots, clear boundary
Bhs	- 75 cm	Reddish brown (5 YR4/8), granular with sequans (and argillans in thin sections), slightly cemented, moderately loose, gravelly loamy sand, frequent roots, diffuse boundary
Bts	-100 cm	Reddish brown (2.5YR4/6), fine granular with argillans, moderately loose, stony loamy sand, frequent roots, diffuse boundary
IICbtv	-130 cm	Bright reddish brown (2.5YR5/6), single grain, firm, some few mm thick clay pans, very stony loamy sand, rare roots, diffuse boundary
IICv	-250 cm	Reddish orange (10YR5/6), single grain, fragipan, very stony sand, oriented stones, no roots
IIICn	+250 cm	Red (10R5/6) sandstone.

a) Typic Podsol with lessivage

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	Mn_d mg/kg	Pa mg/kg
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
411	Aeh	0- 22	69	1.3	42.6	41.2	85.1	7.4	4.3	2.2	13.9	1.0	10	3.2
412	Ae	- 55	72	2.5	42.6	38.9	84.0	8.1	3.2	2.5	13.8	2.2	10	1.2
413	Bh	- 60	47	2.4	38.8	36.5	77.7	7.1	4.6	4.8	16.5	5.8	15	4.1
414	Bhs	- 75	55	2.8	37.9	32.1	72.8	7.7	4.6	4.0	16.3	10.9	35	2.7
415	Bts	-100	40	2.4	39.8	30.4	72.6	8.0	4.2	3.1	15.3	12.1	32	0.9
416	IICbtv	-130	68	3.0	45.1	36.8	84.9	5.6	3.1	2.3	11.0	4.1	25	0.6
417	Cv	-250	58	4.1	49.7	35.9	89.7	3.4	2.1	2.1	7.6	2.7	25	1.2
418	IIImC	+250		11.7	54.6	31.1	97.4	0.5	0.2	0.1	0.8	1.8		

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Fe_p mg/g	Al_o mg/g
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
411	Aeh	1.62	38	30	21	17	3.3	4.1	2.7	1.00	0.18	0.18	0.11	0.15
412	Ae	2.00	25	18	10	8.0	3.0	4.1	3.1	1.00	0.09	0.09	0.03	0.30
413	Bh	1.46	45	36	21	18	8.5	4.0	3.2	5.20	2.30	0.44	0.74	1.10
414	Bhs	1.58	41	32	21	18	10	4.4	4.0	6.65	3.55	0.53	0.48	5.30
415	Bts	1.61	39	31	21	19	11	4.4	4.1	5.80	2.15	0.37	0.22	4.05
416	IICbtv	2.08	23	17	9.0	8.0	2.3	4.5	4.2	3.80	0.65	0.17	0.09	1.10
417	Cv	1.77	27	21	11	9.6	2.8	4.9	4.2	2.05	0.13	0.06	0.03	0.35

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
411	Aeh	2.00	0.90	22	0	133	51	23	1.9	6.1	1.8	15	3.0	25
412	Ae	0.42	0.19	22	0	43	21	9.0	0.25	1.7	0.20	7.5	2.5	26
413	Bh	1.25	0.47	27	0	115	38	11	0.45	3.5	0.52	20	2.5	13
414	Bhs	1.20	0.49	24	0	75	35	4.6	0.80	1.2	0.35	15	13	9
415	Bts	0.68	0.31	22	0	55	43	4.9	1.12	1.4	0.33	20	15	14
416	IICbtv	0.24	0.08	30	0	40	21	5.4	0.62	1.5	0.31	10	3.0	20
417	Cv	0.06	0.03	20	0	22	12	4.0	0.31	0.9	0.24	5	1.0	25

b) Braunerde-Podsol with lessivage (Spodo-Dystric Cambisol, Dystrochrept) from loess/sandstone-solifluction deposits (4.2)

Aeh	0- 6 cm	Brownish black (10YR3/1), bleached sand particles, fine crumb to single grain, loose,gravelly sand, common roots, clear boundary
Ahe	- 16 cm	Dark brown (10YR3/3), fine crumb to single grain, loose to firm, stony gravelly sand, few roots, clear boundary
Bhs	- 35 cm	Dark reddish brown (7.5YR4/3), granular with sesquans, firm, stony loamy sand, frequent roots, diffuse boundary
Btv	- 60 cm	Reddish brown (5YR4/8), single grain to fine granular with argillans (in thin sections), firm, stony laomy sand, frequent roots, diffuse boundary
B(t)C	-100 cm	Reddish brown (5YR4/6), single grain, firm, very stony sand, rare roots, diffuse boundary
IICbtv	-250 cm	Grey reddish brown (2.5YR5/4), single grain, few mm thick clay pans, very stony sand, orientated stones, partly fragipans, no roots.

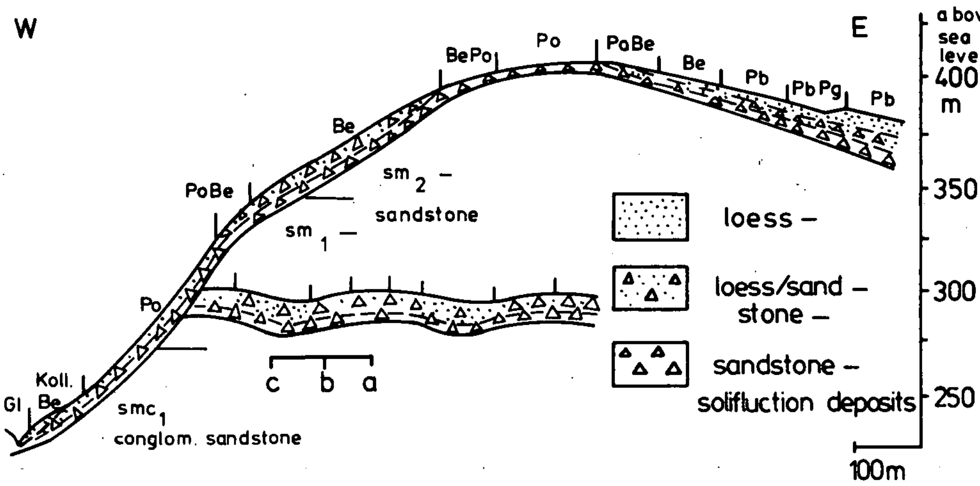

Figure A 4.1: Soil catena of sandstone slopes + loess of the Odenwald near Heiligkreuzsteinach (Be Braunerde (Cambisol), Gl Gley (Gleysol), Pb Parabraunerde (Luvisol), Pg Pseudogley (Stagno-dystric Gleysol) Po Podzol; a - c analyzed soil sequence; after Szabados 1976)

b) Braunerde-Podsol with lessivage

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	Mn_d mg/kg	Pa mg/kg
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
421	Ah	0- 6	13	0.9	32.6	39.7	73.2	10.8	7.5	5.1	23.4	3.4	50	26
422	Ahe	-16	18	1.6	31.6	41.5	74.8	10.4	7.2	3.7	21.3	3.9	22	6.3
423	Bhs	-35	46	1.0	30.4	40.6	72.0	10.6	6.6	4.4	21.6	6.4	35	4.1
424	Btv	-60	46	1.7	31.6	38.0	71.2	10.0	6.4	4.6	21.0	7.8	40	1.8
425	BtvC	-100	59	5.9	36.9	33.9	76.7	12.3	5.5	2.8	20.6	2.7	40	1.0
526	IICbtv	-250	65	5.3	49.4	30.8	85.5	8.0	2.8	1.1	11.9	2.6	42	0.7

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Fe_p mg/g	Al_o mg/g
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
421	Ah	0.94	63	42	32	28	15	3.4	2.5	2.60	0.68	0.26	0.52	0.60
422	Ahe	1.28	51	36	25	21	7.2	3.5	2.6	1.81	0.43	0.24	0.30	0.85
423	Bhs	1.64	38	27	18	16	5.0	3.7	2.9	4.80	2.50	0.52	1.08	1.00
424	Btv	1.64	38	26	17	15	4.9	4.4	4.0	4.20	0.93	0.22	0.44	2.80
425	BtvC	1.83	31	21	14	12	4.0	4.7	4.2	2.70	0.27	0.10	0.10	0.80
526	IICbtv	1.98	25	18	11	7.5	2.0	4.8	4.3	1.90	0.17	0.09	0.06	0.30

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	car-bon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
421	Ah	8.00	4.3	19	0	385	103	53	2.3	9.1	0.61	31	3.0	17
422	Ahe	2.70	1.14	24	0	164	45	16	0.61	7.3	0.42	18	2.5	15
423	Bhs	2.16	0.84	26	0	161	53	11	0.45	5.0	0.48	23	13	11
424	Btv	1.18	0.47	25	0	76	22	4.4	0.45	1.6	0.28	10	5.0	9
425	BtvC	0.24	0.07	34	0	36	25	4.2	0.26	1.0	0.21	12	7.8	14
526	IICbtv	0.16	0.03	53	0	35	27	5.3	0.20	1.4	0.39	10	10	20

c) Basenarme Braunerde (Dystric Cambisol, Dystrochrept) from loess-sandstone-solifluction deposits (4.3)

Ah	0- 7 cm	Brownish black (7.5YR3/1), fine crumb, loose, stony silty sand, few to frequent roots, clear boundary
Bv	- 40 cm	Brown (7.5YR 4/6), fine crumb, loose, stony loamy sand, few to frequent roots, clear boundary
B(k)v	- 80 cm	Grey reddish brown (5YR5/4), fine crumb, loose, some small black concretions, gravelly loamy sand, few roots, diffuse boundary
BvC	-100 cm	Reddish brown (5YR4/4), single grain, moderately loose, loamy sand, few roots, clear boundary
IICv	-120 cm	Reddish brown (5YR4/6), single grain, firm, very stony sand, no roots.

Table A 4.1: Minerals of the clay fraction (< 2 μm Ø) of soils from loess/sand-solifluction deposits

Horizon	depth	kaolinite	illite	Mg- chlorite	Al- chlorite	smectite + interstrat.m.
a) Podzol (4.1)						
Aeh	0- 20	44	11	-	-	45
Ae	- 55	40	14	-	-	46
Bh	- 60	33	17	-	-	50
Bhs	- 75	21	11	-	-	68
Bts	-100	20	12	-	-	68
Cbtv	-130	32	15	-	-	53
IICv	-250	35	37	-	-	28
c) Braunerde (4.3)						
Ah	0- 7	21	11	4	6	58
Bv	- 40	27	5	10	23	35
B(k)v	- 80	34	9	9	12	36
BvC	-100	29	14	12	8	37
IICv	-120	34	24	10	3	29

c) Basenarme Braunerde

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	Mn_d mg/kg	Pa mg/kg
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
431	Ah	0- 7	23	0.8	25.2	33.2	59.2	16.9	11.6	6.1	34.6	6.2	60	13.5
432	Br	-40	14	0.5	22.3	33.5	56.3	17.0	11.2	6.7	34.9	8.8	180	1.2
433	BkV	-80	12	1.3	24.4	31.1	56.8	16.5	11.7	6.3	34.5	8.7	140	0.7
434	BvC	-100	7.5	1.2	26.2	30.9	58.3	16.4	11.4	6.4	34.2	7.5	130	0.4
435	IICv	-120	79	4.2	29.1	32.1	65.4	15.9	9.7	4.2	29.8	4.8	110	0.6

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Fe_p mg/g	Al_o mg/g
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
431	Ah	1.03	60	42	31	27	12	3.6	2.9	5.30	1.75	0.33	1.20	1.05
432	Bv	1.35	48	36	26	22	8.5	4.4	3.9	5.30	1.45	0.31	0.43	1.50
433	Bkv	1.46	45	35	27	22	8.2	4.5	4.0	4.80	1.05	0.22	0.21	1.20
434	BvC	1.58	40	33	28	23	7.9	4.5	4.1	4.60	0.91	0.20	0.15	1.05
435	IICv	2.01	23	19	16	14	4.3	4.5	4.0	4.05	0.58	0.14	0.09	0.50

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
431	Ah	6.10	5.8	11	0	336	100	45	1.7	7.4	1.8	26	18	17
432	Bv	0.92	0.42	22	0	98	47	20	0.9	3.6	0.77	16	55	27
433	Bkv	0.36	0.17	21	0	64	43	20	0.9	3.4	0.81	13	2.5	39
434	BvC	0.20	0.16	13	0	56	27	16	0.6	2.2	0.78	5.0	2.5	35
435	IICv	0.16	0.07	23	0	45	19	11	0.4	2.2	0.55	2.5	2.5	32

Genesis and Ecology

Solifluction deposits are the parent material of the three soils. The lower solifluction deposits (IIC) are free of loess and glasses of volcanic origin; they are therefore more than 60000 years old, perhaps Riß aged. The upper solifluction deposits contain loess (identified by the presence of picotite and almandine garnet, which are typical minerals in deep loess deposits from other localities), and volcanic glasses of about 60000 years b.p. (identified by K.E. Bleich); they were formed during the Würm glaciation therefore.

The Ah horizon of the Braunerde seems to be formed from a late glacial loess. The upper solifluction deposits of the Podzol contain 5 - 10 % of loess (calculated after the silt contents), the Braunerde-Podzol 8 - 15 %, and the Braunerde 25 - 30 %.

We think that differences in clay content between the A and B horizons of the Podzols are mainly caused by **lessivage**, because the fine earth apears to be homogenous in these horizons, and thin sections show strong clay orientation in the Bts horizon. The clay was partly transported into the C horizon, and accumulated in form of thin clay pans. There was nearly no lessivage in the Braunerde, perhaps because the content of primary coarse pores is lower, and secondary pores did not form. **Podzolisation** becomes more evident in the profiles as their loess content decreases. The strong lessivage in profile a is taken as evidence of podzolisation, because under these circumstances perched water flows laterally in the A horizons. Al and Mn moved further down in the Podzols than Fe; in the Braunerde only Mn was translocated.

The lower solifluction deposits are very dense (partly fragipan) and hardly penetrable by roots therefore. The available water capacity (pF 1.8-4.2) of the roots zone arises from the Podzol with 110 mm to the Braunerde-Podzol with 123 mm, and the Braunerde with 185 mm. The soils are extremely acid, have low contents of available nutrients. The nutrient reserves of the root zones are smaller for the Podzol than the Braunerde because the former contains more stones and less loess.

Soil near Wallertheim

by H.-P. Blume (Kiel)

Location: NW-side of the brick ditch of Hofmann & Co. in Wallertheim, 135 m O.D., 2^{o} NE-slope
Climate : 520 mm annual rainfall, 9^{o} C

Tschernosem of the Rhine valley (Haplic Kastanozem, Typic Hapludoll) from loess under field ridge

Ap	0- 30 cm	Dark brown (10YR3/3, crumb, loose, some small carbonate concretions, silt loam, abundant roots, clear boundary
Ah	- 57 cm	Brown (10YR4/3), crumb to subangular, loose, pseudomycels, carbonates, silt loam, frequent roots, gradual boundary
AhC	-100 cm	Yellowish brown (10YR5/3), crumb to subangular, firm; carbonates, partly as pseudomycels and concretions, some crotowines, loamy silt, gradual boundary
Ccv	-170 cm	Dull yellowish orange (10YR6/3), coarse subangular to coherent; carbonates partly as pseudomycels and concretions, loamy silt, clear boundary
fAh	-185 cm	Yellowish brown (10YR5/3), coherent, carbonate concretions, loamy silt, clear boundary
C	-200 cm	Dull yellowish orange (10YR6/3), coherent, firm, carbonates, loamy silt.

Table A 4.4: Minerals of the clay fraction (2 um 0) of a Tschernosem from loess in %

Horizon	depth cm	kaolinite	illite	Mg- chlorite	Al- chlorite	vermiculite	smectite	stratified m.
Ap	0- 30	12	25	7	7	8	14	27
Ah	- 57	12	22	8	5	7	25	21
AhC	-100	13	20	7	4	7	34	15
Ccv	-170	14	19	8	4	9	33	13
fAh	-185	16	25	8	2	7	26	16
C	-200	16	24	8	2	6	26	18

Tschernosem of the Rhine valley

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	Mn_d mg/kg	Pa mg/kg
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
441	Ap	0- 30	0	2.8	5.2	17.1	25.1	33.9	16.7	6.6	57.2	17.7	480	14.9
442	Ah	- 57	0	1.7	3.3	15.6	20.6	35.5	18.7	7.7	61.9	17.5	390	7.1
443	AhC	-100	0	0.1	0.4	8.4	8.9	43.4	23.1	8.0	74.5	16.6	200	1.7
444	Ccv	-170	0	0.1	0.2	8.3	8.6	47.8	23.7	7.4	78.9	12.5	200	1.1
445	fAh	-185	0	.03	0.1	5.1	5.5	53.0	21.6	5.7	80.2	14.3	230	1.0
446	C	-200	0	0	0.1	8.0	8.1	54.3	21.1	5.3	80.7	11.2	200	1.1

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Fe_p mg/ g	Al_o mg/ g
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
441	Ap	1.07	60.4	47.9	32.2	28.3	13.8	8.2	7.1	6.50	0.84	0.13	0.02	0.75
442	Ah	1.24	54.1	44.2	30.3	27.7	12.2	8.5	7.4	6.35	0.59	0.09	<.01	0.75
443	AhC	1.37	49.3	44.3	38.1	36.2	10.8	8.3	7.6	5.60	0.39	0.07	<.01	0.75
444	Ccv	1.36	49.6	43.6	39.2	35.8	8.0	8.2	7.6	5.65	0.43	0.08	<.01	0.70
445	fAh							8.3	7.6	5.65	0.61	0.11	<.01	0.75
446	C							8.2	7.6	6.10	0.34	0.06	0.01	0.35

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	car-bon %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
441	Ap	2.00	1.23	14	14.8	172		150	1.76	7.4	0.65	12		92
442	Ah	0.90	0.71	13	15.2	155		133	1.88	6.5	3.4	10		93
443	AhC	0.46	0.29	14	25.3	128		118	0.78	6.6	2.0	0		100
444	Ccv	0.25	0.18	14	22.7	112		102	0.96	7.3	1.4	0		100
445	fAh	0.50	0.31	16	16.2	120		109	0.91	8.1	1.8	0		100
446	C	0.13	.08	14	19.5	105		94	0.91	8.0	2.3	0		100

Interpretation

In the brickworks pit mighty loess deposits are exposed. They cover the residual Weisbach Terraces over Oligocene sandy marl. The loess profile contains several fossile Chernozems. The recent soil has formed on Late Würm (=Weichselian) loess.

The thick humus-rich A-horizon and the occurrence of krotovines are indicative of a steppe soil. It may have formed during the Pre-Boreal or Boreal Period. Since until today the climate has been relatively dry and warm, and the site has been tilled for a long time, it is not degraded during thousands of years.

Intense bioturbation, humus accumulation and carbonate depletion are the predominant soil forming processes here. In the topsoil some of the smectites seem to have been transformed into Al-Chlorite. The soil has a great rooting depth. Available water capacity is high (210 mm in the top meter), it is well aerated and has high nutrient reserves.

Soil near Nierstein

by H.-P.Blume, B.Meyer and K.Stahr

Profile Description

Horizon German	FAO	Depth (cm)	Description
Ah	Ah	o-lo	dark grey brown, crumb structure, loose, frequent roots, moderate lime content earthworm holes and root channels, gradual boundary
AM	AB	lo-18	grey brown, crumb structure, loose, frequent roots, moderate lime content, earthworm holes and root channels, gradual boundary
M_1	Bw_1	18-45	-, crumb structure, loose to slightly hard, some roots,moderate lime content, earthworm holes and root channels, gradual boundary
M_2	Bw_2	45-65	-, crumb to weak subangular blocky,slightly hard, some roots, moderate lime content, earthworm holes and root channels, gradual boundary
M_3	Bw_3	65-95	-, subangular blocky, slightly hard, some roots, moderate lime content, few rusty spots of iron oxides and concretions, earthworm holes and root channels
M_4	Bw_4	95-12o	-, subangular blocky, loose, some roots, moderate lime content, frequent rosty spots of iron oxides along root channels, earthworm holes, fluviatile shell fragments, abrupt boundary
fAh	bAh	12o-14o	-, coherent to subangular blocky, slightly hard, some roots, moderate lime content, frequent rusty spots along root channels, earthworm holes, fluviatile shell fragments, gradual boundary.
Go	Bg	14o-162	-, subangular blocky, slightly hard, few roots, moderate lime content, frequent rusty spots along root channels, earthworm holes, fluviatile shell fragments, abrupt boundary
Gr	Cr	162- > 2oo	-, coherent to single grained, loose, no roots, moderate lime content, reduced matrix, groundwater table, 11th April 1985 at 235 cm.

Kalkvega

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d
1	Ah	o-1o	o										78o
2	MAh	-18	o										4oo
3	M 1	-45	o										2o8
4	M 2	-65	o										73
5	M 3	-95	o										15
6	M 4	-12o	o										-
7	fAh	-14o	o										2
8	Go	-162	o										6
9	Gr	-18o	o										46o

No	cm	bulk dens. g/cm³	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH $CaCl_2$	pH H_2O	Fe_d mg/g	Fe_o mg/g	Fe_o/Fe_d	Mn_o mg/g	P_a mg/g
1a	2,5	0,81	68,5	58,9	41,1	34,6	13,9	>7,2	>7,1	6,o	1,5	0,26	o,39	o,2o
2a	12	1,26	52,4	52,o	41,2	36,2	16,7	"	"	5,9	1,6	0,28	o,39	o,3o
3a	32	1,5o	43,6	43,6	34,6	31,1	18,9	"	"	5,9	1,6	0,26	o,36	o,29
4a	62	1,47	43,4	42,8	34,4	3o,6	18,8	"	"	6,3	1,6	o,25	o,41	o,27
5a	82	1,43	46,o	46,o	42,o	4o,4	3o,4	"	"	9,5	1,7	o,17	o,67	o,60
6a	112	1,44	45,8	45,8	42,5	39,7	27,4	"	"	7,7	1,2	o,15	o,9o	o,58
7a	132	1,49	44,o	44,o	43,6	42,o	22,8	"	"	7,9	1,7	o,21	o,59	o,57
8a	162	1,56	41,2	41,2	4o,6	38,7	19,8	"	"	8,3	o,7	o,o8	o,3o	o,21
9a	192	1,54	42,2	41,5	16,o	1o,5	2,7	"	"	o,6	o,2	o,28	o,o4	o,o2

No	hor.	$C_{org.}$ mg/g	N_t mg/g	C/N	carbonate mg/g	CEC_p meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1b	Ah	2,91	2,7	11,8	15,9	213	192	5,6	15,7	o,1	o		1oo
2b	MAh	2,15	2,1	1o,2	18,o	198	182	2,6	13,2	o,4	o		1oo
3b	M 1	1,22	1,3	9,4	18,7	15o	136	1,5	11,5	o,7	o		1oo
4b	M 2	1,1o	1,2	9,2	18,7	141	128	2,3	9,7	o,8	o		1oo
5b	M 3	1,23	1,3	9,5	12,o	234	2o6	1,4	24,5	2,o	o		1oo
6b	M 4	o,83	1,o	8,6	18,8	219	19o	1,3	25,5	2,2	o		1oo
7b	fAh	1,o5	o,9	11,8	16,o	235	214	2,1	16,3	3,o	o		1oo
8b	Go	o,66	o,5	13,2	24,9	142	127	1,5	9,7	2,6	o		1oo
9b	Gr	o,13	o,1	22	5,o	42	39	o,5	2,3	o,1	o		1oo

Location: Rhine floodplain about 5oo m from rhineferry at Nierstein direction to Groß-Gerau.

Parent material: Loam of holocene fluviatile origin

Relief: flat levelled plain with slight inclination NE towards a depression. Old rhine mäanders, diked.

Vegetation: Grassland (Glatthaferwiese) with willow trees

Landuse: No landuse, earlier pasture

Soil classification: German: Allochtone Kalkvega
FAO : Fluvic Eutric Cambisol
USDA : Fluventic Eutrochrept

Interpretation of Kalkvega Nierstein

The soil is comperatively young and has developed from seasonal sediments of the Rhine. Since about 13o years the Rhine is diked and the sedimentation stopped (relictic floodplain). The sediments here have been medium to fine textured mainly containing eroded materials from the loess hills and the tertiary claystones. The sedimentation took place the entire holocene period but was much stronger after clear cut and cultivation of the surrounding areas (mainly since 1o.-12. century). The clayminerals (not analysed here) are generally inherited from the sources and are dominated by illites and smectites. Although the river is diked the high fluctuation of groundwater (more than 2,5m) is still present with high levels generally in march and april and low in september and october. The mixed mineralogy, the loamy texture, the moderate lime content and the good air and water supply are the features, which guarantee an extremly high biological activity.

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Excursion A, 5th day

Soils Excursion through Central Hesse

by

T. Harrach, E. Schönhals, H.-R. Wegener*, and H.-J. Altemüller**

Route description:

1. Start of the excursion in Mainz at the north-eastern brink of the Rhine-Hessian slates and hills (1).
2. Rhine bridge (85 m a.s.l.): coach trip through the Main-Taunus-Foreland (2) which constitutes the passage between the relatively wooded Lower Main Plaines in the south (right side of driving direction) - 90 to 130 m a.s.l.-and the Taunus in the north.
   The Main-Taunus-Foreland is a moderately undulated loess landscape with Luvisols and eroded soils; in the ground Tertiary marls, limes, sands, and gravels which are partly covered by Pleistocene deposits of Rhine and Main; climate: about 9 °C annual temperature and an average precipitation of approx. 650 mm; intensive agricultural use with sugar beets and grain, fruit and partly vini culture; dense settlement.
3. Autobahn journey Wiesbaden-Erbenheim (150 m a.s.l.): coach trip on the Autobahn Wiesbaden - Frankfurt in eastern and north-eastern direction.
4. Autobahn intersection Wiesbaden (158 m a.s.l.): on the left hand side wooded hill ranges of the Taunus (Rhenish Massif) - up to 410 m a.s.l. - gneisz, greenslate, phyllite, and sand- and claystones of the Lower Permean (Rotliegendes).
5. Autobahn junction Frankfurt-Zeilsheim: on right hand side the chemical plant of Hoechst AG and new residential quarters at the west end of Frankfurt/Main (population of 630,000).
   To the left: the Upper Taunus with Großer Feldberg (880 m a.s.l.), Kleiner Feldberg (826 m), and Altkönig(798 m).

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6. North-eastern junction Frankfurt/Main (110 m a.s.l.): proceeding journey on the Autobahn Basel - Hamburg in northern direction through the north-eastern Main-Taunus-Foreland.

7. Gradual ascent of the range from Autobahn intersection Bad Homburg. Right side of driving direction shows view into the Southern Wetterau.

8. Proceeding ascent of the range; the Autobahn cuts the eastern border of the Upper Taunus: Forested ridge of Lower Devonian quartzites and clay shale (Rhenish Massif).

9. We leave the Autobahn at the junction Friedberg. On the Bundesstraße B 455 near Ober-Rosbach we reach the western border of the Wetterau: undulated, partly hilly, partly flat loess landscape between Taunus and Vogelsberg. The ground consists mainly of Tertiary limnic sediments and locally of basaltic volcanics. The thickness of the loess layer (including loess loam) varies beetween less than 1 m and more than 10 m. Intensive agriculture with sugar beets and grain, relatively small meadows in the valleys, very small forest sheets.

10. Friedberg: with 25,000 inhabitants the largest town of the Wetterau - castle and settlement during the era of the Roman Empire, in the Middle Ages important Reichscastle, from 1257 free Reichstown, Gothic Liebfrauenchurch built 1260 - 1410. A sugar factory was in operation since 1882, but closed in 1981 due to rationalization; since that time the sugar beets have been transported to Groß-Gerau (approx.70 km south of Friedberg).

11. Below the Friedberg castle (165 m a.s.l.) we cross the valley of the river Usa (130 m a.s.l.) and a few km farther east in Dorheim the Wetter valley 127 m a.s.l.).

12. After a short journey in north-eastern direction we reach the Horloff Depression (north-eastern Wetterau), a mostly flat, woodless loess landscape with Phaeozems.
On the left hand side the brown coal power-station Wölfersheim.
South-west of Echzell (see SCHÖNHALS, Fig. 6 in this volume) a short illustration of the brown coal opencast by Mr. Lingemann, mining director. The present soil profile cut resembles profile No. 1.

13. In Echzell inspection of a farmstead (H.G. Eichelmann, s. General View).

14. From Echzell on the Römerstraße in north-western direction to profile No. 1 (see SCHÖNHALS, Fig. 6).

15. Continuing journey along recultivated former brown coal cast area - formerly underground mining, since 1962 opencast only - the range north-west of profile No. 1 has been in agricultural use again since 1969/70.

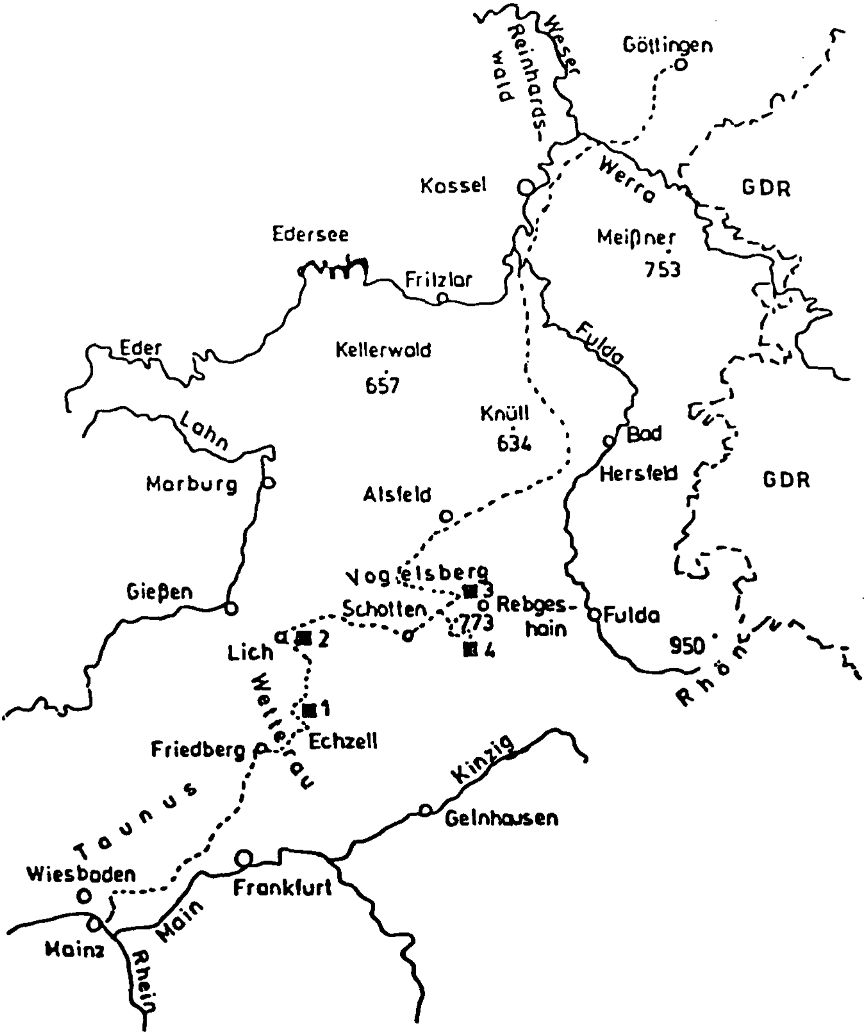

Fig. 1: Route of excursion from Mainz to Göttingen

16. From Berstadt we continue the journey on the B 489 in northern direction to Hungen. Fertile loess soils along the road. On the right hand side the partly forested western border of the Anterior Vogelsberg. Between the road and the edges of the Vogelsberg, a brown coal cast area is situated in a 300 - 600 m wide strip running also in north-south direction with three watersheets ("residual holes"). Near Trais-Horloff we can see an old dump.

General View of the Farm of H.G. Eichelmann

in 6363 Echzell 1

comp.profile No. 1, p. 2o5 ff

Farmland: 45 ha, of which 15 ha are leased land
- 43 ha arable land:
  - 25 ha winter wheat
  - 3 ha winter barley
  - 2 ha rye
  - 3 ha summer wheat
  - 7 ha sugar beets
  - 3 ha corn for ensilage
- 1.7 ha meadows (not arable, moist locations)
- 0.3 ha farmstead

Livestock: 30 bulls

Workers: 1.5

Equipment and buildings: own machines (tractor, combine); old building substance with possibility for grain storage; narrow farmstead typical for the Wetterau, therefore equipment building at the outskirts of town

Yield and artificial fertilization:

winter wheat	60 - 80 dt/ha;	N 120 - 200 kg/ha
winter barley	55 - 75 dt/ha;	N 100 - 160 kg/ha
rye	45 - 55 dt/ha;	N 60 - 100 kg/ha
summer wheat	50 - 65 dt/ha;	N 120 - 160 kg/ha
sugar beets	500 - 600 dt/ha;	N 150 - 200 kg/ha

corn 7000 KSTE/ha (kg starch units); N 200 kg/ha

Annual average of P- and K- fertilizer 90 kg P_2O_5 and 120 kg K_2O per ha

Mean annual consumption of plant protection products 230.- DM per ha.

17. On the west end of Hungen (left hand side) view of a former brickyard: Luvisols and eroded Luvisols from loess over carbonate containing loess (loess and loess loam extending from 2 to over 4 m), underneath periglacial solifluction layers (approx. thickness of 1 m) over decomposed basalt (extending over 5 m).

18. The road Hungen - Langsdorf - Lich is marking the border between the Wetterau (on the left hand side) and the Anterior Vogelsberg (right side): hilly basalt landscape with levelled plains from the Pliocene; loess loam layers of varying thickness; Cambisols from debris layers and Luvisols from loess; re-

lictic soils (mostly Plastosols) and vulcanites (SCHÖNHALS, Fig. 7), and hydromorphic soils; along with the gradual ascent (up to 300 m a.s.l.) increasing precipitation; significant occurrence of ground-water; numerous ground-water reservoirs for the Gießen and Frankfurt area; agriculture producing mainly cereals, while sugar beets are grown in favourable areas only.

19. Lich: small provincial town with 7,000 inhabitants; first mentioned by documents in 788 as village; building of a water castle and founding of town in the 13th century; late gothic church built in the 16th century. Large and famous brewery.

20. Profile No. 2 situated in a former bauxite quarry almost 2.5 km ESE of Lich: red Paleosols (Acrisols) from basalt (SCHÖNHALS, Fig. 7).

21. Continuing journey in north-eastern direction along the valley of the river Wetter (wide valley bottom); in the meadows north-east of Lich (167 - 170 m a.s.l.; Cambisols and Gleysols) a new reservoir for flood control, in the retention area extensive use of meadows and reorganized wetland habitat.

22. Lunch break in a barbecue cabin at the edge of the forest between Lich and Laubach (lunch package).

23. Laubach: small provincial town with an approx. population of 10,000 (including surrounding villages); castle of the Earl of Solms-Laubach: first built as a fortress during the 13th and 14th century, then expanded in the 17th and 19th century; town church with gothic parts of the 13th century.

24. Continuing journey in south-eastern direction.

    East of Laubach: a larger coherent forest area, private property of the Earl, the so-called "Laubach Forest", mostly belonging to the Lower Vogelsberg: a basalt landscape, parted by numerous small rivers with knolls of over 400 m and larger deciduous wood stands (mixed beech forests close to natural state).

25. Schotten: Irish-scotch church foundation in 778, construction of gothic city church in 1300, city rights since 1354; today 3,600 inhabitants.

    After proceeding journey in north-eastern direction we reach the western edges of the Upper Vogelsberg: radial vallied flat basalt cone with cool-moist climate; with increasing height decreasing arable land in favour of pastures; the slopes are still partly terraced, but numerous terraces and hedges which are running parallel to the slopes have been sacrificed due to rationalization of the farms (enlargement of lots).

26. Road junction 620 m a.s.l. at the western edges of an almost coherent forest area; continuing journey in north-eastern direction.

27. Profile No. 3: Humic Cambisol over basaltic saprolite (Basaltzersatz) at the northern slope of the Upper Vogelsberg near Rebgeshain.

28. Back to the road junction (No. 26); ascent to the Oberwaldplateau (700 - 740 m a.s.l.): remnants of a levelled plain of the Pliocene; cool-moist area with precipitation of 1200 mm per year; numerous springs; predominantly cultivated spruce forests (danger of breaking branches because of wet snow in winter).

29. In the center of the Oberwaldplateau on left hand side: a high moor developed over fen peat, now a national preserve.

30. Profile No. 4: "Lockerbraunerde" (Loose Brown Earth) at the eastern slope of the Upper Vogelsberg.

31. Return to the intersection (No. 26) across the Oberwaldplateau; continuing journey first in north-eastern, then in north-western direction to the Lower Vogelsberg (No. 24); the asymmetric Ohm Valley is shaped as a basin valley between Ulrichstein and Ober-Ohmen while further down it developes into a plane valley bottom.

32. From Ober-Ohmen we are proceeding in north-eastern direction through plains and valleys of the Lower Vogelsberg.

33. We are entering the Autobahn at the intersection Alsfeld-West in northern, partly north-eastern direction. The intersection is situated in the Alsfeld Basin with Luvisols from loess loam; mainly agriculture.

34. East of the Autobahn junction Alsfeld-Ost the onsets of the East Hessian Upland: well-wooded Buntsandstein tableland with Muschelkalk and Keuper clods; scattered basalt knolls, i.e. the Rimberg (592 m a.s.l.) on the left side of driving direction.

35. Between Melsungen and Guxhagen we reach the Westhessian Depression with the city of Kassel (302,000 inhabitants).

36. North-east of Kassel: Buntsandstein area of the Kaufungen Forest and descent into the Werra Valley;
after passing through the southern Solling Foreland (predominantly Muschelkalk) we reach the city of Göttingen in the depression of the rivers Leine and Ilme (Leinegraben).

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The Landscape of Middle Hesse

(Vogelsberg and Wetterau)

by

E. Schönhals *

1. Survey of Natural Landscape Units

The landscape of Middle Hesse is composed of numerous units, each of which is endowed with a different set of landscape elements. The region depicted in Fig. 1 can be subdivided into the following landscape units (from W to E): Rhenish Massif (Rheinisches Schiefergebirge) with Taunus and Lahn-Dill Mountains; West Hessian Mountains (34), comprising Burgwald, Upper Hessian Ridge, Anterior Vogelsberg, Kirchhain and Gießen Basins; East Hessian Mountains (35), comprising Fulda-Haune Tableland (355), Lower and Upper Vogelsberg and the Rhön; Rhine-Main Lowlands (23) with Wetterau and Ronneburg Hills (233), and, on the south-east margin, the forested heights of the Sandstone Spessart and Southern Rhön (140).

The dominating natural landscape unit of Middle Hesse is the Vogelsberg, the largest coherent European basalt region. Morphologically it consists of levelled plains and a system of radial valleys. These morphological elements, together with elevation and, with it, differences in climate and vegetation, provide the basis for the subdivision of this basaltic mountain range into Anterior, Lower, and Upper Vogelsberg. Its highest point is the Taufstein (773 m a.s.l.; Fig. 2).

Besides Palaeozoic rocks in the west (Taunus, Lahn-Dill Mountains), Trias rocks, especially Buntsandstein, and, to a lesser extent, Muschelkalk and Keuper, are the main geologic elements of Middle Hesse. Unconsolidated Tertiary deposits are not widely encountered; partly because they have been covered by volcanics of the Vogelsberg and Pleistocene sediments.

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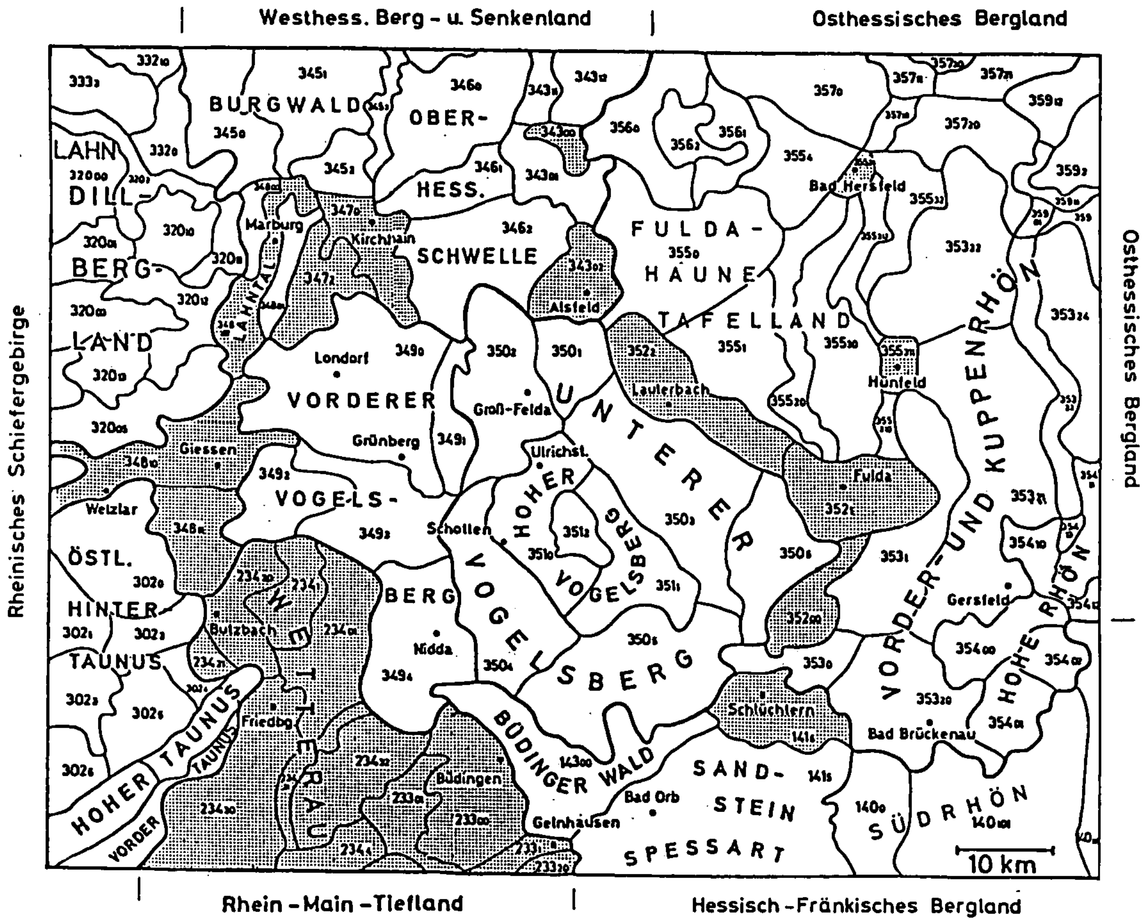

Fig. 1: Natural landscape units in Middle Hesse

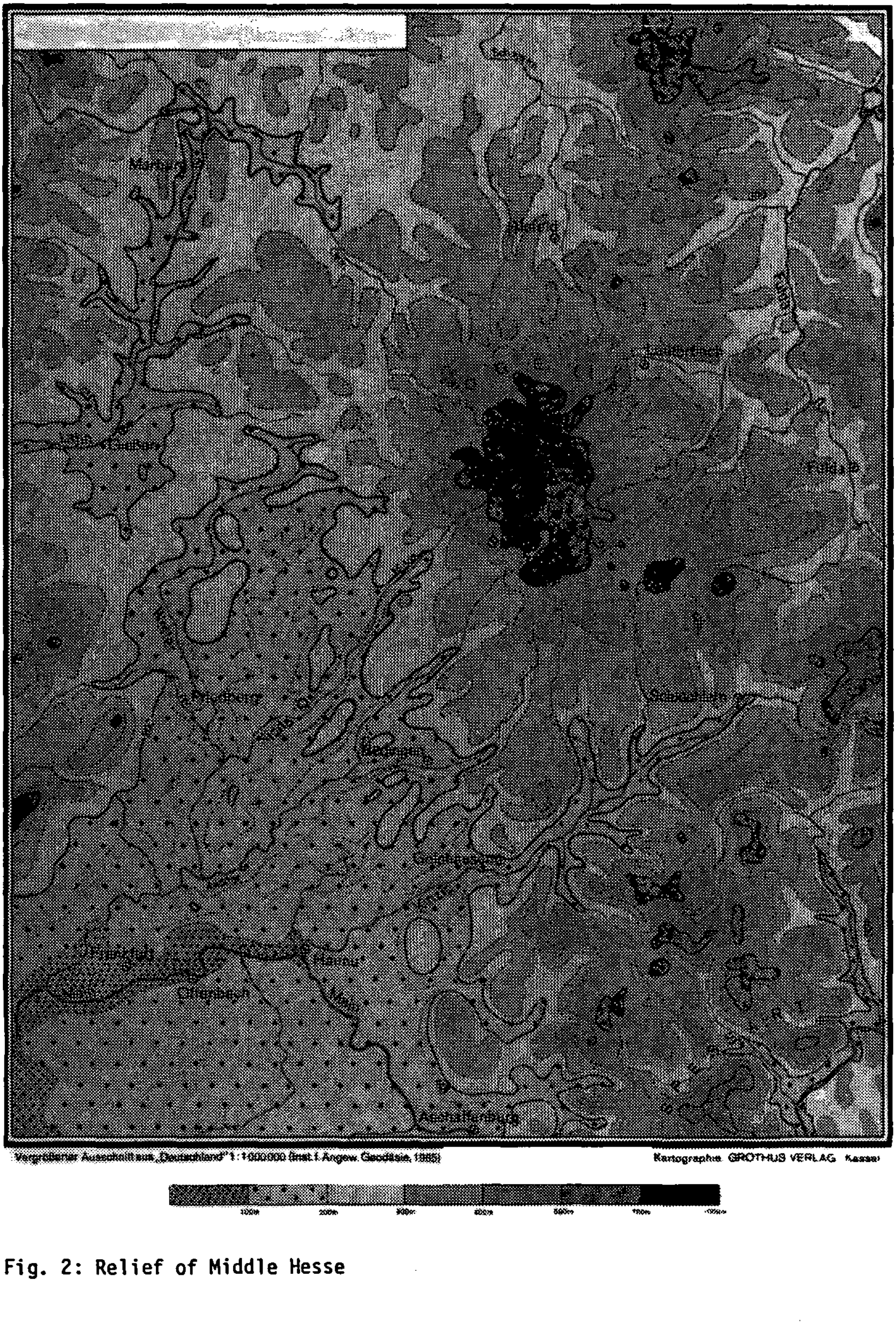

Fig. 2: Relief of Middle Hesse

The basalt region, which is inhabited and cultivated up to a height of 650 m, is surrounded by a nearly closed ring of basins, depressions, and wide river valleys. These marginal depressions were formed by tectonic activities during the Late Mesozoic, Tertiary, and Pleistocene, and additionally, by fluvial erosion.

These marginal depressions, which lie between 150 and 350 m a.s.l., support intensive agriculture because of their favourable climate and the widespread occurrence of fertile loess soils. The Wetterau is one of the most productive parts of these landscapes. Here the dominant crops are root crops and cereals (sugar beets, wheat, barley).

The Wetterau is an undulating to hilly landscape with an extension of about 800 km². It is bordered by the Taunus in the west, by the Vogelsberg in the north and east, and the Ronneburg Hills in the south-east (233). The north-east end of the Upper Taunus near Bad Nauheim, together with the valleys of the rivers Nidda and Wetter subdivide the Wetterau into a northern and a southern part. The Northern Wetterau has two parts divided by the Münzenberg Ridge (2341); the Butzbach Basin (2342) including the Mörlen Bight (23421) in the west, and the Horloff Depression (23401) in the east.

The Southern Wetterau has two parts divided by the valley of the river Nidda, which is up to 2 km wide. The Friedberg Wetterau lies to the west (23430). It is incised by numerous creeks. The Heldenbergen Wetterau lies to the east (23432) between the rivers Nidda and Nidder. Since Palaeozoic conglomerates, sandstones and claystones as well as basalts are abundant in this landscape; the relief here is much stronger than in the Friedberg Wetterau, where Tertiary sediments are generally covered by thick loess layers.

The southern boundary of the Wetterau is the Bergen Ridge (2344), which is up to 210 m high. Orographically, it is similar to the Heldenbergen Wetterau.

2. Geologic Structure and Parent Materials of Soils

The oldest rocks of Middle Hesse occur in the Rhenish Massif, where Devonian and Lower Carboniferous sandstones, quartzites, arkoses, schists, siliceous schists, and limestones of a thickness of several thousand meters were deposited in a deep sea trough. By the end of the Lower Carboniferous, crust movements caused folding and overfolding of these sediments. Finally they were elevated to form a part of the Variscan Mountains, and subsequently levelled until the end of the Palaeozoic.

During the Early Permian (Rotliegendes) the eroded material was deposited in the southern foreland belonging to the Saar-Selke-Trough. Hence red conglomerates, sandstones and claystones are found in the Southern Wetterau and the bordering Ronneburg Hills. They are covered by sediments of the Late Permian (Zechstein), which form a band of ca. 1 km width at the margin of the Büdinger Wald. Early Trias deposits (Buntsandstein) follow.

The geological map (Fig. 3) shows the wide distribution of Trias sedimentary rocks, above all sandstones (Buntsandstein). The sand- and claystones of the Buntsandstein reach a thickness of up to 700 m. They occupy the southern margin of the Vogelsberg, the landscape between Vogelsberg and Rhön, and the West Hessian Mountain and Basin Range. Marine limestones and marls (Muschelkalk) are confined to much smaller areas, the same applies to clay- and sandstones of the Keuper. Sediments of the Muschelkalk and Keuper are often confined to narrow graben structures, where they were protected against erosion during the Jurassic and Cretaceous, when the area was land.

During the Tertiary, different materials were deposited in Middle Hesse at the eastern margin of the Rhenish Massif. Especially in the Hessian Depression, which comprises the Wetterau and the Gießen and Amöneburg Basins, sand, clay, and marl were deposited in limnic and brackish environments.

With greater tectonic activity during the Middle Oligocene, these shallow sedimentary basins were lowered to such an extent that the sea could advance from the south through the Hessian Depression to reach the region of the North Sea of today. Marine sediments (sand, clay) were deposited in this narrow zone. After the retreat of the sea, limnic sands and clays were deposited north of the Vogelsberg, and brackish marls in the Wetterau. They are followed by sandy-clayey limnic, and lime-rich marly deposits similar to those of the Mainz Basin.

During the Pliocene, the Rhenish Massif was lifted. The deposits in the northern Hessian Depression and in the Wetterau of this time comprise fluvial sand, gravel, and clay, which are called "Bauernheim Layers" in the Wetterau. They are mostly covered by loess. Since they occur near the surface, they exert influence on soil formation.

During the Younger Pliocene brown coal formed in the Horloff Graben, which is of some economic importance. The brown coal layers of an average thickness of 9 m are used exclusively to generate electricity. The open cut has resulted in the loss of fertile soils. A large proportion of the mining areas has been recultivated and

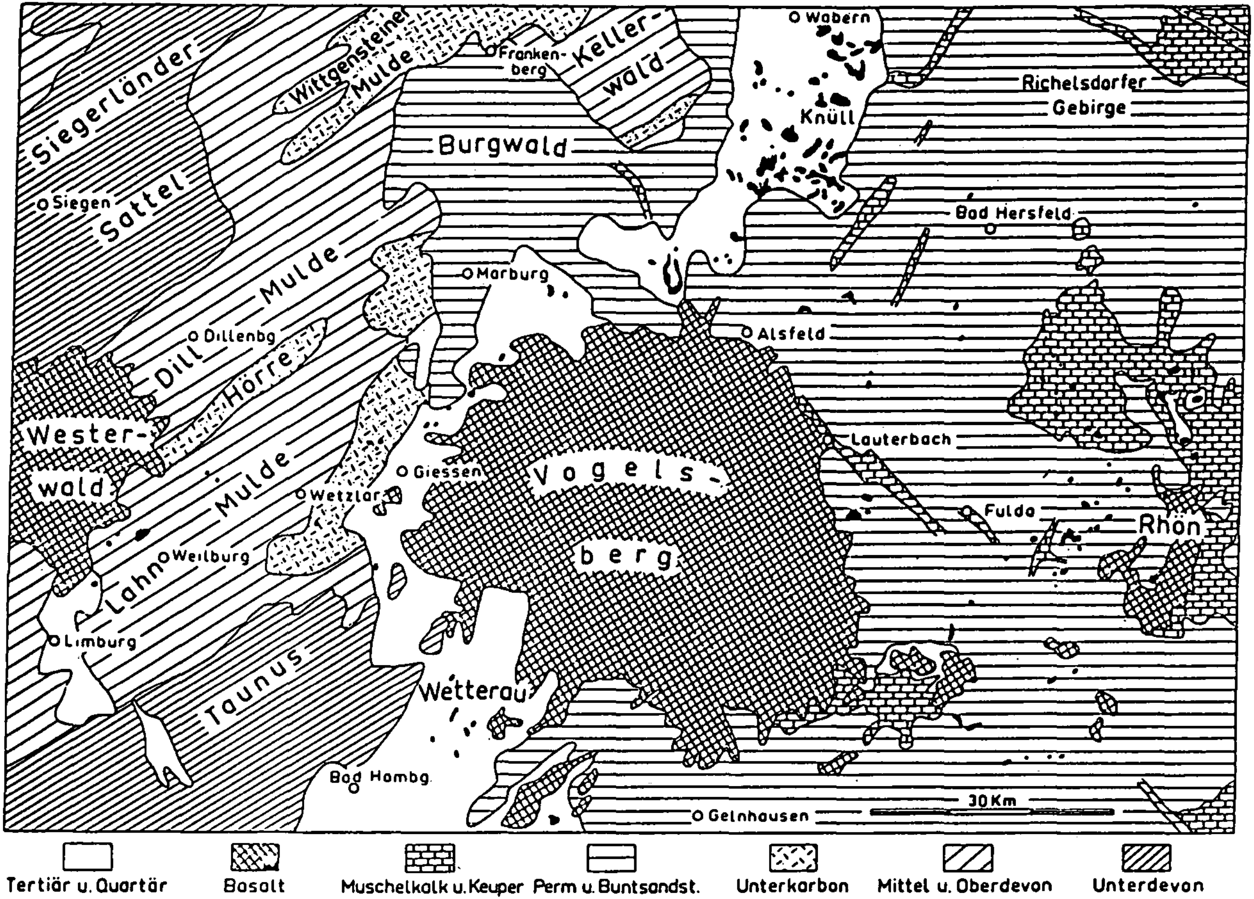

Fig. 3: Geological map of Middle Hesse (WEYL 1982)

is in agricultural use again; part of this area is today covered by water.

Vivid volcanism during the Tertiary with the peak of activity in the Miocene is of great importance for the morphology and land use in Middle Hesse. In the Westerwald, Vogelsberg, and the Rhön, basalts and basaltic tuffs erupted (and phonolites in the Rhön).

Below the basaltic mass of the Vogelsberg, which covers 2,500 km², lie deposits of the Trias, predominantly Buntsandstein, and Tertiary unconsolidated sediments. The thickness of the basalt is varying. On the western margin of the Lower Vogelsberg (Ohm Valley) it is less than 200 m, while in the region of the south-western Lower Vogelsberg it reaches a thickness of more than 400 m. Various intra- and postbasaltic tectonic movements, followed by different erosive processes, are thought to have caused these differences.

According to their mineral composition and chemistry, the basalts can be assigned to two series: the alkali-olivine basaltic, and the tholeiitic series (SCHRICKE 1975, 1976). Tholeiitic basalts have SiO_2 contents of 52 - 55%, alkali-olivine basalts to basanite contain 42 – 46% SiO_2. The alkali-olivine basalt to olivine basalt (ca. 48.5% SiO_2) and olivine basalt (ca. 50% SiO_2)are intermediate. These rocks also differ in colour and structure.

The volcanic body of the Vogelsberg is complicately structured. Layers and streams can be distinguished, their thickness is often variable. Thus four streams of a total thickness of 10 - 12 m could be distinguished in a quarry, and five streams, 22 m thick, in another quarry in the northern Lower Vogelsberg (SCHRICKE 1975). Bases and tops of any one stream have a vesicular and slaggy structure, their central parts are finely porous. Differences in the segregation patterns of the basalts (pillars, plates, spheres, polyhedric columns) are important for soil formation on them, e.g. in regard to drainage and stone content.

Since Hesse was a periglacial region during the Pleistocene, different sediments characteristic of such a climatic regime have been deposited on the Palaeozoic, Mesozoic, and Tertiary rocks, as well as on remains of Pre-Quaternary weathering.

With respect to soil formation and land use, loess is the most important of these. It has not only been deposited in the basins, but also in the Vogelsberg and other mountain ranges. In the Wetterau, where eastern slopes and hollows provided favourable conditions for its deposition and preservation, the loess is up to 20 m thick, e.g. near Ostheim in the south-eastern Wetterau (SABELBERG et al. 1974).

Here the Würm (= Weichselian) loess alone is 10 m thick. In such places fossil soils have been preserved, and important findings regarding stratigraphy, palaeopedology, and other branches of Quaternary research have been obtained here.

The mean carbonate content of the loess is ca. 16.3% in the Southern, and 12.0% in the Northern Wetterau, mean clay content is 19.5% in both regions.

The periglacial region is characterized by deposits of material which was transformed by frost action. These deposits constitute the parent material of the bulk of the soils. As a rule, they consist of relictic weathered loam, rock fragments, and loess in greatly varying proportions. Three solifluction layers can be distinguished (SEMMEL 1964, 1968): basal debris without loess ("Basisschutt"), middle debris with loess ("Mittelschutt"), and cover debris ("Deckschutt", also known as "Decksediment"). The "Decksediment" is most abundant. It is 30 - 60 cm thick and contains various amounts of silt, stones, and Laacher See Tephra. The "Decksediment" was formed during the Late Tundra (Dryas) period under periglacial conditions, ca. 10,500 B.P.

Some centuries before, during the Middle Allerød, volcanic eruptions in the Laacher See basin (East Eifel) yielded phonolite magma (pumice tuffs and pyroclastic flow) of a total volume of more than 5 km³ (BOGAARD & SCHMINCKE 1984). The light pumice grains were transported over great distances by wind, mainly to the east and south-east. Also in Middle Hesse some decimeters of this material have been deposited, which is found in numerous places of the Wetterau and Vogelsberg. Those tephra layers, which have not been eroded, were mixed into the above mentioned cover sediment by cryoturbation and solifluction. This means that the cover sediment is characterized by typical pumice tuff constituents (POETSCH 1974, 1975). The formation of the cover sediment was also essentially influenced by eolian processes (SCHÖNHALS 1957, 1957a, 1959).

Since during the Middle Ages large areas have been cleared of forests, soil erosion has become an important process. Therefore, loamy silt and silty loam have been deposited at the feet of the slopes and in depressions. The soils formed on these colluvia have high agricultural potential.

Similar materials are deposited within the flooding range of the rivers. They are called Aue loam. In the Horloff Valley poorly decomposed peat up to 2 m thickness is found in several places, mostly covered by Aue loam and mud. Fen peats cover a total area of about 815 acres. In the Wetter Valley fen peat under Aue loam is found on 148 acres (SCHRADER 1976, 1978, 1983).

3. Climate of Vogelsberg and Wetterau

The Vogelsberg (Oberwald ca. 750 m a.s.l.) rises considerably over its surroundings (200 - 300 m a.s.l.). Oceanic air masses transported by westerly winds are therefore forced upward with the consequence of rain on the lee side. Any location on the western slope of the Vogelsberg thus receives more precipitation than comparable locations on the eastern side. Annual precipitation in Schotten (272 m) is 855 mm, in Lauterbach (291 m) it is 627 mm. The Anterior Vogelsberg receives an average of 650 - 750 mm, the Lower Vogelsberg up to 450 m a.s.l. 700 - 900 mm, and the Upper Vogelsberg 980 - 1200 mm (Fig. 4).

Concerning the growth factor temperature, the southern and middle Anterior Vogelsberg have favourable conditions with an annual mean of 8.5 - 9.0 °C. With increasing elevation the temperature decreases; in some parts of the Anterior Vogelsberg and the western and southern Lower Vogelsberg, 8 - 8.5 °C are reached up to heights of 350 m a.s.l. In other parts of these regions mean temperatures are lower (7 - 7.5 °C) due to greater elevation or northern exposition. In the steep upper regions it quickly decreases to 6 °C, which is the value for the Oberwald plateau, 700 - 740 m a.s.l. Differences of several degrees also exist during the vegetation period (May - July). In the lower regions (up to ca. 250 m a.s.l.), 15 - 16 °C are reached as opposed to 12 °C in the Oberwald. The daily mean of 5 °C is reached considerably earlier in the year in the lower parts. This is the case before March 20th below 200 m, on March 30th at 350 - 400 m , and on April 20th in the highest parts, which means a difference of 30 days between the Upper Vogelsberg and parts of the Lower Vogelsberg. Mean temperatures of above 5 °C prevail for 230 - 240 days in areas below 200 m and only for 180 - 190 days on the Oberwald plateau.

The climate of the narrow marginal zone of the Northern Wetterau, with an annual precipitation of 600 - 650 mm and a mean temperature of just below 9 °C prevails in the regions further north, too, such as the Hüttenberg Hills, the Gießen Basin, the Lahn Valley, and the lower region of the western Anterior Vogelsberg.

The climate of the Wetterau is influenced by its lee position east of the Rhenish Massif. This holds especially for the Northern Wetterau, where the greatest part lies in the strike direction of the Upper Taunus with its Feldberg-Pferdskopf heights (800 m a.s.l.) and the forested mountains north of the Mörlen Bight, which are partly higher than 500 m. A great proportion of the air humidity, brought by westerly winds, falls on these heights (Kleiner Feldberg 1000 mm). Precipitation decreases steadily in north-eastern direction. The Usingen Basin bordering the

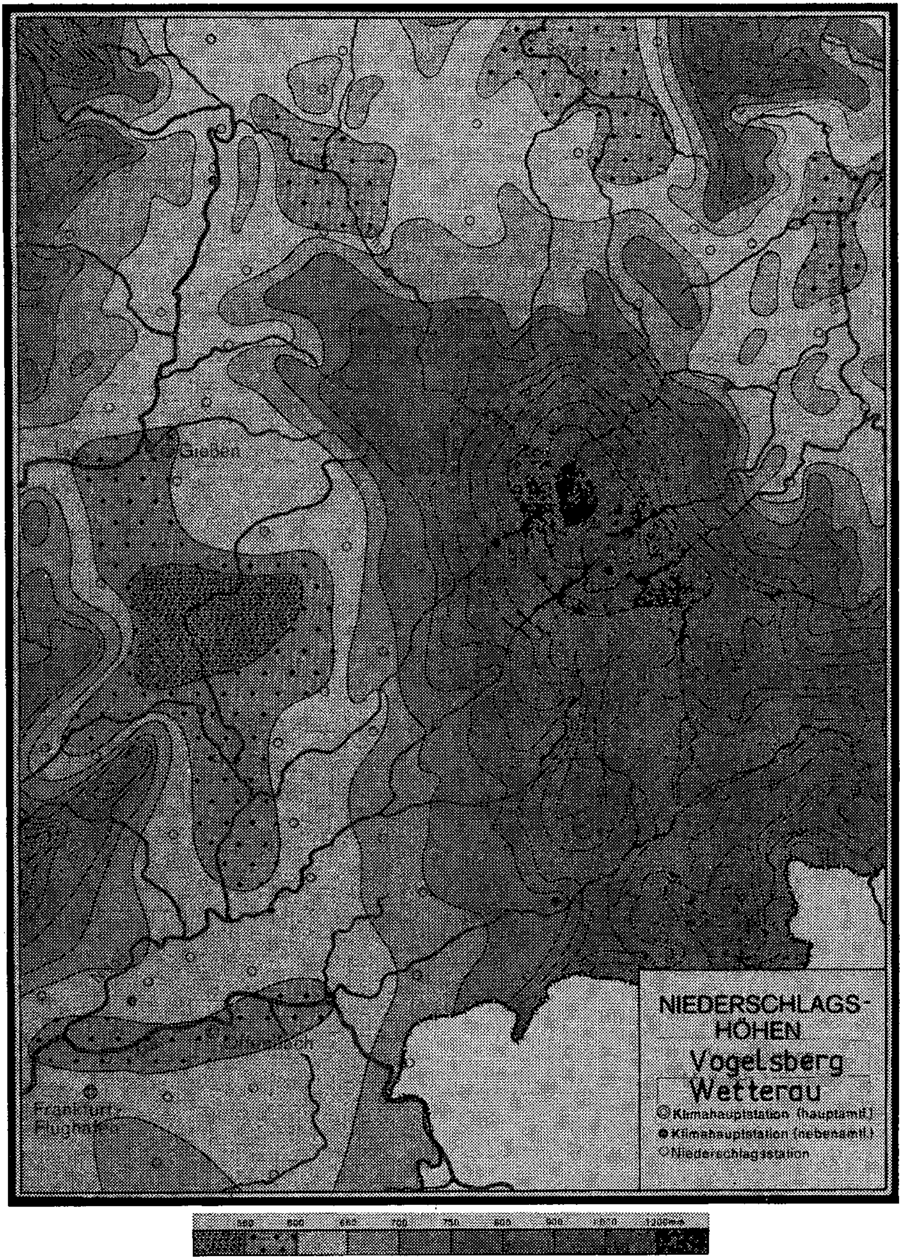

Fig. 4: Mean annual precipitation in Middle Hesse (1891 - 1955)

Feldberg-Pferdskopf mountains receives 616 mm, 336 mm of which fall during summer (April - September). A consequence of this low precipitation is the occurrence of carbonate-containing loess. To the north-east of the Usingen Basin precipitation decreases to 536 mm at Münzenberg (163 m a.s.l.). The dry region with less than 550 mm extends from Butzbach to the Horloff Depression, near Arnsburg Abbey in the north and Bad Nauheim (577 mm) in the south. It comprises an area of about 100 km². The directly adjoining areas have precipitations of 600 - 625 mm. The dryness of the Northern Wetterau is enhanced by dry northern and north-eastern winds during summer. During this time the potential evapotranspiration has values of 550 - 600 mm. The low precipitation during summer (304 - 335 mm) often falls as strong rains. The precipitation deficit can only be met by high available water capacities of the soils.

The Southern Wetterau lacks such a dry region. Rain-bringing south-westerly winds from the Lower Main Region can easily reach this area because of the favourable conditions. The lowest precipitation figures (550 - 600 mm) are found in the central part, a belt of 16 km width on either side of the river Nidda. Near the Taunus and Vogelsberg 650 mm are reached. Higher precipitation and temperature favour the vegetation in the Southern Wetterau, as the mean temperature lies above 9 °C (Bad Vilbel, 109 m a.s.l.: 9.3 °C). In the Northern Wetterau, however, the values are below 9 °C (Münzenberg, 163 m: 8.7 °C, Lich, 172 m: 8.8 °C). Thus, for example, the beginning of the apple blossom is before April 30th in the Southern, and between April 30th and May 5th in the Northern Wetterau.

4. Morphology and Soils of the Wetterau and Vogelsberg

Wetterau

Under the influence of the dry and warm climate and the once prevailing mixed forests of oak in the lower and beech in the higher regions (Fig. 5, KNAPP 1967), Luvisols were formed out of loess. This soil type is regarded as the climax stage. Clay translocation is generally strong, the clay content of the Bt horizons is 34 - 40% as a rule. The Luvisols are brown to reddish-brown, have prismatic or polyhedric structure and clay cutanes. Luvisols out of loess have high available water capacities and great rooting depth. Their agricultural potential is high and they are very well suited for demanding crops such as sugar beets.

Other typical soils of the Wetterau are Phaeozems (Luvic Phaeozems, Mollic Luvisols, and Stagno-Gleyic Phaeozems)(ALTMANNSBERGER 1969). These soils have their greatest extension in the Northern Wetterau (Fig. 6). The largest Phaeozem area

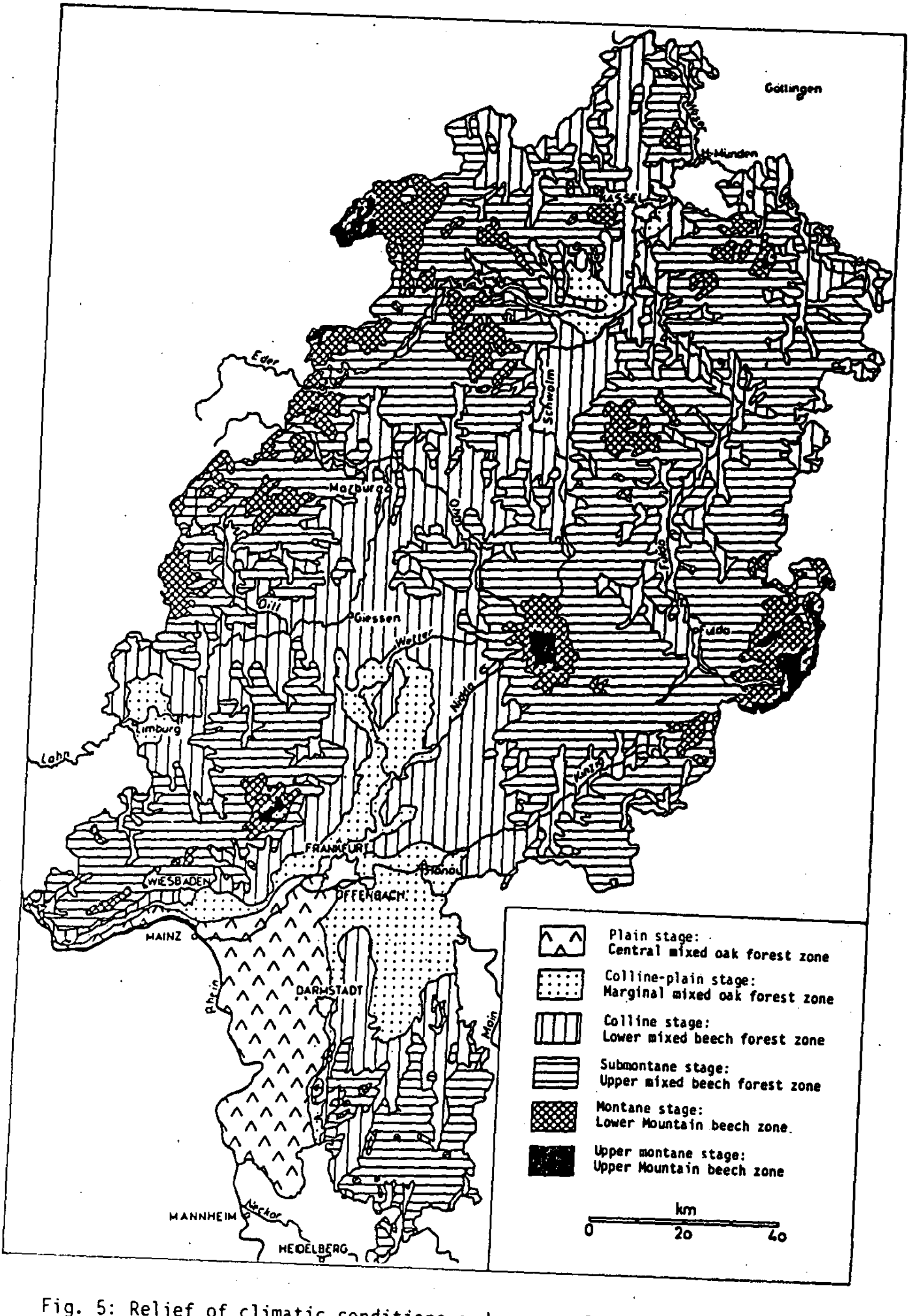

Fig. 5: Relief of climatic conditions and zones of vegetation in Hesse (KNAPP 1967)

lies between the eastern margin of the Münzenberg Ridge and the Horloff Valley. It is 15 km long and 3 - 6 km wide. Profile pit No 1 is located 1.5 km north-west of Echzell (Mollic Luvisol). The approximate extent of this Phaeozem region comprises more than 14,000 acres (including the areas lost by coal mining). With the smaller patches near Butzbach, Eberstadt, and Langsdorf (together 9,200 acres), the total area of the Phaeozem soil associations amounts to nearly 25,000 acres.

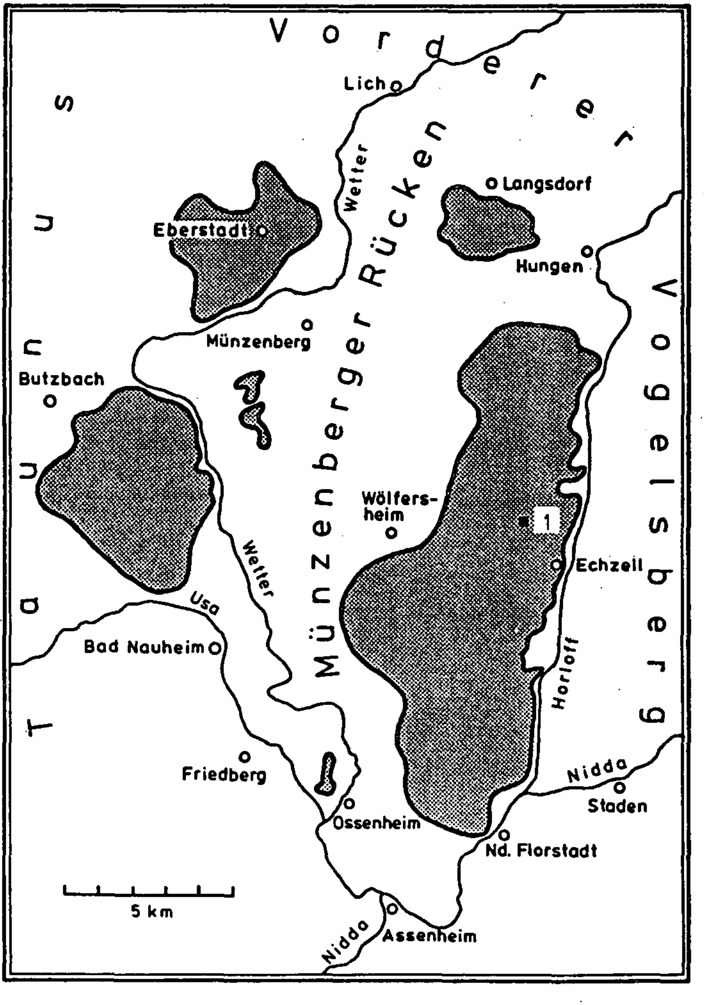

Fig. 6: Distribution of soil associations with Phaeozems in the Northern Wetterau
References: BARGON & SCHÖNHALS (1968), SABEL (1982), SCHRADER (1976, 1978, 1983).

The Phaeozem areas are situated between 125 and 185 m a.s.l. in the eastern Wetterau. Those occurring west of Eberstadt lie on a plateau, weakly inclined to the east, about 230 m a.s.l. This is the highest occurrence of Phaeozems in Middle Hesse.

Phaeozem-like soils also occur in the Southern Wetterau, but only in small patches because of the varied relief. This was confirmed in the mapping of the sheets Frankfurt/M.-East and Hanau (BARGON 1979, 1984). Mollic Luvisols also occur in the Friedberg Wetterau between Ockstadt and Petterweil (SABEL 1981).

As in other loess regions of Middle Europe, soil erosion is far advanced. On tilled soils this process has already led to the complete loss of the solum over large areas and to the exposition of the underlying loess or other rocks.

Erosion is weaker in less endangered areas, but in most cases the original thickness of the solum has been reduced. This is evident in the soil mapping results, where nearly all units of the widespread "Luvisols from loess-loam over loess" were found to be "eroded" or "strongly eroded" (SCHRADER 1976, 1978, 1983).

Together with the mostly eroded Luvisols and Phaeozems, "Pararendzinas" occur in areas where the primary soil has been completely eroded. These soils have an Ap-C profile. The ploughed Ap-horizon mostly contains carbonates from mixed-in C-material. They predominantly occur on sloped areas, for instance in the Butzbach Basin and the margins of valleys. On level and only weakly inclined surfaces this type of soil is lacking or occurring in small patches only.

The material removed by surface runoff, especially with melting snow, collects at the lower part of slopes and in depressions as colluvium. It is a fine humous earth with a high content of silt and numerous earthworms. In areas with Pararendzinas colluvium mostly contains carbonate. Soil mapping of the sheets Hungen, Staden, and Butzbach has revealed that colluvium covers about 10% of the total area. Most of it occurs in the Münzenberg Ridge and the marginal stretches of the Anterior Vogelsberg in the east (SCHRADER 1976, 1978, 1983).

In the areas mentioned above, as well as in the south-eastern Wetterau, volcanic rocks (basalt, basalt tuff), unconsolidated deposits (sand, gravel, clay), and periglacial solifluction layers of greatly varying thickness and texture are widespread. Consequently, Rankers, Cambic Rankers, Cambisols, and Stagnic Gleysols occupy larger areas. Differences in parent material and the influence of the relief cause strong variations in soil depth and physical properties of the soils.

The less favourable soil conditions of the south-eastern Wetterau are also reflected in a somewhat higher proportion of forests.

In the valleys of the rivers Nidda, Horloff, and Wetter Gleysols and Eutric Fluvisols prevail, the latter cover larger areas in some parts of the Nidda Valley. Between Hungen and Nieder-Florstadt Humic Gleysols are abundant together with Eutric Histosols, which are restricted to small areas only in other valleys.

Vogelsberg

Anterior Vogelsberg

This western part of the Vogelsberg stretches about 50 km southward from the Amöneburg Basin (347). Apart from some deeply incised valleys, the relief is not very strong. Between the rivers Ohm, Lumda, Wieseck, and Wetter, levelled undulating plains with some basaltic domes and ridges prevail. On the northern margin heights of 350 - 400 m a.s.l. are reached. In southward direction the plains lose height; therfore only some domes up to 250 m height occur in the southern Anterior Vogelsberg.

The predominant parent materials of the soils are loess loam and solifluction layers rich in silt. The upper soil horizons (Ah and Al) were formed out of cover sediment. In the region of these silty parent materials Luvisols dominate west of the line Nidda - Laubach - Londorf. On level ground and on lower parts of slopes weak hydromorphism occurs due to stagnating water. Since in this area also carbonate containg loess is preserved, the slopes of the valleys of the rivers Nidda, Wieseck, and Lumda have Pararendzinas and eroded Luvisols (REICHMANN 1968). Precipitation in the areas of carbonate-containing loess is 620 - 700 mm per year, and, in the warmer region of the Anterior Vogelsberg, 750 mm.

In the northern higher parts of the Anterior Vogelsberg west of the Ohm Valley weakly to strongly hydromorphic Luvisols and Stagnic Gleysols have formed on loess loam and solifluction layers. With precipitation rates between 700 and 800 mm per year, surface topography has a strong influence on the degree of hydromorphism of the soils. Especially in level to weakly inclined areas and in depressions Stagnic Gleysols occur. Material rich in clay from relictic brown and red loam which is contained in the solifluction layers is another reason for water stagnation (PLASS 1975). The respective IISd horizons are very dense and compact; they are drainage barriers and restrict growth. Cambisols out of cover sediment over basalt debris and basalt or over remains of brown and red loam are rare. In the latter cases they often are also influenced by water stagnation.

Under the influence of a "humid subtropical to temperate climate" during the Miocene and probably the Early Pliocene (WIRTZ 1972), red-brown and red soils (Acrisols and Ferralsols) formed out of basic volcanic rocks of the Vogelsberg and Wetterau; weathering-depth was up to 50 m. With the uplift of the Vogelsberg during the Pliocene and Early Pleistocene they were eroded in large areas, esp. in the Upper Vogelsberg. Only the base of the red Paleosols, decomposed basalt ("Basaltzersatz") has been conserved in larger areas. Relictic red soils occur in the Anterior and Lower Vogelsberg between 160 and 360 m a.s.l. on surfaces levelled during the Middle and Late Pliocene (profile pit No 2). Also they are mostly Plastosols (Acrisols), some Latosols (Ferralsols) occur. In large areas the Paleosols are covered by loess loam (Fig. 7).

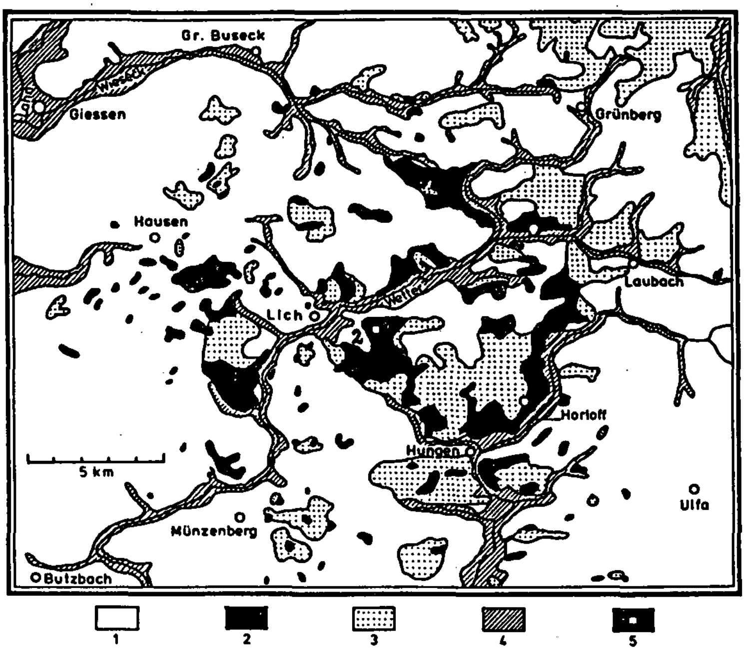

Fig. 7: Distribution of Paleosols out of Tertiary volcanic rocks in the Northern Wetterau and Anterior Vogelsberg

1 = Tertiary (mostly basalt) and Pleistocene (loess and loess loam)
2 = Paleosols, partly with thin cover (30 cm) of loamy silt
3 = Paleosols covered by loess and loess loam
4 = Holocene deposits in valleys
5 = position of profile No 2 (2.3 km ESE of Lich).

References: SCHOTTLER (1918, 1921), SCHÖNHALS (1954), SCHRADER (1978, 1981, 1983), SCHRICKE (1975).

Lower Vogelsberg

The Lower Vogelsberg comprises the landscapes between the Anterior Vogelsberg in the west and the marginal depressions up to heights of 400 - 450 m. The width of this circular belt is varying: 5 km in the west, and 10 - 20 km in the east. Numerous creeks and rivers divide the Lower and Upper Vogelsberg into segments of varying length and width. Distinct height differences are encountered on the western side between the valleys of the rivers Nidder in the south and Felda in the north. Here some valleys are incised up to 100 m deep. The valley slopes with their varying expositions and inclinations have loess layers varying in thickness, with different degrees of translocation of the material and mixing with the underlying substrate (stones, clayey weathered products). Hence the contents of silt, clay, and stones are greatly varying in the solifluction layers, and different soils formed out of these parent materials overlying decomposed basalt ("Basaltzersatz"), basalt debris, or basalt, or residues of older clayey soils (Acrisols).

The thickness of the solifluction layers, which in most cases determines the soil depth, is greater in the lower parts of the landscape, that is near the watercourses. On the ridges between them, mainly shallow Rankers and Ranker-Cambisols prevail. In these positions often older loamy-clayey weathering residues are preserved, which cause some hydromorphism because of their low water conductivity (Gleyic Cambisols). On lower slopes and in hollows the unconsolidated material is thicker. Here deeply developed soils with loamy and silty-clayey textures prevail; hydromorphism is widespread (Gleyic Luvisols), too, often due to groundwater from uphill which seeps through clefts in the basalt.

Tilled areas with strong erosion of the topsoil, which forms colluvium downhill, often are also influenced by stagnating or ground water. Marked differences of the soils are observed in asymmetric valleys: southern exposition favours shallow Rankers and Cambisols; northern exposition and translocated loess loam favour the formation of Gleyic Luvisols and Stagno-Luvic Gleysols. The different soil properties are reflected in different land use: Tilled land on the southern, grassland on the northern slopes. Where the slopes are steep, one tried to reduce soil erosion by terracing. The terraces, often overgrown by hedgerows, are characteristic of the Vogelsberg.

The eastern Lower Vogelsberg has a much less pronounced relief than the western. Here the watercourses are not very deeply incised into the Middle and Young Pliocene levelled plain. Between the creeks, the levelled plain, inclined towards the east, is surmounted by basalt domes often no more than 5 - 20 m high. In these undulating to hilly areas agriculture has almost completely replaced the forests, which are confined to a few steeper slopes on the lower courses of the creeks. Generally the valleys are wider on the upper courses of the creeks and sometimes shallow basins of several km length have formed there. In these basins Gleysols and Stagnic Gleysols prevail.

Compared to the western Lower Vogelsberg, the conditions for the deposition and conservation of loess were much better in the eastern Lower Vogelsberg. Hence loess loam and solifluction deposits are the most abundant soil parent materials in this landscape. Rankers and Cambisols of little to medium soil depth out of loamy silt and silty-clayey loam over "Basaltzersatz" or basalt are restricted to higher domes and ridges. Generally Gleyic Luvisols have develloped on top of the widely distributed loess loam, on level ground and in hollows hydromorphism is stronger (Stagno-Luvic Gleysols).

It has been mentioned before that loamy-clayey weathering products of Pre-Pleistocene origin are important for the water regime of the soils. This is especially true in regard to the eastern Lower Vogelsberg, which receives a high precipitation of 850 - 950 mm. Here relictic and fossil red Plastosols occur quite frequently. With their high clay content they constitute drainage barriers and, together with surface form, favour the occurrence of hydromorphic soils in small patches (Stagnic Gleysols).

Upper Vogelsberg

Residual plains conserved at 350 - 450 m a.s.l. are considered the lower boundary of the Upper Vogelsberg. SANDER (1960) distinguishes between the Oberwald plateau and its eastern and western roofings. Similar to the Lower Vogelsberg, the western side of the Upper Vogelsberg is more strongly partitioned than the eastern side. Here broad rounded ridges and wide valleys prevail, while steep slopes are rare (Fig. 8, profile No 3).

The Oberwald plateau stretches from 3 km south-east of Ulrichstein to the Herchenhainer Höhe (733 m a.s.l.) between heights of 700 - 740 m. The gently undulating plateau, which, according to SCHULZE (1959, 1961), is thought to be an Early Pliocene piedmont surface, is surmounted by three flat domes: Siebenahorn (753 m), Taufstein (773 m), and Hoherodskopf (763 m). Nearly the whole area is covered by forest (mainly spruce). Ground water of the highest level issues in several springs; a number of creeks originate here. Some headwaters and a small drained high moor are natural reserves.

The periglacial solifluction layers in the Upper Vogelsberg can be classified in three categories: basal debris, middle debris, and cover sediment. In connection with investigations regarding the parent materials of the Loose Brown Earths ("Lockerbraunerden"), it was shown that the basal debris contains fossil soil residues besides basaltic rocks. According to their chemical and mineral composition, they are siallites. CaO and MgO are nearly completely lost, SiO_2 is partly leached, Fe_2O_3 and Al_2O_3 are relatively enriched. The primary silicates of the basalts and basalt tuffs are stronly to completely weathered (POETSCH 1975).

Middle debris has a lower stone content and a higher proportion of eolian allochtonous components, such as quartz, potash felspars, acid plagioclases and fragments of different rocks. Also Plastosol residues with high content of kaolinite and gibbsite aggregates occur.

The cover sediment has a much greater content of medium silt and quartz than the middle debris. Moreover, extraneous components occur which are lacking in the older solifluction layers. These are especially characteristic heavy minerals of the aegirite-augite series, brown volcanic hornblendes and titanites as well as alkali-felspars, especially sanidine. These components are distinctive for the cover sediment. They originate from the Laacher See Tephra.

Micromorphological investigations by ALTEMÜLLER (1961) showed that the Loose Brown Earths possess a characteristic micro-structure, which distinctly differs from the structure of all the other soils by a complete formation of aggregates as far as the clay fraction. This particularity may be attributed to higher allophane contents as proved by SAKR & MEYER (1970), HUGENROTH, MEYER & SAKR (1970) and HILGER-ALEXANDROU (1976).

Loose Brown Earths out of cover sediment were described by SCHÖNHALS (1957) for the first time. Typical Loose Brown Earths (profile pit 4) have the following properties: Extraordinary great looseness, an extremely high pore volume (70 - 80%) with an extremely high proportion of coarse pores (over 35%), and mostly more than 20% medium pores; a very low bulk density of 0.5 - 0.8 g/cm³; "greasing effect"; no or only a very small clay translocation, and high air and water permeability.

The Loose Brown Earths are strongly to very strongly acidified (pH-KCl 4.3 - 2.8), have high exchange capacities, largely due to the variable charge of the allophanes (HILGER-ALEXANDROU 1976), the base saturation is extremely low (under 3.0%), the fraction of dithionite-extractable free Fe is high, especially in the grain size fraction, smaller than 0.6 µm, the proportion Fe_o/Fe_d is 0.2 - 0.6. The high iron

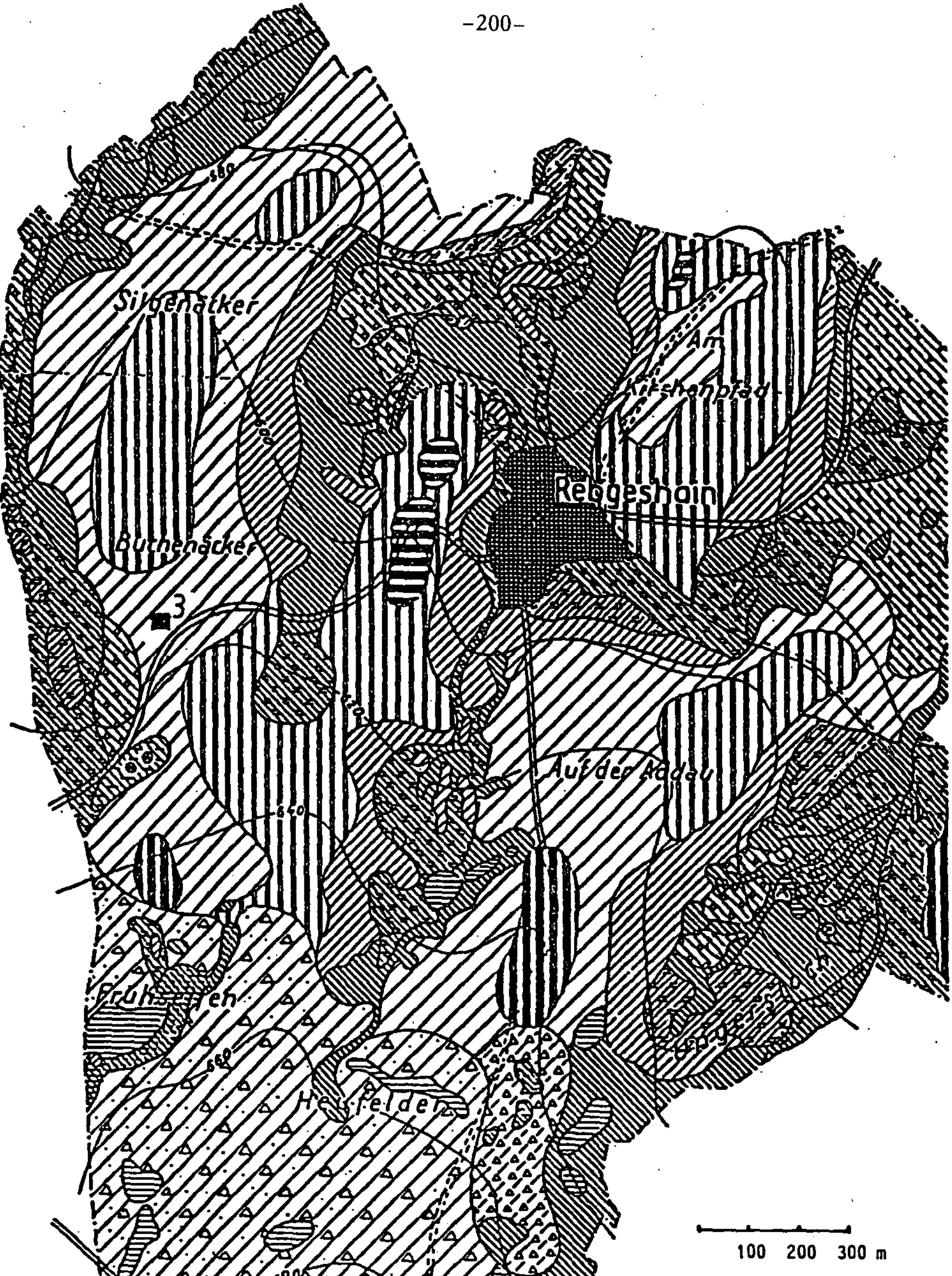

Fig. 8: Soil map of the community Rebgeshain in the Upper Vogelsberg
(SCHÖNHALS 1953)

Soil Units

1 Rankers out of stony-grity loamy silt over decomposed basalt ("Basaltzersatz") and basalt

2 Rankers and Cambic Rankers out of strong stony-grity loamy silt over decomposed basalt and basalt; sporadically basalt rocks

3 Cambic Rankers and Cambisols out of stony-grity loamy silt over decomposed basalt, basalt debris, and basalt

4 Cambisols out of grity sandy-loamy silt to sandy loam over decomposed basalt; soil depth 60 - 100 cm

5 Cambisols out of stony-grity sandy loamy silt with basalt blocks over decomposed basalt; soil depth 60 - 100 cm

6 Cambisols out of sandy-loamy silt with stones and blocks of basalt over decomposed basalt; soil depth 60 - 100 cm

7 Cambisols and Luvisols out of loamy silt over decomposed basalt; soil depth mostly above 80 cm

8 Gleyic Cambisols out of loamy silt over stony loam

9 Stagno-Dystric Gleysols out of loamy silt over stony loam

10 Fluvial Colluvium; sandy-loamy silt

11 Stagno-Gleyic Colluvium; sandy-loamy silt

12 Gleyic Colluvium; sandy-loamy silt; Ah + M horizon ca. 50 cm thick

13 Gleyic Colluvium; sandy-loamy silt; Ah + M horizon ca. 30 cm thick

14 Gleysols, locally Stagno-Dystric Gleysols

15 Dystric and Humic Gleysols

16 Humic Gleysols

17 Dystric Histosols, slightly to moderately decomposed over mud

18 Dystric Histosols on spring-water with sphagnous peat on the surface, 10 - 20 cm thick

oxide content of the Al-poor Allophane is responsible for the large proportion of adsorbed organic matter (SAKR & MEYER 1970). It predominatly consists of fulvic acids; humic acids are less abundant (AKINCI 1973). Differences in organic matter composition are due to vegetation history and present land use.

The crystalline components of the clay fraction are rich in Al-chlorites which only occur in the coarse clay fraction (0.2 - 2 µm). The finer fractions are dominated by labile three-layer minerals lacking a peak at 1.8 nm, which extremely expand above 2.0 nm. Illite content decreases from bottom to top due to strong mineral weathering. In the Bv_1 horizon essentially chlorite and kaolinite interferences are registered. The allophane content of the clay fraction is ca. 30%, in the fraction smaller than 0.2 µm it reaches 61% (HILGER-ALEXANDROU 1976).

As can be gathered from the foregoing enumeration of the properties of the Loose Brown Earths, they take a particular position in the spectrum of the Brown Earths. Consequently, the forming of a new subtype was necessary, for whose denomination the extraordinary looseness appeared most suitable.

Although some properties of the Loose Brown Earths are also typical for Andosols (Andepts), they cannot be definend as Andosols because the parent material is not predominantly of pyroclastic origin and the allophane content of the clay fraction under 2 µm does not come up to at least 50% (Andepts 60%).

According to the FAO-nomenclature, the Loose Brown Earths could be defined as Loosic Cambisols.

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Profile No. 1:

Mollic Luvisol from loess near Echzell in the Northern Wetterau

Location: 2.5 km north-west of Echzell

Natural landscape unit: Horloff Depression (geologically: Horloff Graben)

Relief: Weakly inclined plain toward the east, 130 m a.s.l.

Geology: Loess (13 m thick) over Early Pleistocene/Tertiary fluvial loamy-clayey deposits, partly over brown coal (Upper Pliocene), partly over decomposed basalt (from about 43 m below surface)

Climatic data: Precipitation: 600 mm
about 9 °C mean annual temperature
0 to 1 °C mean temperature in January
18 to 19 °C mean temperature in July
period of vegetation: 240 to 250 days (mean daily temp. above 5 °C)

Potential natural vegetation: Melico-Fagetum (eutraphent, colline-plain stage)

Soil formation: During Boreal period development of Phaeozems under continental silvo-steppe or steppe, which were later degraded (eluviation of clay); early agricultural use and therefore strong bioturbation (numerous earthworm channels in the subsoil)

Soil association: Wide patches of Mollic Luvisols besides eroded soils and colluvia; Gleyic Phaeozems further east in lower areas; reclaimed ground about 300 m west of the profile at the edges of a former brown coal cast area (here underground mining; after setting of the soil refilling and recultivation; agricultural use since 1965)

Land use: Intensive cultivation with sugar beets (up to 33% of arable land) and winter grains. Comp. Farm Eichelmann, p. 178
Analytical methods please refer to end of guidebook

Description of Profile No. 1: Echzell

Ap1	0-20 cm	Dark grey-brown (10 YR 4/2), slightly humose loamy silt, crumb structure, packing density*: low to medium; partly coherent structure, packing density: medium to high; well rooted
Ap2	20-27 cm	Dark grey-brown (10 YR 4/2), slightly humose loamy silt, coherent structure, packing density: medium to high; partly crumb structure, packing density: low to medium; moderately rooted; slightly undulating distinct transition to
Al	27-40 cm	Brown (10 YR 4/3), weakly humose silty loam, coherent structure, packing density: medium; isolated earthworm channels, moderately rooted; undulating less distinct transition to
BtAh	40-65 cm	Brown-black (10 YR 3/2), slightly humose silty loam, polyhedric structure, packing density: low; numerous earthworm channels,well rooted; undulating less distinct transition to
AhBt	65-90 cm	Dark brown (10 YR 3/4), silty-clayey loam, polyhedric structure, packing density: low to medium; numerous earthworm channels, well rooted; tongue-shaped distinct transition to
Btv	90-105 cm	Yellowish-brown (10 YR 5/4), silty loam, coherent structure, packing density: low to medium; numerous earthworm channels, well rooted; undulating distinct transition to
C	105-120 cm +	Yellowish-brown (10 YR 6/4), silty loam, coherent structure, packing density: medium; isolated earthworm channels with some roots.

*Degree of compactness or looseness, determined by field methods

Profile No. 1 - Echzell

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k_{oo} µm²	k_{oo} var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
8972	Ap	0 - 27		0,3	1,3	2,2	3,8	43,1	28,5	7,3	78,9	17,2	7,8	
8973	Al	- 40		0,1	0,6	1,8	2,5	43,2	26,2	7,7	77,0	20,5	3,2	
8974	BtAh	- 65		<0,1	0,2	1,1	1,3	36,7	25,7	8,3	70,7	28,0	35,3	
8975	AhBt	- 90		<0,1	0,4	0,9	1,3	35,6	22,6	7,7	65,9	32,9		
8976	Btv	-105		<0,1	0,1	0,8	0,9	37,5	25,6	7,5	70,6	28,6	17,4	
8977	C	-120+		<0,1	0,3	1,6	2,0	44,6	22,3	8,0	74,5	23,1		

No	hor.	bulk dens. g/cm³	GPV %	water content in Vol.-% at pF 1.4	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
8972	Ap 1	1,36	49,5	38,8	36,2	29,4	12,0	7,03	6,38	7,75	1,57	0,20	526	290
	Ap 2	1,47	45,3	36,3	35,2	31,6	13,0							
8973	Al	1,53	43,5	37,8	35,3	30,9	13,4	7,01	6,24	8,75	1,49	0,17	508	115
8974	BtAh	1,38	49,4	34,2	31,8	28,4	15,9	7,03	6,33	11,13	1,84	0,17	554	56
8975	AhBt	1,44	47,6	36,4	35,3	33,2	23,0	7,34	6,53	13,79	1,64	0,12	448	68
8976	Btv	1,40	49,2	39,1	38,3	35,0	19,6	7,51	6,72	12,93	1,34	0,10	438	95
8977	C	1,52	44,9	37,2	36,3	31,8	16,3	8,22	7,47	10,07	0,93	0,09	274	5

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H + Al	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
8972	Ap	1,29	0,98	13,2		147,2	131,6	133,1	14,1	9,2	0,7	n.n.	n.n.	107
8973	Al	0,68	0,86	7,9		141,5	123,3	114,5	5,9	10,9	1,3	8,2	n.n.	94
8974	BtAh	0,79	1,05	7,5		201,9	177,0	145,5	2,1	21,3	2,6	27,8	n.n.	85
8975	AhBt	0,68	0,52	13,1		240,4	206,5	172,1	2,3	30,4	4,5	30,0	n.n.	87
8976	Btv	0,46	0,39	11,8	n.n.	215,2	199,0	164,5	2,5	26,3	3,3	19,2	n.n.	91
8977	C	0,46	0,46	10,0	10,25	182,0	172,5	175,4	1,8	17,6	1,8	n.n.	n.n.	108

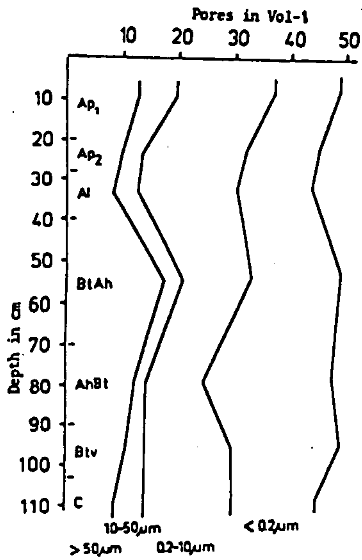
Thin sections exhibit the characteristic grain size distribution of predominant coarse and medium silt sizes (cf. texture analysis) with an admixture of minerals and rock fragments of pyroclastic origin.

Due to agricultural measures and seasonal influence the topsoil structure is subject to extensive change, leading to fine crumbly or sponge like arrangements, or compacted zones as well. The open soil cut, presented at the excursion, shows compaction features which are partly caused by heavy traffic around the coal mine.

A typical zone of compaction is the subsoil below the plough layer (27 - 40 cm) where close packing of grains is predominating. Earthworm channels from deeper horizons often do not continue though this zone.

The dark horizons (BtAh and AhBt) contain an appreciable amount of melanized plant tissue fragments in sizes around 1 to 5 µm which may influence the dark external appearance. - Features of clay migration and accumulation are clearly visible but coatings are mainly formed on walls of smaller channels and only less distinct on cleavage planes. The same applies to the following Btv-horizon.

In the C-horizon the carbonates consist generally of calcite microlites, distributed throughout the intergranular matrix. Some efflorescent larger crystals are to be observed in former root channels. Besides, also carbonate concretions were found. They do not exceed cm-size.



Pore-size distribution of the Mollic Luvisol near Echzell (DUMBECK 1986)

Profile No. 2:

Red Paleosol out of volcanites near Lich in the Anterior Vogelsberg

Location: 2.5 km east of Lich, quarry "Eiserne Hose" (iron pants)

Relief: Weakly inclined plain toward the west, 185 m a.s.l.

Geology: Volcanism of the Upper Miocene (basalt, basalt tuff)

Climatic data: Precipitation: 620 mm
about 9 °C mean annual temperature
about -1 to 0 °C mean temperature in January
17 to 18 °C mean temperature in July
230 to 240 days period of vegatation (mean dayly temp. above 5 °C)

Potential natural vegetation: Melico-Fagetum (Luzulo-Fagetum) in colline stage

Soil formation: Intensive weathering in tropical/subtropical climate during the Miocene and Pliocene, development of Plastosols and Latosols; during Pleistocene destruction of Paleosols by erosion and solifluction

Soil association: Wide patches of Red Plastosols, Red Latosols; Cambisols out of solifluction layers with varying content of loess loam over basalt; Rankers in knoll areas; Stagnic Gleysols in hollows

Land use: Former bauxite mine, cultivated land in surrounding areas (mostly cereal crops and corn)

Description of Profile No. 2:

Ah	0-8 cm	Dusky red (10 YR 3/4), humus, slightly clayey loam, pebbly-stony, crumb to subpolyhedric structure, packing density: low, indistinct transition to
Ah Bj	8-30 cm	Dusky red (10 R 3/6), slightly humus loamy clay, strongly pebbly-stony, subpolyhedric structure, packing density: low, well rooted, gradual transition to
Bj 1	30-70 cm	Dark red (2.5 YR 3/6), loamy clay, strongly pebbly-stony, prismatic structure degrading into subpolyhedric structure, packing density: medium, well rooted, gradual transition to
Bj 2	70-120 cm	Dusky red (10 YR 3/6), clayey loam, pebbly-stony, prismatic structure, packing density: high, gradual transition to
Bj 3	120-140 cm	Dark red (2.5 YR 3/6), clayey loam to loamy clay, strongly pebbly-stony, packing density high to very high, gradual transition to
Bj 4	140-180 cm+	Dark red (2.5 YR 3/6), clayey loam, strongly pebbly-stony, packing density: high to very high
II BjCr *		Red (2.5 YR 4/8), Basaltzersatz
II Cv*		Grey (10 YR 5/1), Basaltzersatz

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* see table

Profile No. 2 - Lich

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12199	Ah	- 8		3,6	10,8	9,7	24,2	16,1	16,3	9,9	42,3	33,5		
12200	AhBj	- 30		5,2	8,2	8,3	21,7	12,0	10,8	9,5	32,3	46,1		
12201	Bj1	- 70		4,5	6,6	8,5	19,5	12,2	11,0	9,4	32,6	48,0		
12202	Bj2	-120		7,7	8,4	9,1	25,3	12,1	11,2	12,3	35,6	39,1		
12203	Bj3	-140		5,7	6,4	8,5	20,6	12,1	11,1	11,7	34,9	44,6		
12204	Bj4	-180+		6,0	6,6	9,1	21,7	12,7	11,9	10,7	35,2	43,2		
12206	IIBjCv*			3,4	14,0	32,7	50,1	22,1	10,5	5,7	38,3	11,6		
12205	Cv*			1,8	12,0	37,1	51,0	22,1	12,0	7,7	41,8	7,3		

No	hor.	bulk dens.** g/cm³	GPV** %	water content in Vol.-% at pF** 1.4	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
12199	Ah							5,69	4,99	85,24	2,71	0,03	1050	40
12200	AhBj	1,45	48,7	38,0	37,0	34,8	25,8	6,09	5,55	103,96	2,43	0,02	495	14
12201	Bj1	1,42	49,5	45,5	43,1	39,3	36,8	6,20	5,73	116,86	2,53	0,02	409	21
12202	Bj2	1,47	47,8	44,1	42,1	38,6	35,5	5,17	4,85	138,98	2,67	0,02	310	14
12203	Bj3							5,16	4,90	142,67	2,57	0,02	279	15
12204	Bj4							5,11	4,93	146,78	2,51	0,02	288	10
12206	IIBjCv*	1,17	59,2	52,3	51,0	48,60	34,0	5,50	4,81	74,85	1,50	0,02	783	23
12205	Cv*	1,19	58,7	51.6	49.7	47.4	35.8	5.89	5.45	76.30	1.74	0,02	1125	26

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H + Al	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
12199	Ah	1,43	1,23	11,6		174,5	88,9	57,3	4,0	8,7	0,2	103	3,6	40
12200	AhBj	0,84	1,01	8,3		177,4	110,9	66,8	1,6	16,6	0,4	89	n.n.	48
12201	Bj1	0,68	0,80	8,5		170,9	102,1	66,2	1,0	19,1	0,5	80	n.n.	51
12202	Bj2	0,30	0,51			130,0	48,1	25,8	0,4	9,4	0,7	87	n.n.	28
12203	Bj3	0,30	0,21			129,8	52,1	27,0	0,5	10,4	0,9	88	n.n.	30
12204	Bj4	0,32	0,45			117,4	48,2	27,0	0,5	10,1	0,9	83	n.n.	33
12206	IIBjCv*	0,10	0,28			130,9	58,4	27,9	0,5	10,6	2,6	91	3,3	32
12205	Cv*	0,09	0,26			130,2	61,5	30,3	1,2	11,9	2,2	75	n.n.	35

*Samples taken at southern edges of the open-cut

** Soil physical data from another similar profile

The sequence of horizons given in the description is merely to a little extend the result of younger soil processes. Some agricultural influence is to be mentioned. According to the admixture of loess born material, the upper 70 cm of the profile appears as a younger cover sediment, which is in several places of the open cut also marked by a stone line. The grain size analysis contributes not much to this point because of the uncontrolled dispersion and "pseudo sand" formation of the iron rich material during the laboratory treatment. Thin sections give clear evidence of the loess components.

The following red material, down to a thickness of several meters consists of solifluction debris of Pliocene paleosols. The stones, mixed in nearly allover are nodules of gibbsite which normally preserve basaltic rock fabrics. The microscopic features of the red solum are manifold. They make evident the origin of the material as a weathering product of basaltic rock or tuff. More information, however, is to be found at the transition of red clay-loam into an underlying basaltic saprolite of light gray colour. This part is discovered at the southern edge of the quarry.

Recognizeable units in the saprolite are chiefly iddingsite pseudomorphs after olivine, rim-formations according to pre existing pyroxene aggregates, and pseudomorphs of whitish clay after plagioclase feldspars. Solely the ore component, predominantly ilmenite and some magnetite, is present in unaltered condition. From this an alkaline-olivine-basaltic rock may be reconstructed as parent material.

According to ALTEMOLLER & POETSCH (1984), a feature of general importance is the weathering of ilmenite into red iron oxides and uncoloured titanium oxides at the transition into the red clay-loam. In thin sections under the microscope all stages of transformation are clearly observable, making evident that the red material in contact with the saprolite is a formation in place.

A continuous breakdown of the pseudomorphic clay fabric after plagioclase mineral patterns creates the higher density of the red clay-loam and also contributes to the noticeable translocation of reddish fine clay along cleavage planes in the saprolite. Clay material of the coatings consists mainly of kaolinite and halloysite and resembles so far the whitish clay matrix of the saprolite. The main difference is based on the content of fine dispersed iron oxides.

Profile No. 3:

Cambisol with high humus content near Rebgeshain in the Upper Vogelsberg

Location: 50 m north-west of the road Ulrichstein - Rebgeshain
topographical map 1 : 25,000, sheet Ulrichstein, No. 5421
coordinates: H: 56 03 750, R: 35 16 125

Relief: Very weakly inclined plateau to the north, 615 m a.s.l.

Geology: I. Solifluction layers ("Decksediment") of the Late Würm period, composed of relictic weathered basalt loam, only slightly weathered basalt debris (stones with weathering crusts), and loess loam over
II. relictic weathered basalt (saprolite, "Basaltzersatz"), developed from Upper Miocene to Early Pleistocene

Climatic data: Precipitation: 1,000 to 1,100 mm
6 to 7 °C mean annual temperature
-3 to -2 °C mean temperature in January
15 to 16 °C mean temperature in July
Period of vegetation:

Potential natural vegetation: Dentario-Fagetum (eutraphent, Upper Montane stage)

Soil formation: Intensive chemical basalt weathering during Young Tertiary (and Old Pleistocene?); erosion, frost weathering, aeolian processes and solifluction during Pleistocene; development of Cambisols during Holocene

Soil association: Mostly Cambisols, on knolls Rankers also, in hollows Colluvia or hydromorphic soils

Land use: Formerly arable land, now grass land.

Description of Profile No 3:

Ah	0-3 cm	Dark brown (10 YR 3/3), strongly humus silty loam, grity; crumb structure, packing density: low, very well rooted, indistinct transition
rAp	3-18 cm	Dark brown (10 YR 3/3), strongly humus silty loam, grity-stony; crumb structure, packing density: low, very well rooted; distinct, even transition
AhBv1	18-40 cm	Dark brown (10 YR 3/3), humus silty-sandy loam, grity-stony; crumb to subpolyhedric structure, packing density: low, indistinct transition
AhBv2	40-65 cm	Dark greyish-brown (10 YR 4/2), humus silty-sandy loam, grity-stony; crumb to subpolyhedric structure, packing density: low to medium; distinct, even transition
IIBv	65-70 cm	Dark yellowish-brown (10YR 3/4), slightly humus, strongly loamy sand, grity-stony
IICv	70-90 cm +	Decomposed basalt

Profile No. 3 - Rebgeshain

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12207	Ah	- 3	30	2,3	5,5	15,1	22,9	17,6	20,3	13,9	51,7	25,4		
12208	rAp	- 18	40	3,1	5,2	14,3	22,7	17,3	20,8	12,4	50,5	26,9	126,7	
12209	AhBv1	- 40	60	4,7	9,0	19,6	32,9	16,3	17,2	12,4	45,9	20,7	974,0	
12210	AhBv2	- 65	60	6,0	11,6	18,9	36,5	17,8	16,6	11,6	46,0	17,5		
12211	IIBv	- 70	60	5,3	15,0	27,9	48,2	17,9	11,8	8,2	37,9	13,9		
12212	IICv	- 90 +	30	15,2	20,6	25,8	61,6	15,2	8,8	5,5	29,4	9,0		

No	hor.	bulk dens. g/cm^3	GPV %	water content in Vol.-% at pF 1.4	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
12207	Ah							5,63	6,19	30,26	17,07	0,56	1117	210
12208	rAp		52,4			30,6	12,6	5,55	6,27	30,17	15,60	0,52	952	109
12209	AhBv1		47,9			27,0	10,8	5,47	6,18	26,42	14,34	0,54	881	185
12210	AhBv2							5,50	6,27	24,72	12,58	0,51	820	228
12211	IIBv							5,54	6,30	26,22	8,75	0,33	802	272
12212	IICv							5,58	6,44	16,89	5,00	0,30	418	343

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H + Al	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
12207	Ah	4,38	3,52	12,4		519,3	342,0	261,3	1,5	68,6	1,3	184	9,9	64
12208	rAp	3,15	3,05	10,3		476,5	278,4	187,2	0,8	75,9	1,2	211	10,4	56
12209	AhBv1	2,22	2,29	9,7		486,4	297,0	174,7	0,5	102,6	2,2	210	9,0	58
12210	AhBv2	1,66	1,66	10,0		475,4	281,7	168,5	0,4	113,0	2,7	191	7,4	60
12211	IIBv	0,91	0,92	9,9		511,6	350,3	193,8	0,6	138,6	3,1	180	4,9	66
12212	IICv	0,36	0,47	7,7		323,1	198,5	121,7	0,4	84,4	3,8	116	1,3	65

Profile No. 3

The admixture of loess derived material in the upper layer is already indicated by the high content of coarse and medium silt (cf. grain size distribution). This is confirmed by microscopic studies. Observations on their sections show moreover that a large portion of grains is originating from basaltic material. The minerals (olivine, pyroxene, plagioclase etc) show distinct weathering features, whereas rock fragments include both, rather fresh basalt debris and fragments of saprolite as well.

The clay matrix appears in transmitted light still relatively dark brown and covers nearly all mineral and rock surfaces,so that in field observations even with a hand lens, mineral surfaces are rarely visible. There are no indications of any clay migration and no orientation patterns. The clay material seems to be very stable and obviously causes the predominating crumb structure which is also to be found in microscopic size ranges.

A stone line, distinct in some places, separates the cover sediment from the saprolitic basalt and some basaltic clay-loam. Compared to profile No. 2, the degree of weathering is much lower. Most of the minerals are still present, but more or less altered. Cores of fresh basalt are also still existing.

Profile No. 4:

Loose Brown Earth over decomposed basalt in the Köhlerwald, Upper Vogelsberg

Location: Schotten forest range, dept. 388 b, "Köhlerwald", 10 km east of Schotten
topographical map 1 : 25,000 sheet Ulrichstein No. 5421
coordinates: H: 56 03 750, R: 35 16 125

Natural landscape unit: Upper Vogelsberg

Relief: Middle slope, slightly inclined toward the south-east, 656 m a.s.l.

Geology: I. Solifluction layers of the Late Würm period ("Decksediment" of the Younger Tundra period), composed out of: loess loam, relictic weathered basalt loam, weathered pumice tuff and only slightly weathered* basalt stones over

II. older Pleistocene solifluction layers ("Mittelschutt"), composed out of loess loam, relictic weathered basalt loam and only slightly weathered* basalt debris over

III. decomposed basalt ("Basaltzersatz")

Climatic data: Precipitation: about 1,200 mm
5 to 6 °C mean annual temperature
below -3 °C mean temperature in January
14 to 15 °C mean temperature in July
period of vegetation: 180 to 190 days (av. dayly temp. above 5 °C)

Land use: 94 years old stand of Picea abies, site quality class 1.0; (first generation), before extensive pasture

Vegetation: Picea abies
Fagus silvatica
Dryopteris spinulosa
Avenella flexuosa
Polytrichum attenuatum
Majanthemum bifolium
Galium saxatile
Oxalis acetosella
Anemone nemorosa
Sorbus aucuparia
Vaccinium myrtillus
Equisetum silvaticum
Stellaria nemorum
Senecio fuchsii
Milium effusum
Lycopodium annotinum
Epilobium angustifolium

Potential natural vegetation: Luzulo-Fagetum (mesotraphent, Upper Montane stage)

Soil formation: Like Profile No. 3, except: development of Loose Brown Earth during Holocene

Soil association: Loose Brown Earth, Cambisols, Slope Gleysols, Slope Stagnic Gleysols, and Spring-water Gleysols

* unweathered basalt stones with only thin weathered crust

Description of Profile No 4:

L		Needle mulch
Of		Decomposed mulch
Oh		Black fine humus
Ah	0-6 cm	Dark brown (7.5 YR 3/2), silty-clayey loam, strongly humus, crumb structure, packing density: extremely low, very well rooted, distinct undulating transition
AhBv	6-10 cm	Reddish dark brown (7.5 YR 3/4), silty-clayey loam, slightly stony, strongly humus, crumb to coherent structure; packing density: extremely low (extremely loose), well rooted, distinct undulating transition
Bv1	10-25 cm	Yellowish-brown (7.5 YR 4/6), loamy silt, slightly grity-stony, foamy coherent structure, packing density: extremely low (extremely loose), strongly rooted, distinct wavy transition
Bv2	25-45 cm	Yellowish-brown (7.5 YR 4/6), silty loam, grity-stony, foamy coherent structure, packing density: extremely low (extremely loose), indistinct wavy transition
Bv3	45-60 cm	Yellowish-brown (7.5 YR 4/6), silty loam, grity-stony, foamy coherent structure, packing density: extremely low; wavy, indistinct transition
IIBv1	60-90 cm	Dark yellowish-brown (7.5 YR 4/4), silty loam, grity-stony, loose coherent structure, packing density: very low; wavy, indistinct transition
IIBv1	90-115 cm	Brown to dark brown (7.5 YR 4/6), silty loam, grity-stony, subpolyhedric to coherent structure, packing density: low, still weakly rooted
IIBv2	115-125 cm +	Dark brown (7.5 YR 5/6), silty loam, grity-stony, subpolyhedric structure, packing density: low to medium

Profile No. 4 - Köhlerwald

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12213	L	0,5/1												
12214	Of	1,5/2												
12215	Oh	2/4												
12216	Ah	0 - 6	20	1,0	2,3	3,9	7,3	20,5	22,1	14,1	56,9	35,7		
12217	AhBv	- 10	11	1,3	2,4	3,8	7,6	19,9	21,2	17,2	58,3	34,1	1022	
12218	Bv1	- 25	8	1,6	3,8	14,3	19,7	30,8	24,3	14,4	69,5	10,6*)		
12219	Bv2	- 45	23	2,3	3,7	6,2	12,3	24,8	23,3	14,1	62,2	25,4	3008	
12220	Bv3	- 60	37	2,1	5,7	9,2	17,0	23,6	22,3	12,1	58,1	24,8	1409	
12221	IIBv1	- 90	44	2,2	6,0	9,9	18,2	23,9	20,6	12,9	57,5	24,2	667	
12222	IIBv2	-115	43	2,1	6,7	10,9	19,7	27,1	20,2	11,8	59,2	20,8		
12223	IIBv3	-125+	28	2,7	8,2	12,4	23,4	28,8	20,1	8,8	57,7	18,7		

No	hor.	bulk dens. g/cm^3	GPV %	water content in Vol.-% at pF 1.4	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
12213	L							3,89	3,20		0,50		46	275
12214	Of							3,85	2,93		2,23		46	110
12215	Oh							3,62	2,79		4,37		26	46
12216	Ah							3,86	3,08	38,40	19,70	0,51	138	50
12217	AhBv	0,51	80,6	59,7	51,0	38,5	11,3	4,02	3,46	37,56	22,26	0,59	765	44
12218	Bv1							4,47	4,01	36,89	13,85	0,38	174	103
12219	Bv2	0,57	78,6	57,6	45,2	35,1	12,8	4,46	4,09	39,51	12,73	0,32	347	92
12220	Bv3	0,83	70,1	52,7	43,5	36,1	14,3	4,41	3,91	43,78	6,69	0,15	488	45
12221	IIBv1	1,17	57,5	49,8	46,7	41,6	18,1	4,37	3,90	43,86	6,12	0,14	502	36
12222	IIBv2							4,75	4,03	53,34	6,93	0,13	212	43
12223	IIBv3							5,12	4,21	51,40	8,19	0,16	130	23

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H + Al	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
12213	L	45,85	19,76	23,3		772,4	198,4	55,1	15,0	10,8	1,5	696	0,8	1
12214	Of	44,85	15,84	28,3		1226,4	300,3	54,3	9,3	8,8	1,8	1093	5,9	6
12215	Oh	39,85	15,86	25,1		1182,2	284,3	42,3	5,0	7,5	1,1	1141	19,7	5
12216	Ah	11,40	4,13	27,6		605,1	194,2	7,9	1,6	4,1	0,5	593	38,4	2
12217	AhBv	8,61	3,06	28,1		536,3	123,5	3,5	0,8	2,1	0,3	534	26,1	1
12218	Bv1	5,45	2,33	23,4		385,2	48,1	1,1	0,4	0,6	0,1	424	38,4	< 1
12219	Bv2	2,03	1,00	20,3		250,8	22,6	0,7	0,3	0,4	0,1	300	29,0	< 1
12220	Bv3	0,96	0,52	18,5		268,2	68,4	1,1	0,5	1,0	0,3	304	32,0	1
12221	IIBv1	0,83	0,59	14,1		255,6	57,5	1,0	0,5	0,9	0,3	296	42,3	1
12222	IIBv2	0,65	0,54	12,0		250,8	67,2	7,3	0,4	9,5	0,6	238	27,0	7
12223	IIBv3	0,33	0,31	10,6		226,0	62,4	12,6	0,4	22,7	0,9	196	16,2	16

*Pretreatment according to DIN 19683, sheet 2; change of data corresponding to intensive sesquioxide destruction

Profile No. 4

The most characteristic structural features of the Loose Brown Earth are developed in the solum consisting of the horizons Ah to Bv3. This corresponds generally to the cover sediment layer. High porosity values with remarkable amounts of coarsepores are caused by a system of aggregation through several size classes and obviously very high stability. Larger aggregates are arrangements of smaller ones wherein still smaller congulates are observable. A clay size material of yellowish-brown colour, completely isotropic, is the binding substance. It forms the finest congulates as well as interconnected coatings around mineral grains or rock fragments. There are no migration features of any kind. The absolute absence of clay orientation patterns is typical for clay materials with high allophane content. The clay material is also rich in iron oxides originating from the basaltic rocks. Sesquioxide destruction, as pre-treatment for mechanical analyses, can reduce the clay values more than one half (cf. Table).

The deeper layer of debris ("Mittelschutt") still contains mixed loess and basaltic material, but now in much more dense packing. Features of clay orientation are locally present, but generally not in place. These are remnants of earlier soil processes, transported by solifluction.

Profile No. 4 - Köhlerwald

fraction	horizon	0.426nm quartz	0.483nm gibbsite	0.441nm halloysite	0.715nm kaolinite	1.0nm illite	1.0-1.4nm *	1.4nm Mg-chl.	1.4nm Al-chl.	1.4-1.8nm **	1.8nm** smectite	1.8nm***
2 - 0.2 µm	B_{v1}	+	+	+	++	+	(+)	++	+++			
	B_{v2}	++	+	+	+++	++	++	++	+++			
	IIB_{v1}	+	++	++	+++++	+++	++	+++	++			
	IIB_{v2}	+	++	+	+++	++	(+)	(+)	+			
0.2 - 0.06 µm	B_{v1}			++	+++					+++		+++
	B_{v2}			++	+++					++		+++
	IIB_{v1}			+++	++++	+				+		+++
	IIB_{v2}			++	+++	+				+		+
< 0.06 µm	B_{v1}			++++	+++					+++		+++++
	B_{v2}			++++	++++					+++		++++
	IIB_{v1}			+++	++++	+				++		+++
	IIB_{v2}			+++	+++	+				+		(+)

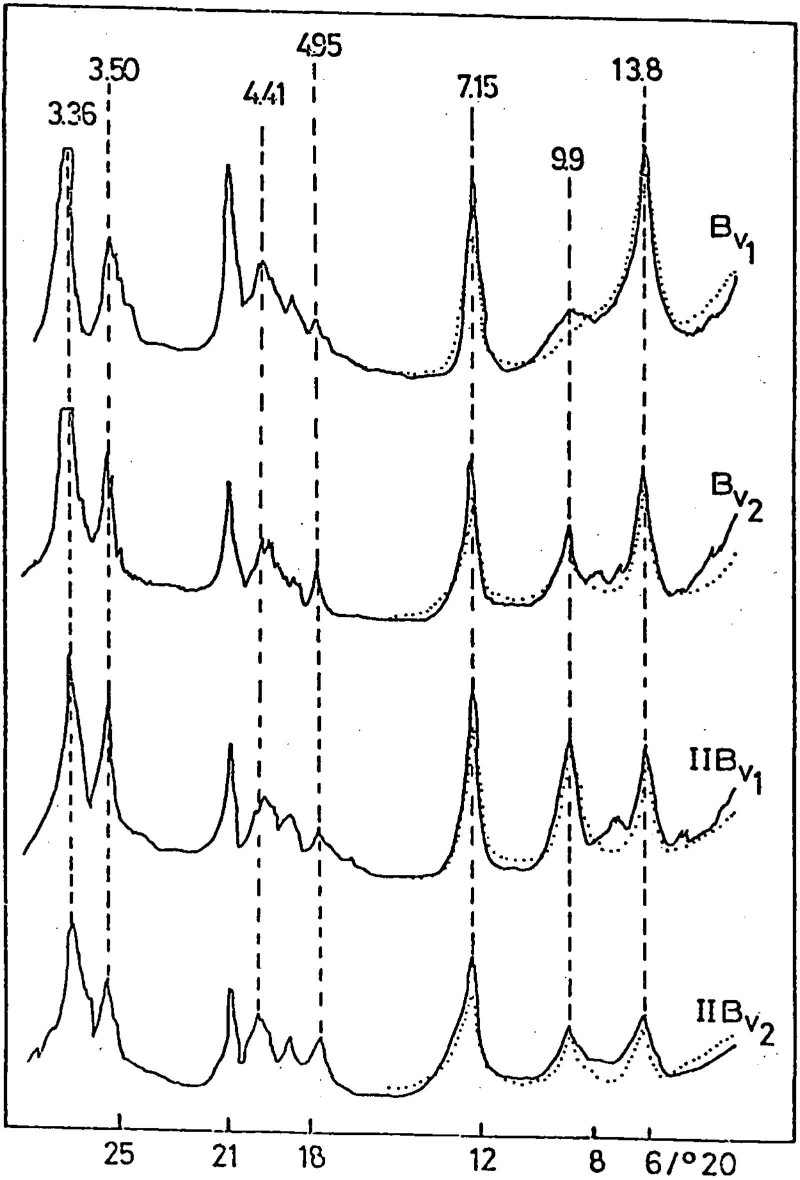
Composition of clay minerals of analysed fractions (coarse clay 2-0.2µm, medium clay 0.2-0.06µm, fine clay < 0.06µm in the Loose Brown Earth (HILGER-ALEXANDROU 1976)

* interstratified illite-smectite

** interstratified vermiculite-smectite

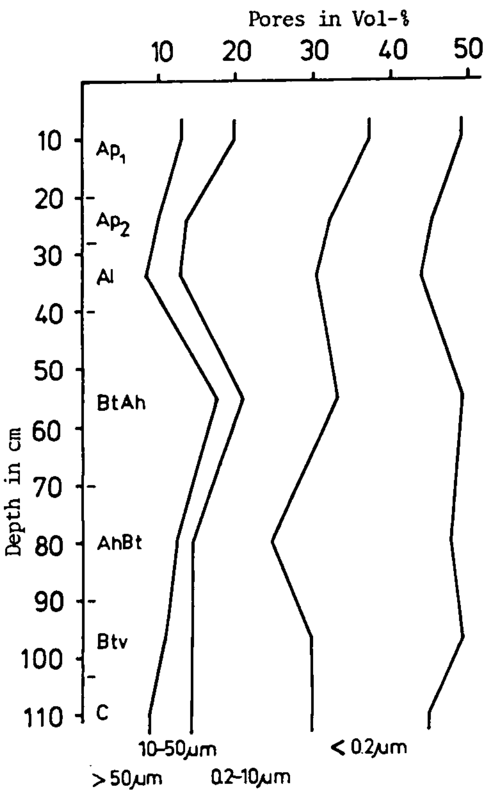
*** labile minerals

Profile No. 4 - Köhlerwald



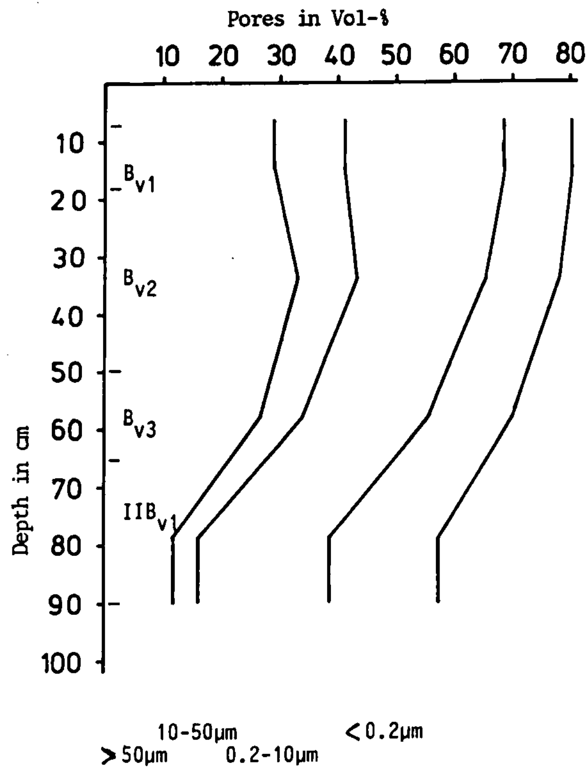
X-ray diagrams of the total clay fraction (<2 µm) of typical Loose Brown Earth (HILGER-ALEXANDROU 1976)

Profile No. 1



Pore-size distribution of the Mollic Luvisol near Echzell (DUMBECK 1986)

Profile No. 4



Pore-size distribution of the Loose Brown Earth in the Köhlerwald

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Mitteilgn. Dtsch. Bodenkundl. Gesellsch. 46, 225-226 (1986)

Excursion A, 6th and 7th Day

by

B. Meyer, Göttingen

Description of landscapes and soils were not prepared in time. They can be found in the following literature:

Forest of Göttingen with Rendzina and Terrafusca	Meyer et al. 1985
Drakenberg with Rendzina under agriculture	Ahl et al. 1985
Hildesheimer Börde with Chernozem	Meyer and Roeschmann 1971
Wietzeniederung with Raseneisengley	Roeschmann 1971
Lüneburger Heide with Bänderparabraunerde and Podzol	Roeschmann 1971

Literature

Ahl, Chr., H.-G. Frede, B. Meyer, V. Thomsen, I. Wang, and H. Wildhagen: Agrar-Ökosystem-Meß- und Versuchsflächen auf Rendzina-Terra-Fusca-Flächen des oberen Muschelkalks auf dem Drakenberg bei Göttingen. Mitteilgn. Dtsch. Bodenkundl. Gesellsch. 42, 321-358 (1985)

Meyer, B., R. Jörgensen, P. Hugenroth and Chr. Ahl: Entwicklung und Gesellschaft der Böden aus Kalkstein im Muschelkalk-Gebiet des Göttinger Waldes. Mitteilgn. Dtsch. Bodenkundl. Gesellsch. 42, 437-453 (1985)

Meyer, B. and G. Roeschmann: Die Lößbörden am Nordrand der Mitteldeutschen Schwellen - Das Schwarzerdegebiet um Hildesheim. Mitteilgn. Dtsch. Bodenkundl. Gesellsch. 13, 287-310 (1971).

Roeschmann, G.: Die Böden der nordwestdeutschen Geest-Landschaft. Mitteilgn. Dtsch. Bodenkundl. Gesellsch. 13, 151-231 (1971)

Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 46, 227-248 (1986)

Excursion A, 8th Day

Wetland soils in Lower Saxony

by

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General Outline

Lower Saxony is the region with the highest percentage of peatlands (430.000 ha = 9,1 %) in the Federal Republic, of which raised bogs comprise 240.000 ha. The geographical distribution of raised bogs is given in Fig.1.

The excursion area (Fig.2) including the raised bogs Ekelmoor and Königsmoor is located at the north-west border of the "Lüneburger Heide" (national park) approximately half way between Hamburg and Bremen.

Geology

During the Drenthe stadial of the Saale glacial this area had been passed over by the Scandinavian glaciers. At the spreading glacier edge gravelly sands had been deposited during the summer melt, which had been overlayed by the ground moraine of the progressing glacier. After the interior ice had vanished a new move of the Scandinavian glaciers took place towards the end of the Drenthe stadial. Again melt water sands and a ground moraine were formed and during a short stop of the glaciers the Otterhill had been built up.

During the Warthe stadial the region remained without ice. In the Eem-Interglacial alluvial sedimentation and growth of fens (low moors) occurred in the valleys. However, most of these layers had been eroded again during the Warthe-glacial before sedimentation of fluvial sands took place. On top of the perma-frost-soil a flat diffusion of these sands had happened. Due to poor vegetation sands had been blown out forming dunes. Large parts of the moraine have been supported by sands from fluvial as well as aerial deposition in the Weichsel-stadial, especially the northern and eastern part (Otterhill).

Already in the Alleröd-interstadial (10.000-9.000 BC) the development of fens from green mosses-sedge peat began in the blowing off flats, which had resulted from the drifting sandhills (SCHWAAR, 1983). It should be emphasized that dune formation had occurred since the early historical time due to human activity (SCHNEEKLOTH, 1963).

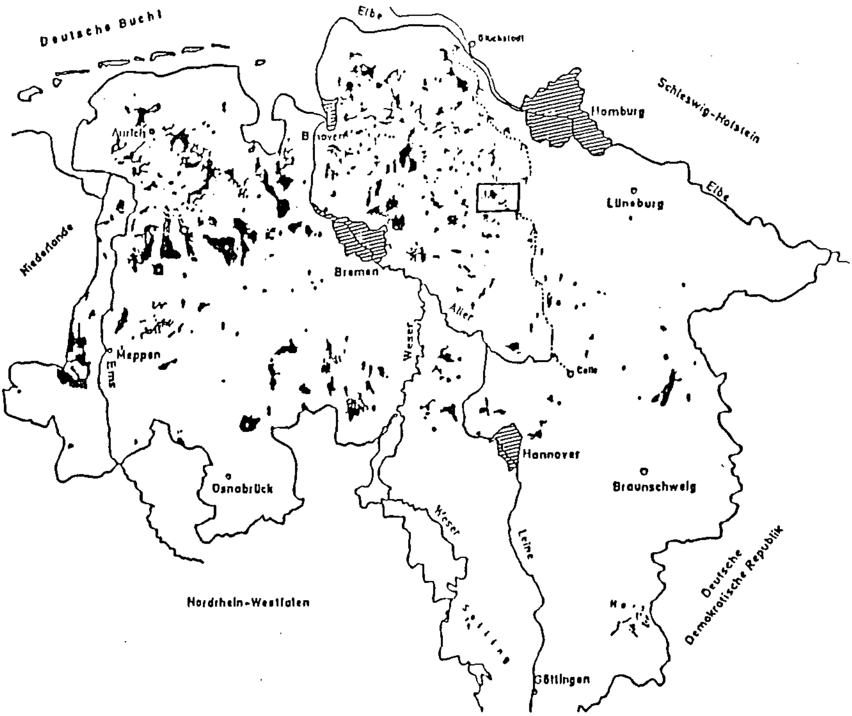
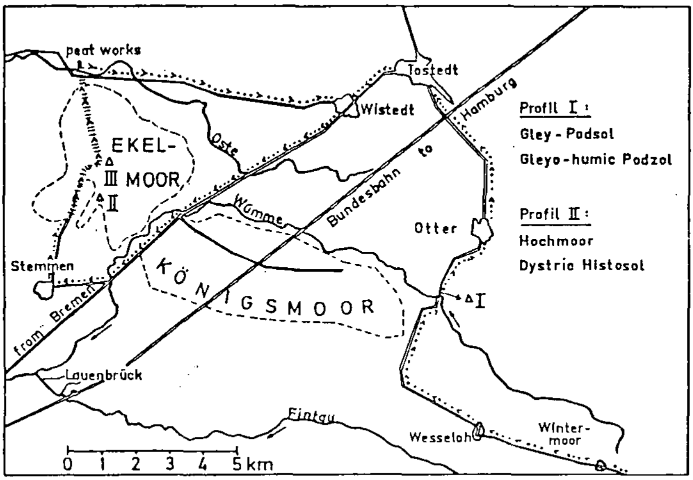


Fig.1: Map of the raised bogs in Lower Saxony (acc.to Schneekloth, 1983)



<·····<·····<·· Route of excursion △ Stop

Fig.2: Map of the excursion area

Climate

Table 1: Climatological Data

Average temperature	7.8°C		
Total average rainfall	645 mm		
Summer rainfall	351 mm		
Evapotranspiration average	400-450 mm		
Climatic water balance	+200-250 mm		
Ave.rel.humidity	83 % (75-100 %)		
Duration of sunshine	1.583 hrs (April-Oct.: 1.200 hrs.)		
Number of days with:		Rainfall>0,1 mm	188
		Fog	91
		Frost at 2 m height	99
		Ground frost	142
		Max.Temp.≥ 25°C	18

Vegetation

The current vegetation of the northwest German lowland is strongly influenced by human activity. Since in most cases the soils have been formed primarily by climate and vegetation of former times, for better understanding the post-glacial development of vegetation and climate should be explained.

SCHWAAR's results of pollenanalytical investigations will be referred to in Table 2 (Pollenzones).

The potential natural vegetation has been surveyed by KRAUSE and SCHRÖDER (1979):

1. Elevated Plaines and Dunes
Oak-birch forest has been the dominating association. On mineral soils rich in nutrients (moraine areas with gleyic brown earth) beeches and hornbeams could have maintained. Pine forests (Dicrano-Pinion) have been dominating on acid soils like poor sand dunes.

2. Lowlands (ground water)
The lowlands as well as their borders influenced by high ground-water level have been covered by alder swamps (Carici elongatae-

Alnetum). The surroundings of springs would be occupied by Parvo Caricetum (Scheuchzerio-Caricetea fuscae).

3. Raised Bogs

According to our own investigations the dominating plant association of virgin bogs has been mainly consisting of mixed peat mosses (Sphagnetum magellanici) next to a hollow association (Rhynchosporetum albae). In the transition to the mineral soils and low moors, respectively, birch swamps (Betuletum pubescentis) and bog myrtle shrubs (Myricetum gale) were found.

4. Cultivated Areas (Deep Plough Cultivation)

The potential natural vegetation of deep plough soils is not known yet.

Table 2: Formation of late and post glacial in the excursion area (SCHWAAR, 1983)

Time scale	Pollen-zones*	Vegetation	Climate-zones	History
1000 A.D.	XII	Heath, culture vegetation	Subatlanticum	Middle age
	XI	Oak-birch forests Oak-beech forests		Mass imigration Roman time
	X	Spreading out from beech and hornbeam	cool and wet	Iron age
1000 B.C. 2000 3000	IX	Pine-oak forests with elms and limes	Subboreal warm and dry	Bronze age Neolithicum
4000 5000	VIII	Pine forests with elms and limes	Atlanticum warm and wet	Mesolithicum
6000 7000	VII + VI	Pine forests	Boreal warm and dry	
8000	V	Birch-pine forests	Pre-Boreal	
9000	IV	Tundra with pine and birch	young. Dryas subarctic	Palaeolithicum
10000	III	Light Birch-pine woodlands	Alleröd subarctic warm summer	

* Pollenzones (OVERBECK)

Soils

The geographical distribution of elevated plaines and melt water gullies of the Saale-glacial is evident in the soil map (Fig.3).

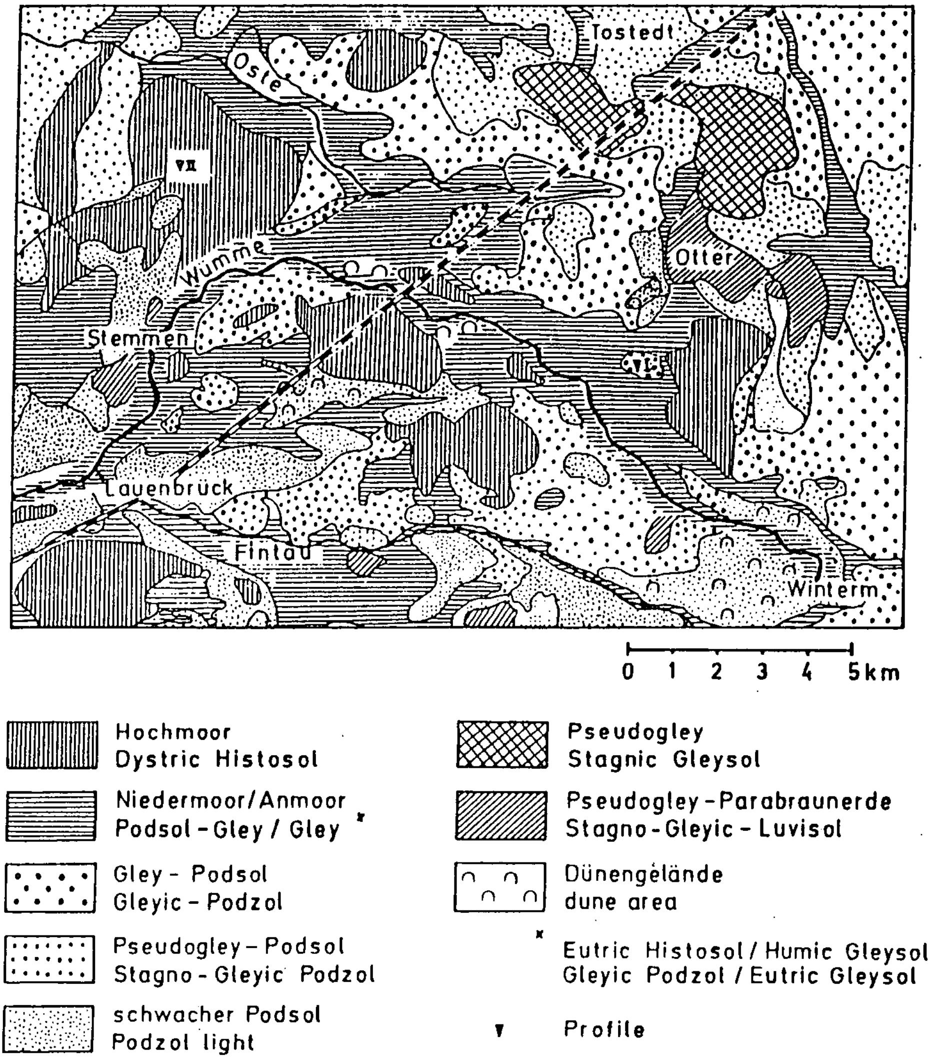


Fig.3: Soil map of the excursion area

Soil Types of the Ground Moraine

The elevated area of the glacial (Saale) ground moraine is located northeast (Otter) and northwest (Stemmen) framing the actual area of the excursion. It is cut through by the Oste and Wümme river valleys.Densely packed bolder clay has been the initial substrate for gleyic soils (FAO: Stagnic gleysols) and gleyic Parabrown Earth (FAO: Stagno-gleyic luvisols). On fine and coarse sands which covered the elevated plaines in varying thickness Gley-Podzols (FAO: Stagno-gleyic podzols) have formed. Typical podzols are found on fine sands of larger thickness and locations close to the Geest border only.

Soil Types of the Sanders (Lowland pleistocene sand)

The wide valley lowland formed by melting water between the high plaines is covered by fluvial, eolian and dune sands. As a function of relief and depth of ground water fens, histic gleysols, humic gleysols and transition podzol gleysols developed. Flat remainder of former dunes inbetween the sander area are covered by gleyic podzols (Profile 1).
Podzolic gleye soils and gleyic podzols should be described as "drowned" podzols, i.e. they became influenced by ground water not before the Atlanticum period.

Soil Types of the Dune Areas

Dunes formed during the Weichsel glacial time are found especially on the sander areas of the Wümme Valley. On the dunes of great height (< 20 m) far from the groundwater typical podzols developed.

The pleistocene sediments as well as the covering dune sands usually have a low nutrient content. Therefore, almost all mineral soils of the area more or less have been podzolized.

Raised Bog Soils

On sandy soils of eolian or pleistozene origin located in river valleys primarily unaffected by ground water usually podzols were formed first. The rising water table, however, turned the soils into swamps (gleyic podzols). After a transitional stage with a birch forest swamp the surface rose out of the ground water. With the beginning of mesotrophic and finally oligotrophic conditions the growth of Sphagnum species forming the raised bog became possible. Finally large areas of the land surface covered with it. Also podzols which never were influenced by ground water with changing climate were overgrown by raised bogs (own-rooted raised bogs). Only in depressions and blown-out tubs where a nigh water table occurred from the beginning peat formation of leafy-moss sedge peat and in some cases muds formed the basis of the bogs

Anthropogenic Soils

These comprise soils recently initialized by deep-plough cultivation of raised bogs over sand (German Deep Plough or Sand Mix Cultivation) or podzols (Heath Cultivation).

Stop 1

Description of the Location

Location	Otter; TK 25 Bl.Tostedt 2724
Elevation:	+45 m above sea level
Slope:	Levelled - slightly sloped towards W.and S. flat ridge
Drainage:	None
Vegetation:	Ericetum tetralicis
Utilization:	Occasional sheep grazing
Parent material:	River dune, sander of the Saale glacial (Warthe stadial) end moraine
Soil classification:	German: Gley-Podsol
	FAO: Gleyo-humic Podzol
	USDA: Spodic Psamaquent

Description of the Profile No.1

Depth (cm)	Horizon	Description
0- 1	L	Litter cover, weakly decomposed Erica-roots and stalks with rests of leafy moss and liches
-12	Of	Raw humus, moderately decomposed. Erica and Calluna roots with sand
-15	Oh/Ah	Strongly humic fine to medium sand, plant residues not detectable microscopicly
-27	Ae	Fine to medium textured sand, extremely eluated, some recent rooting
-55	Bh	Strongly developed humic ortstein. -42 cm darkly coloured, some fossile roots. Lower part occasionally influenced by ground water and capillary fringe, slightly bleaded, ortstein less compacted due to wetness
-75	Bv/Go	Brown color, weak lamination
>75	Gr/C	Increase of coarse and medium sand, permanent ground water

Table 3: Analytical data - Gley Podsol - Otter

No.	hor.	depth cm		texture in % of humus -/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	L	0-1												
2	Of	-12											15	
3	Oh/Ah	-15		2	59	34	95	2	0,9		3	2	n.a.	
4	Ae	-27		2	53	42	97	1	0,3		2	1	61	
5	Bh	-55		2	63	31	95	2	0,8		2	3	4	
6	Bv/Go	-75		4	49	45	98	0,2	0,5		1	2	136	
7	Gr/C	> 75		3	71	25	98	0,2	0,1		0,3	2	10	

No.	hor.	bulk dens. g/cm³	GPV %	water content in Vol% at pf 1.0	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d		
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	L	0,30	n.a.	n.a.	n.a.	n.a.	n.a.	4,0	2,8	1,9	0,8	0,4		
2	Of	0,46	75		66	51	26	3,7	2,6	0,5	0,3	0,6		
3	Oh/Ah	1,20	n.a.	n.a.	n.a.	n.a.	n.a.	3,6	2,7	0,3	0,3	1,0		
4	A_e	1,47	38		12	6	2	4,1	3,2	0,1	0,05	0,5		
5	Bh	1,36	39		27	21	8	3,9	3,2	0,2	0,1	0,5		
6	Bv/Go	1,51	38		12	5	3	4,5	3,9	0,1	0,05	0,5		
7	Gr/C	164	36		12	5	2	4,9	4,3	0,1	0,05	0,5		

No	hor.	C org. %	N_t %	C:N	carbon	CEC* pot. meq/l	CEC* act meq/l	exchang. cations in meq/l Ca	K	Mg	Na	H	Al	V pH 7,0 %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	L	39,4	1,5	25		270	178	11	3	6	1	(282)	n.a.	7
2	Of	25,2	0,68	17		300	187	6	1	5	1	323	n.a.	4
3	Oh/Ah	4,7	0,22	22		244	162	2	01	4	0,5	286	n.a.	2
4	A_e	0,95				57	29	n.a.	n.a.	n.a.	n.a.	63	n.a.	0
5	Bh	2,8	0,05	52		191	94	n.a.	n.a.	n.a.	n.a.	191	n.a.	0
6	Bv/Go	0,6				86	33	n.a.	n.a.	n.a.	n.a.	83	n.a.	0
7	Gr/C	0,4				35	22	n.a.	n.a.	n.a.	n.a.	41	n.a.	0

CEC_{pot}: pH 7,0 CEC_{act}: pH 5,0

Stop 2

Location:	Ekelmoor; TK 25 Bl.Sittensen 2723
Elevation:	+36 m above sea level
Slope:	Flat, levelled
Drainage:	None
Vegetation:	Raised bog covered with heath (Molinia coerulea Erica tetralix and Calluna vulgaris). Bush land in some spots with Pinus sylvestris, Betula pubescens and Myrica gale. In some spots the initial stadium of peat formation (Sphagnetum magellanici) can be observed
Utilization:	Natural Conservation Area
Parent material:	Typical raised bog peat above swamp forest, in some spots mud Mineral subsurface: Glaciated sands, alluvial, partial eolian sands
Soil Classification:	German: Hochmoor FAO : Dystric Histosol USDA : Typic Sphagnofibrist

Renaturation of a cut-over peatland

Actual Vegetation:

After the end of industrial peat cutting (hand-cut) the natural vegetation reestablished. The beginning cannot be dated precisely. According to the Bog Conservation Law 1923 and 1955 the saved top spit (Bunkerde) was spread on the surface levelling most of the former ditches. The actual vegetation is determined by peat depth as well as by presence of the forest near by.

Plant Associations:

1. Sparse encroachment by shrubs with herbacious vegetation (Molinia)

Shrubzone:	Pinus, Betula, Myrica gale
Herbacious zone:	Molinia coerulea, Erica tetralix, Eriophorum vaginatum, young plants of Betula and Myrica, sporadically Calluna and Eriophorum angustifolium
Soil surface zone:	Various Sphagnum mosses, leafy mosses and liverwort species

2. Sphagnum-assosiation - without shrubs

   - peat depth > 2 m -

Herbacious zone:	Molinia coerulea, Erica tetralix, Eriophorum vaginatum, Eriophorum angustifolium, Drosera rotundifolia, Drosera intermedia, mixed with Betula-, Pinus- and Myrica plantlets

Soil surface zone: Sphagnum magellanicum (typical moss of the raised bog hummock association), Sph.rubellum, Sph.papillosum, Sph.tenellum, Odontoschisma sphagne and Cephalozio connivens occur on some areas (all species of virgin bogs). Sph.subsecundum, Sph.imbricatum, Sph.palustre (Sphagnum mosses of more mesotrophic conditions)

3. Molinia coerulea association - without Sphagnum species

- peat depth < 1 m, in some areas < 0,5 m -

Shrub zone: not existing

Herbacious zone: Molinia coerulea (dominant)
Erica tetralix, Eriophorum vaginatum, Calluna vulgaris. Sporadically Drosera rotundifolia, Eriophorum angustifolium

Soil surface zone: Liverwort: (Odontoschisma sphagni, Telerania setacea, Cephalozia connivens). Leafy mosses retreat.

The species observed here certainly represent different ecological conditions. Despite the occurence of larger areas with little Sphagnum dominated by Molinia, the present water regime should allow the regeneration of raised bog in the total area. The occurrence of Liverwort and Drosera rotundifolia indicate a sufficient water regime. Therefore, the expansion of Sphagnum species on to these areas should be a matter of time.

Stop 3

Site Description

Location: Ekelmoor, TK 25, Sittensen Bl.2723

Elevation: +36 m above sea level. Ekel-Hill: +38,9 m msl

Slope: Flat, levelled

Drainage: Ditches for peat cutting

Vegetation: Remaines of a raised bog community with Calluna vulgaris

Utilization: Total area of the Ekelmoor:
12 km^2
5 km^2 industrial peat-cutting
3 km^2 agricultural use
3 km^2 waste land
1 km^2 forest

Parent material: Raised bog peat above forest-swamp peat
Depth of the raised bog: 2-3 m, max.3,4 m
Mineral subground: Periglacial cover sand, fluvial sands, partly eolian sand cover

Soil Classification: German: Typisches Hochmoor
FAO : Dystric Histosol
USDA : Typic Sphagnofibrist

Description of the profile No.2 - Ekelmoor - dystric histosol

No.	Depth (cm)	Horizon	Description
1	0- 25	yY/hH	Slags mixed with raised bog peat, dark grayish brown (5 YR 2/2), many roots from E.tetralix, Molinia; main peat components: Sph.magellanicum, Sph.imbricatum, Sph. papillosum
2	25- 75	hH_1	Sphagnum-peat (Hhs), dark reddish brown (5YR 2/2 m), very weak to weak decomposed (H 2-3), Sph.imbricatum, Sph.Acutifolia-Section
3	75-102	hH_2	Sphagnum-peat (Hhs), dark brown (5YR 2/1 m) weak decomposed (H 3-4), Sph.imbricatum, Eriophorum vaginatum
4	102-115	hH_3	Sphagnum-peat (Hhs), dark reddish brown (5YR 2/2 m), very weak to weak decomposed (H 2-3), Sph.imbricatum, Sph.Acutifolia-Section
5	115-143	hH_4	Sphagnum-peat (Hhs), dark brown (5YR 2/1 m) weak to medium decomposed (H 4-5), Sph. imbricatum, Sph.Acutifolia-Section
	^{14}C-Dating^{+}: 260 B.C., beginning of the white peat formation		
6	143-202	hH_5	Eriophorum-Calluna-peat (Hhei), black (5YR 1,7/1 m), medium decomposed (H 5-6), Calluna vulgaris, Eriophorum vaginatum, Sph.imbricatum
7	202-210	hH_6	Eriophorum-Calluna-peat (Hhei), black (5YR 1,7/1 m), medium to strong decomposed (H 6-7), Eriophorum vaginatum
8	210-230	hH_7	Eriophorum-peat (Hhe), black (5YR 1,7/1 m) strong decomposed (H 7-8), Eriophorum vaginatum- Polytrichum strictum, Calluna vulgaris
	^{14}C-Dating^{+}: 2130 B.C., beginning of the black peat formation		
9	230-245	nH	Birchwood-peat (Hulb), black (5YR 1,7/1 m) strong decomposed (H 7-8), Betula spec., Polytrichum strictum, Eriophorum vaginatum
10	245-252	nH	Pine wood swamp-peat (Hulk), black 5YR 1,7/1 m), strong decomposed (H 7-8), Pinus, Scheuchzeria palustris
	^{14}C-Dating^{+}: 3490 B.C., beginning of the forest swamp peat		
11	252-260	IIfAhe	Fossil Ah-horizon, medium-fine sand (msfS), black (10YR 2/1 m), very humic, podsolized
12	260-275	IIfBh/Gr	Weakly compacted humic ortstein-horizon weak-gravely, medium-fine sand (msfS), dark brown (10YR 2/2 m), influenced by groundwater

$^{+}$Datings are corrected according to WILLKOMM (1974)

Tab. 4: Pollenanalytical and ^{14}C-Investigations (Connection SCHWAAR, 1983)

No. Depth cm	Horizon	Diagnostic Species	% acc.to v.Post	Time and Zone +)	^{14}C-Datings BP (1950)
		alder	52.6	Pollenzone X	2210 ± 65
No.4/5				(OVERBECK)	
140-143	hH4 -		0.7		
	hH5	lime		Sub-Atlanticum	
		beech	1.1	260 B.C.	
		alder	32.5	Pollenzone IX	
No. 8		lime	4.3	(OVERBECK)	
	hH 7				
210-215		elm	1.6	Sub-Boreal	3730 ± 130
		beech	-	2130 B.C.	
		alder	37.3	Pollenzone XIII	
No. 10		lime	4.6	(OVERBECK)	4670 ± 60
250-252	nH			Atlanticum	
		beech	-	3420 B.C.	

+) Dendrochronological Correction (WILLKOMM, 1974)

Macrofossil and Pollenanalytical Investigations

Growth of bogs started in the Atlanticum period (3420 B.C.) according to pollenanalytical investigations and ^{14}C-datings. The Scheuchzeria peat at a depth of 250-252 cm is compressed to a few centimeters only. On top of it a pine swamp forest already containing Eriophorum vaginatum, Calluna vulgaris, and Sphagnum papillosum was spread out. In the following period a treeless plant association with Erioph.vaginatum, Calluna vulgaris and Sph.magellanicum appeared (now at 240-245 cm depth) following by a birch swamp forest (230-240 cm depth). After that time raised bog without any wood species grew up. The beginning of bog growth is dated for 2130 ± 130 B.C. according to ^{14}C-datings.

Plant species forming the black peat (at 143-230 cm depth) were not uniform. Eriophorum vaginatum, Polytrichum strictum, Sphagnum imbricatum and Calluna vulgaris were alternating as major peat constituents. Eriophorum dominated at the change from the Atlanticum to

Subboreal peri . Sphagnum species of the Acutifolia section had been interming d during that interval.

At a depth of 143 cm WEBER's boundary horizon (interface of black and white peat) is located, which agrees very well with the data of OVERBECK (1975). This climatical change had happened in the Subatlanticum period according to pollen analysis (Zone X by OVERBECK) which is confirmed by ^{14}C-datings (260±65 B.D.).

Regarding their peat forming vegetation the differences between black and white peat are quantitative only. Black peat mainly consists of Eriophorum vaginatum and Calluna vulgaris, whereas Sphagnum species dominate the white peat. Sphagnum species of the Cymbifolia section (Sph.imbricatum, Sph.papillosum) mainly formed the white peat in this region. However, considerable amounts (of species) from the Acutifolia-section and also leafy moss species (Aulacomnium palustre) could be identified, which dominate with more continental influenced climate.

Table 5a: Analytical Data - soil chemical investigations

No.	Horizon	Depth cm	Ash %	C_t %	N_t %	C/N	r %	H v.POST	pH H_2O	pH $CaCl_2$	
1	2	3	4	5	6	7	8	9	10	11	
1	yY/hHp	0- 25	35	29	0.85	34	n.a.*	n.a.	5.2	4.1	mineral soil cover
2	hH1	25- 75	1.1	51	0.62	82	44	2-3	3.7	2.8	white peat
3	hH2	75-102	1.5	51	0.74	68	53	3-4	3.8	2.9	
4	hH3	102-115	1.2	50	0.73	69	41	2-3	3.9	3.0	
5	hH4	115-143	1.7	53	0.83	63	60	4-5	4.0	3.0	
6	hH5	143-202	1.4	57	1.24	46	68	5-6	4.1	3.0	black peat
7	hH6	202-210	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4.0	3.0	
8	hH7	210-230	1.6	58	1.24	47	73	7-8	4.1	3.1	
9	nH	230-245	1.6	60	1.17	51	75	8-9	4.3	3.2	swamp forest peat
10	nH	245-252	43	37	0.97	38	n.a.	8-9	4.7	3.4	
11	IIfAhe	252-260	93	6	0.18	31	n.a.	n.a.	4.9	3.5	fossil mineral soil
12	IIfBh	260-275	97	2	0.05	35	n.a.	n.a.	5.3	3.8	

Table 5b: Analytical Data - soil chemical investigations

No.	Horizon	Depth	CEC pH 7.0	CEC pH 4.5	Ca	K	Mg	Na	H	Al	V pH 7.0	
		cm	meq/l		exchang. cations meq/l						%	
1	2	3	4	5	6	7	8	9	10	11	12	
1	yY/hHp	0- 25	169	92	78	0.5	15	0.8	8.5	15	56	mineral soil cover
2	hH1	25- 75	115	41	9	0.2	5	0.4	30	-	13	
3	hH2	75-102	179	61	14	0.2	13	0.5	40	-	15	white
4	hH3	102-115	181	61	10	0.2	15	0.5	39	-	14	
5	hH4	115-143	197	64	13	0.3	19	0.6	40	-	17	peat
6	hH5	143-202	234	73	13	0.4	17	1.1	42	-	13	
7	hH6	202-210	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-	n.a.	black
8	hH7	210-230	226	71	16	0.4	14	1.5	42	-	13	peat
9	nH	230-245	207	59	15	0.3	10	1.5	37	-	12	swamp
10	nH	245-252	309	104	28	1.1	13	3.0	42	33	13	forest peat
11	IIfAhe	252-260	239	83	13	0.5	7	2.2	18	55	9	fossil mineral soil
12	IIfBh	260-275	91	34	3	0.3	2	0.7	6	28	6	

Mean values

		CEC pH 7.0	CEC pH 4.5	Ca	K	Mg	Na	H	Al	V
white peat		168	56	12	0.2	13	0.5	37	-	15
black peat		230	72	15	0.4	15	1.3	42	-	13
swamp forest peat		207	59	21	0.7	12	2.0	39	-	13
mineral soil (IIfBh)		91	34	3	0.3	2	0.7	6	28	7

Fossil Mineral Soil

No.	Horiz.	texture in % of humus-/carb.free fine soil: sand c	sand m	sand f		silt c	silt m+f		clay	Fe_o ppm	Fe_d ppm	$\frac{Fe_o}{Fe_d}$ ppm	Fe_{pyr} ppm	Mn_d ppm
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11	IIfAhe	0.2	25	56	81	11	0	16	3	172	290	0.6	164	1.01
12	IIfBh	0.7	18	71	90	7	1	8	2	43	63	0.7	352	0.00

Table 5c: Analytical Data - soil physical investigations

No.	Horizon	Depth	bulk dens.	PV	Water content in Vol.% at pF				air capacity	NLWR* pF	k_f	
		cm	g/l	%	1.0	1.8	2.5	4.2	pF<1.8	1.8-4.2	cm/d	
1	2	3	4	5	6	7	8	9	10	11	12	
1	yY/hHp	0- 25	256	83	75	52	33	22	31	30	1056	mineral soil cover
2	hH1	25- 75	78	88	78	56	29	10	31	47	768	white peat
3	hH2	75-102	102	89	84	69	48	14	20	55	590	
4	hH3	102-115	96	89	84	73	46	12	16	61	220	
5	hH4	115-143	126	92	90	85	64	17	7	68	63	
6	hH5	143-202	135	90	88	83	69	18	8	65	47	black peat
7	hH6	202-210	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
8	hH7	210-230	139	90	89	85	74	23	5	62	10	
9	nH	230-245	140	88	85	80	68	20	8	60	37	swamp forest peat
10	nH	245-252	372	82	81	78	74	27	4	51	6	
11	IIfAhe	252-260	1117	55	54	51	46	10	4	41	18	fossil mineral soil
12	IIfBh	260-275	1468	43	41	39	36	9	3	30	70	

Mean values

white peat	101	90	84	71	47	13	19	58	410
black peat	137	90	89	84	72.	21	7	63	29
swamp forest peat	256	85	83	79	71	24	6	56	22
mineral soil	1293	49	48	45	41	10	4	36	44

* NLWR = non limiting water range

Utilization of raised bogs in Northwest Germany

The raised bogs, poor in nutrients, rich in water and extremely hostile to men and traffic have been reclaimed very late. The earliest utilization (since the roman time) was cutting-off black peat for fuel by farmers of the surrounding plains, later ($16-17^{th}$ century) joint to bog cultivation by burning and Dutch fen cultivation (sand mix)(19^{th} century). Discoveries of chemical (LIEBIG) and technical (v.EYTH) sciences opened ideas for better use of this poor landscape. A drastic change in the cultivation of raised bogs since the late 19^{th} century took place. Since than a number of special raised bog cultivation methods have been developed.

The "German Raised Bog Cultivation" (since 1877) and the "German sand-mix-Cultivation (since 1938), both developed in the "Peatland Experimental Station"(established 1877 in Bremen) are the most important reclamation and improving methods. Their history is described by BADEN (1966), KUNTZE (1984), KUNTZE a.VETTER (1980). Figure 4 and 5 show the loss of virgin mires by cultivation within the last 2 centuries for the excursion area.

KUNTZE, SCHÄFER u.SCHWAAR (1986) have prepared a special excursion (H) for the 13^{th} ISSS-Congress, which demonstrates the way from the virgin bog to the peat soil and its developments. During the 20^{th} century the industrial peat cutting of white peat (for substrates and soil reclamation) became more and more important.

Industrial peat cutting comprises about 14 % (30.000 ha) of the raised bog area in Lower Saxony. The remaining cut over bogs have been turned into arable land by Deep-Plough-Cultivation or reclaimed to grassland (German Raised Bog Cultivation) depending on the depth and kind of residual peat.

Since 1972 (Law of Soil Exploitation) and even more since 1981 (Law of Natural Conservation, L.S.) the government tries to renaturate and regenerate such cut-over bogs to virgin bogs (Bog Conservation Program).

This Raised Bog Regeneration includes 3 successive phases (KUNTZE a.EGGELSMANN, 1981):

a) Rewetting by water-logging (short-term-phase)
   - preciptation > evaporation ($P > E$)
   - drainage $D < (P-E)$.
   - Water regime should be well balanced, i.e. no extreme water-logging or draught in winter or summer time.

b) Renaturation by an ecological succession (medium-term-phase)
- Sufficient seeds and spores for populating the area with plants typical for raised bogs

c) Regeneration by peat formation (long-term phase)
- Immission control.

In several peat cutting areas such experiments are conducted. To initiate water-logging the drainage ditches have to be refilled and sealed. At the mire basis a black peat layer of > 0,5 m depth must remain. The reintroduction of typical bog forming plants has been successful in several projects using the top spit (>0,3 m). This former surface material serves as a good source of seeds and spores and also its favourable physical and chemical properties give a high ecological value.
The long-term evaluation about the possible success of Bog Regeneration is not possible yet. Within the L.S.' Conservation Program the final goal of the state government is to save 65.000 ha (≙ about 10% of the former raised bog area) of natural raised bog, or regenerated bog after peat cutting as a Nature Conservation Area.

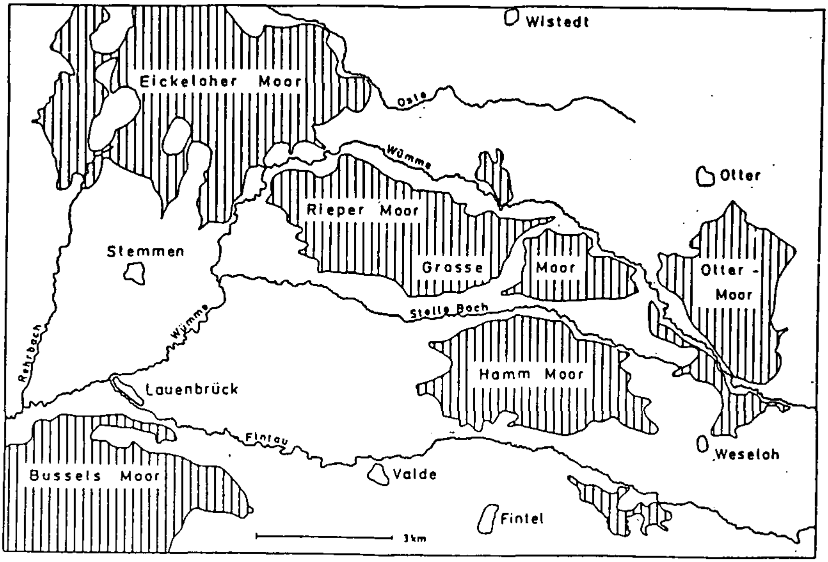


Fig. 4: Raised bogs of the excursion area in the 18th century (1770)

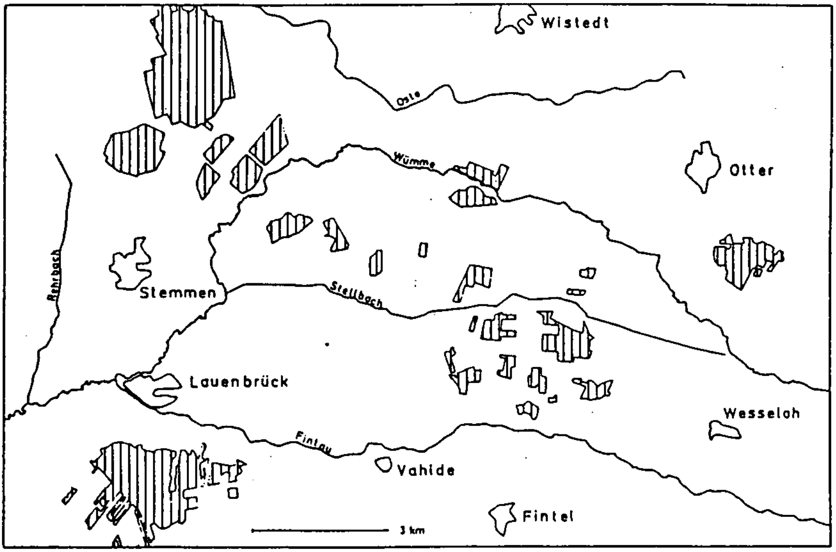


Fig.5: Raised bogs of the excursion area in the 20th century (1980)

Methods

Methods of peat soil analysis (acc.CAMPBELL a.KUNTZE, 1984):

r-Value: Non-hydrolysable (72 % H_2SO_4) organic residue (r) in % of the ashfree organic matter

Degree of Decomposition, H (von POST):
A sample of wet peat is squeezed in the closed hand and the colour of the liquid that is expressed between the fingers, the proportion of the original sample that is extruded, and the nature of the plant residues, are observed.

CEC and Exchangeable Cations (acc.FEIGE, 1969):
Exchange solution: 0,5 N Sr-acetate solution,
pH varies between 4,5 and 7.

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Mitteilungen Dtsch. Bodenkundl. Gesellschaft, 46, 249-261, 1986

EXCURSION A, 9th and 1oth day

Landscapes, Agriculture and Soils of Schleswig-Holstein

by

H.-P.Blume[+], G.Brümmer[+], H.Finnern[++], J.Lamp[+] and E.Schnug[+]

and with contribution

by

H.-K. Siem[++], H.J.Betzer[+++] and B.Meyer[+++]

9th day
Marschland soils of southern Dithmarschen

1oth day Young moraine landscape near Lübeck Bight

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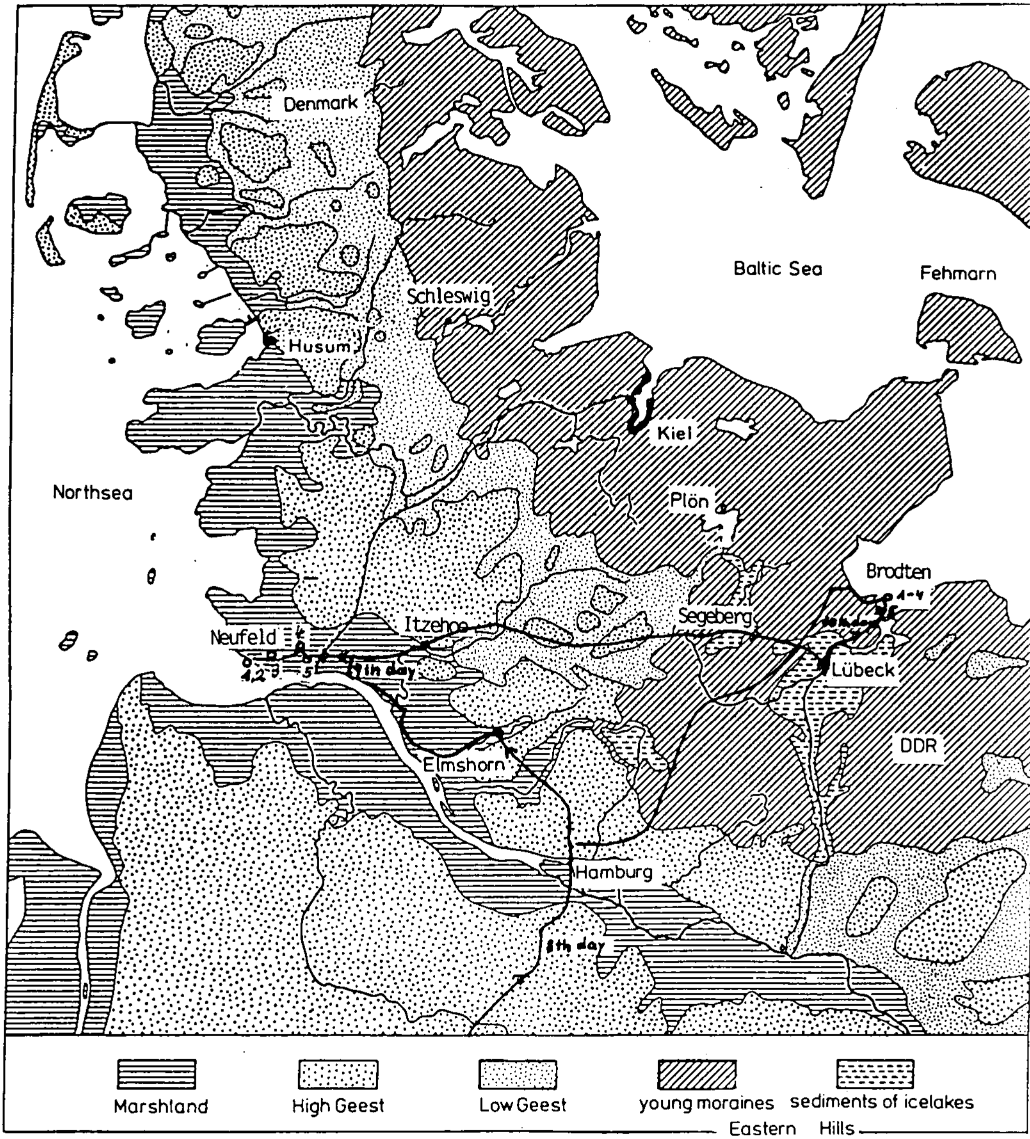

Figure 1: Landscapes of Schleswig-Holstein and excursion routes

Mitteilungen Dtsch. Bodenkundl.Gesellschaft, 46, 251-261 (1986)

Agriculture, Landscapes, and Soils of Schleswig-Holstein

by H.-P. Blume und G. Brümmer (Kiel)

General Information on Schleswig-Holstein

Population: Schleswig-Holstein is inhabited by almost 2.4 mio people, the population density is 156 persons per km^2.

Area: The total area is 15,658 km^2; it is devided into three landscape units: the Eastern Hills (6,107 km^2, 39 %), the "Geest" (7,046 km^2, 45 %), and the Marshland (2,505 km^2, 16 %). About 70 % of the area (11,000 km^2) is in agricultural use (of this 39 % tilled land, 20 % pastures, 10 % meadows, and 1 % horticulture and orchards). Woods and forests cover only 1,370 km^2 (9 %) of the area, thus Schleswig-Holstein is one of Germany's regions with the least proportion of woodland. Lakes and rivers comprise 293 km^2 (1.9 %), roads, housing and industrial areas cover 1941 km^2 (12.5 %); these areas are sealed to a high degree. Natural or near-natural areas without or with hardly any land use such as uncultivated bogs, heaths, fallow land, dunes, and hedges make up to 579 km^2 only (3.7 %), of these areas 0.6 % are protected natural reservates. The highest elevation is the Bungsberg in the Eastern Hills (168 m a.s.l.), in the Marshlands some areas below sea level occur.

Climate: The mean annual temperature is 7.9° C (7.7° C in Schleswig to 8.1° C in Lübeck), the coldest month is January (mean temperature 0.4° C; -0.3° C in Neustadt to +0.6° C in Kappeln), the warmest month is July (mean temperature 16.4° C; 15.9° C in Kappeln to 16.8° C in Lübeck). An average of 76 days with frost occur over the year, day length during the vegetation period is about 13 hrs. Flowering and maturing of plants is delayed by one day per ten km from the south-east to the north-west. In the same direction there is a time lag of a fortnight in the beginning of the winter rye harvest (July 19th, Lauenburg, and August 2nd, North Friesland). Mean annual precipitation is 720 mm (525 mm island of Fehmarn, 850 mm North Friesland). With the regional differentiation the degree of humidity varies regionally from 150 to 350 mm. Maximum rainfall occurs in August (regionally differently from 64 to 97 mm), minimum precipitation in March (32 to 53 mm). Relative air humidity is 84 % (76 % in May and June, 91 % in December).

Vegetation: Schleswig-Holstein belongs to the region of atlantic decidual forests of the Middle European floral region. Typical plant species characterizing the flora are Fagus sil vatica, Tilia cordata, Carpinus betula, Ilex europea, Erica tetralix, and Empetrum nigrum. Besides 938 native plant species there exist 1,087 species which have been brougth to the country, this being an indication of its transitional position between Central Europe and Scandinavia as well as between East and West. With the edaphic conditions changing from the young moraines in the east to the old moraines and sandur deposits in the centre to the marsh lowlands in the west, there are corresponding differences in the vegetational cover. The loamy soils containing marl at low depths carry demanding beech forests, the central "Geest" is covered by oak-birch woods and heath. In the Marshland, forests are nearly totally lacking. Where the sea influences the soils halophytic vegetation prevails.

Surface Formation and Landscape Development in Schleswig-Holstein

(Figure 1)

Three characteristic landscapes exist in Schleswig-Holstein: the **Eastern Hills**, the **"Geest"** and the **Marshland**. Their parent materials are sediments deposited by the action of glaciers, water, and wind: glacial drift sheets (moraines), glaciofluvial deposits (sandur), marine mud, and aeolian sands (dunes). These quaternary sediments cover the underlying tertiary sands and clays with a thickness of up to 425 m. The latter are exposed to the surface at a few points only, cliffs on the islands of Sylt and Fehmarn e.g. Isolated spots of yet older sediments occur near Lieth (Lower Perm clay), Segeberg (Upper Perm gypsum), Lägerdorf (Creteaceous lime), and Helgoland (Mesozoic sand- and limestones). All these rocks have only been elevated since the Jurassic and Creteaceous periods by pressure exerted on the plastic Zechstein (Upper Perm) salts. Salt tectonics has played a role in landscape formation also elsewhere in Schleswig-Holstein. It is one of the causes of petrol and gas deposits in accessable depths. Lime, clay and sand are being industrially exploited as a basis of concrete and cement production. Petrol is being extracted in minor amounts at different locations.

The oldest surface sediments of widespread occurrence in Schleswig-Holstein were deposited during the Saalean Glaciation (until ca. 120,000 b.p.) by glaciers moving southward from Scandinavia to the north of Germany. They consist of boulder marl and boulder sand forming moraines and ice-push ridges and sorted sands deposited by the action of meltwaters. During the consecutive Eemian warm period (from ca. 120,000 to 75,000 b.p.) the ice retreated. Its melting lead to a rising sea level and the North and Baltic Seas were filled with saltwater. Under the influence of a warm oceanic Climate deeply weathered soils formed from the Saalean glacial sediments. The boulder marl became carbonate-free to greater depths and was transformed into boulder loam. With the beginning of the subsequent Weichselian glaciation (ca. 75,000 to 10,200 b.p.) glacial drift was being deposited by glaciers protruding from a more easterly direction, once more, together with transformed material of the earlier glaciation.

Eastern Hills

The Weichselian glaciers covered the eastern part of the country only, the Eastern Hills. This young moraine landscape is characterized by rather conspicious surface forms, moraines and ice-push ridges (Hüttener Berge, Duvenstedter Berge, Westensee region, ridges around the Lübeck Basin), and numerous lakes which formed in depressions excavated by ice lobes, meltwater channels, and after the thawing of isolated ice masses, and which form a lake district in Eastern Holstein. The Großer Plöner See (3,038 hectares) is the largest, and lake Schalsee near Ratzeburg is the deepest (85 m) lake of Northern Germany. Its bottom reaches 50 m b.s.l. and is thus the deepest point in the land surface of the FRG. Fjords deeply penetrating into the country subdivide the Eastern Hills into several smaller landscapes. They were formed by ice lobes and subglacial tunnels. The sea filled these valleys during the Littorina transgression when the ice melted. The fjords are excellent natural harbours (water depth generally greater than 10 m), and old settlements and ports are located at their ends (Flensburg, Schleswig (Haithabu), Eckernförde and Kiel). Near the former margin of the ice in the west, long periods of glacier stagnation lead to a long-lasting flushing of the landscape by meltwaters and the moraines are rather sandy and stony there, consequently. Further east the landscape is more level, the marl is more uniform and compact, a flatly undulating landscape of subglacial moraines dominates, typically expressed on the island of Fehmarn.

Geest

During the Weichselian glaciation the deposits of the former Saalean glaciation were periglacial regions. The old moraines were eroded by great streams of meltwater and vast sand deposits were laid down there. Periglacial processes like solifluction, cryoturbation, and wind erosion levelled the once strong relief under a sub-arctic climate.

Today, old moraines, sandur plains (glaciofluvial sand deposits) and aeolian sand deposits constitute the middle ridge of Schleswig-Holstein, a landscape called "Geest".

The sandur plains (Low Geest) lie next to the Eastern Hills. They often consist of vast outwash fans at the openings of channels and former subglacial tunnels of that landscape. The largest areas of the Low Geest are encountered west of the line Flensburg-Rendsburg and in the Neumünster Basin. This landscape unit is lacking in the south since there the glacier meltwaters drained to the Elbe Valley in the south, where the small outwash fan of Büchen was formed.

Some of the old moraines of the Saalean glaciation project through the sandur deposits; it is in these places where villages and towns were built predominantly. To the west the moraines form the continuous "High Geest" which in some places meets the Marsh lowlands, lying still further west, with steep cliffs. The Geest has hardly any lakes: depressions have partly been filled by landslides during the Weichselian periglacial period or have been filled by organic sediments with the formation of fens and bogs. These were widespread once, they have however largely been drained and cultivated since.

Marshland

To the west of the "Geest" lies the marshland, a belt of varying bredth. During the Weichselian Glaciation, when huge amounts of water were bound in the ice of glaciers, the sea level was up to 130 m lower than today. In vast regions lying today in the Wadden Sea or the North Sea, a tundra landscape formed. With the advent of a warmer climate during the Boreal Period, thin woods of birch and pine spread and, in the lower parts, swamps covered with reed and fen woods formed. A rise in sea- and groundwater level, together with land subsidence, caused further swamp- and bog formation. Finally, with the onset of the Atlantic Period (5500 b.C.) vast areas were covered by the sea (Flandrian Transgression), and swamps and bogs (today layers of "Lower Peat"), as well as sandur plains and old moraines, were buried under marine sediments. Regional differences in sedimentation were caused by the morphology of the Pleistocene land surface.

In the south, where it falls to more than 20 m below today's sea level, the sea reached the western margin of the "Geest", covering the landscapes of Eiderstedt and Dithmarschen; thick mostly fine sandy sediments were laid down there. Thus very stable high lying marshland was formed, which was populated already 2000 years ago. In North Friesia the land surface was much higher (1 - 10 m below today's sea level), less inclined, and also protected against the sea by Pleistocene elevations (around the islands of Sylt and Amrum) so that the sea protruded less far, and only a thin sheet of marine sediments was deposited west of a belt of moors next to the "Geest" margin. During the Sub-Boreal (2400 - 600 b.C.), the rise in sea level stopped (cessation of the Flandrian Transgression) and swamps and bogs formed on the Holocene sediments (Upper Peat).

Another transgression (Dunkirk Transgression) with the onset of the Sub-Atlantic Period has changed especially the North Friesian landscape. On the seaward side marine sediments were deposited, forming the high lying Old Marshland. To the east lay vast lowlands ("Slietland"), where bogs continued to grow. Until a thousand years ago the coastline of North Friesia lay much farther westward than today. The Old Marshland was inhabited by people who protected themselves against floods by building earthern hills ("Warft", "Wurt") and flat dykes. The Upper Peat was cut to obtain fuel and salt. Peat-cutting and, with it, land subsidence, lowered the surface. Thus in the 12th, 13th, and 14th centuries great floods were able to destroy the high western marshland and penetrate into the lowlands further east.

The storm tide of 1362 (Marcellus Flood, "Grote Mandränke") had most catastrophic consequences, it destroyed numerous settlements and villages. The whole of the North Friesian marshland was transformed into intertidal flats, the Wadden Sea. Sand and mud covered the medieval cultured land. Next to the "Geest" new marshland formed, and since the beginning of the 14th century vast areas have been reclaimed. But ever since the marshland has been haunted by great storms tides. Above all, during the Great Flood of 1634 wide stretches of land were lost. Even in recent times (1962, 1976) storm tides made the dykes breach and destroyed land at many points of the coast. In order to protect the marshland and to reclaim land, the mouth of River Eider has been dammed (1971), and the Meldorf- (1978) and Nordstrand- (1986) Bights have been enclosed by dykes.

Development of Climate, Vegetation, and Culture

After the melting of the Weichselian glaciers, 20,000 (Lauenburg) to 13,000 (Fehmarn) years ago, subarctic climatic conditions prevailed in the landscape freed of the ice and a tundra devoid of trees formed. Later birch and pine were the first trees to occur. Man was a hunter of rendeer then, later also other animals were hunted, which provided food and material for clothing, tents, tools, and weapons. Three stages of early man's culture can be distinguished, which are named after three archeological sites near Hamburg, where remaines of the rendeer hunters were excavated: Hamburg Culture I (Meiendorf) and II (Poggenwisch; both late paleolitic), and Ahrensburg Culture (beginning mesolithic).

With the postglacial period (starting ca. 10,000 years ago) the climate became warmer and forests of birch and pine formed. With a further rise in temperature during the Boreal period (warm and dry) more demanding plants as regards temperature spread: hazel, oak, elm, lime, and, in moist places, alder.

The water masses deriving from the molten glaciers led to a marked transgression of the North- and Baltic Seas during the Atlantic period (5,500 to 2,400 b.C.). The Baltic Sea reached its present-day extension by about 2.500 b.C. The climate of northwest Germany (mild, moist) was then determined by the proximity of the sea. Mean annual temperature was probably higher by 3-4^{o} C than today. Oak mixed forests prevailed and heath started to spread on sandy reaches of the Geest, a tendency which was later favoured by neolithic man clearing forests. Low stretches were covered by alder woods which later were overgrown by bogs. Excavations near the Baltic coast (Kiel Bight, Ellerbek culture) reveal the cultural development of man. During late mesolitic times fire-proof pottery and sharpened stone axes were in use. Neolithic man starts to settle, besides being a hunter, he already is a farmer. Crops are wheat, barley, and millet; the first domestic animals (dog, cattle, sheep, and pig) are being bred.

During the subsequent Subboreal period beech appeared besides oak on the carbonate-rich soils of the moraines in the east. Man uses bronze to construct tools and weapons (Bronze Age). In agriculture the wooden plough is used and besides the traditional crops, oats are grown.

With the beginning of the Subatlantic period a change in the climatic conditions set in, which led to the rather cool and moist climate of today. The young moraines of the east were covered with beech forests, while the "Geest" was covered by oak forests and heath. On top of the older bog peat (black peat), which had formed during the Subboreal, younger white peat formed. By now, also in the north-west of Germany the production of iron from bog iron ore came into use (Iron Age) and the iron ploughshare was invented. With this toll even the heavy soils in the Eastern Hills could be ploughed. Seagoing ships with bolted planks were constructed (Nydam boat). Farming and trade expanded. Rye was invented as a new crop and spread fast because of its frost hardiness.

Since the Middle Ages the natural landscape was gradually transformed into a man-made landscape. Forests were cleared and heaths spread as a consequence on the sandy soils of the "Geest" - until 150 years ago half of this landscape was covered by heath. Naturally growing trees were replaced by fast-growing conifers, and the woods transformed into forests of spruce and pine. Peat was taken from the bogs to be used as fuel and litter, the areas later used as grassland. By the end of the 18th century hedgerows were planted on the borders of the fields, they provide excellent protection against wind erosion. These earthen walls planted with bushes and trees are a characteristic feature of Schleswig-Holstein's landscape.

Due to economic constraints during the past 30 years, agricultural areas have been merged, increasing the sizes of individual fields. Along with this a great proportion of the hedges has been sacrified. Nature restitution is now being enforced in several regions of Schleswig-Holstein with the installation of reservates. Hedgerows play an important role in habitat interlocking.

Soils (Figure 2)

Soils of the Eastern Hills

Here the landscape is built predominantly of sediments of the last glaciation. The processes of Ca-carbonate dissolution (the carbonate-free zone is 0.8 to 2 m deep), braunification, loamification, and clay migration have acted on the boulder marls of the undulating ground moraines to form **Parabraunerden** (Luvisols). Their sandy-loamy eluvial horizons are 40 to 60 cm thick. They, and the underlying argillic horizons, are strongly acidified today when covered by forest (pH-values of 3.5 to 4.5). The depth of calcite dissolution and clay migration is greater in the west than in the east, reflecting 1. the direction of the retreat of the glaciers (the west being up to 7,000 years longer free of ice), 2. the substrate conditions (less Ca-carbonate, sandier texture in the west), and 3. differences in precipitation (higher in the west). Clay-illuvial horizons and compacted marl (due to once strong pressure of the overlying ice) constitute drain-age barriers. Stagnating rainwater causes air deficiency, and especially downslope and in flat hollows **Pseudogleye** (Stagno-Gleyic Luvisols) with iron and manganese concretions in the topsoil and mottled subsoil developed. Moraines with stronger relief, especially end moraines, are sandier. Here, as well as on high-lying sandur deposits, deeply carbonate-free acid **Braunerden** (Cambisols) and Bänderparabraunerden (sandy Luvisols with thin clay bands) have formed, some of which

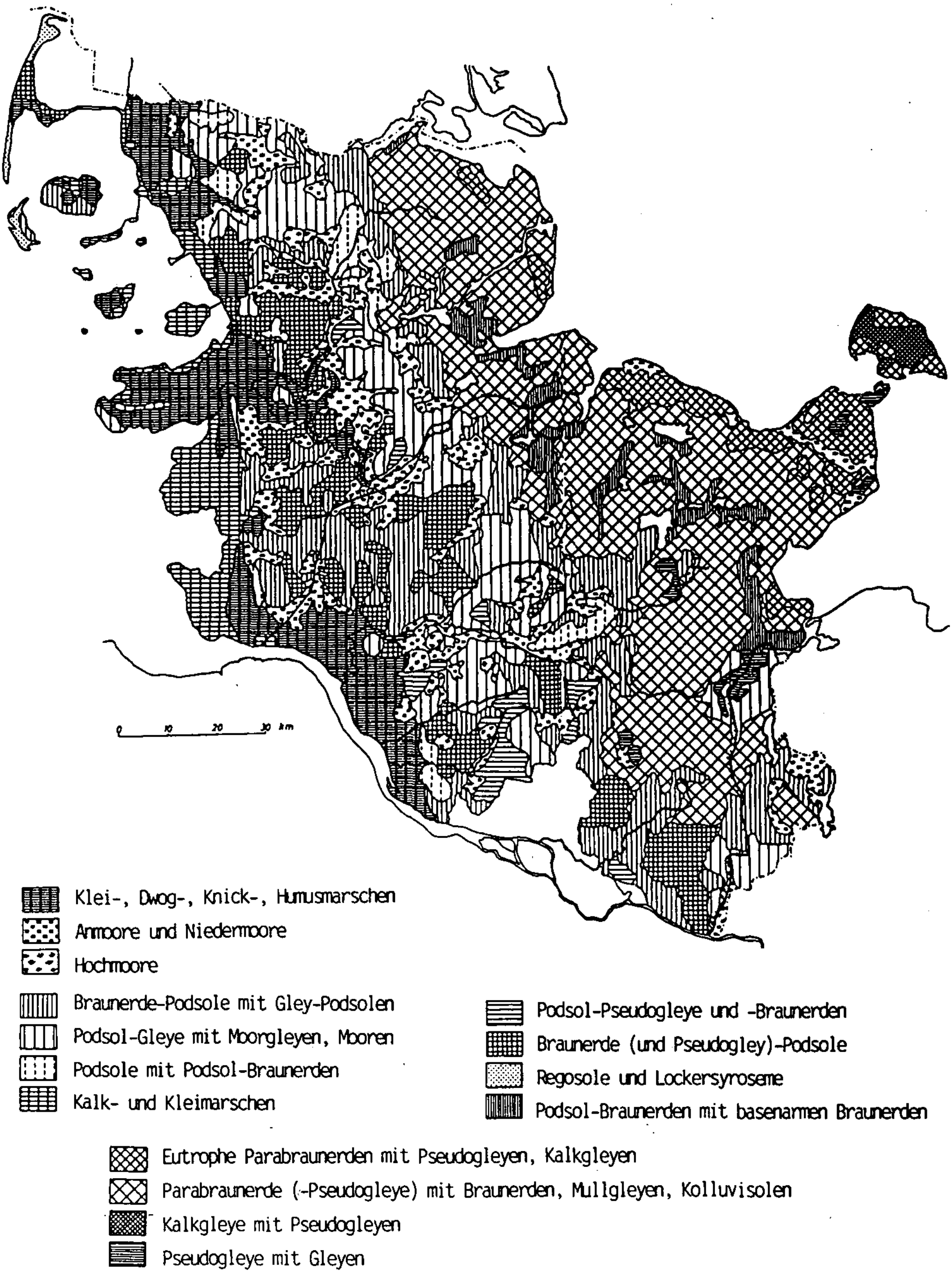

Figure 2: Soils in Schleswig-Holstein (after H.E. Stremme by Schlichting 1960, legend changed)

are moderately podzolized, especially in places with medieval litter removal from the forests.

The mostly sandy valleys are covered by groundwater-influenced soils, **Gleye** with medium to high base content, **Anmoore** (Humic Gleysols), and **Niedermoore** (Histosols), depending on the groundwater level. Especially in the east these groundwater soils are rich in Ca-carbonate (meadow chalk in the Oldenburger Graben). Further to the west (earlier ice-free) also acid **Gleyic Podzols** occur and bogs have formed on top of the fens (Lübeck Basin, Duvenseer Moor). Patchy occurring clay deposits in basins carry clay- and nutrient-rich, wet soils, Gleysols and gleylike soils with high humus contents. Most of the soils are now enriched with nutrients due to their agricultural use. The loamy Luvisols that dominate in the Eastern Hills besides sandy Cambisols have considerable nutrient reserves and useable field capacities. Together with the favourable mild climate, they are sites with very high agricultural yields. Where periodic water stagnation occurs, amelioration is necessary.

Soils of the Low Geest

In the region of the Low Geest, which partly lies below sea level, sandy soils poor in nutrients and with high groundwater tables prevail. The dominating sandur deposits of the Weichselian glaciation are extremely poor in clays (less than 2 %), carbonate-free and base-depleted to great depths. Carbonate- and base depletion presumably commenced in the late Weichselian and was enhanced by then deeper groundwater levels. With the rise in sea level during the Flandrian transgression drainage became poorer and strongly podzolized soils were formed (**Gley-Podsole** (Gleyic Podzols) and **Podsol-Gleye** (Podzolic Gleysols), depending on the nearness of the groundwater). The humus-enriched and often indurated (ortstein) subsoil of the Gley-Podsole still contains some iron as a rule, in the Podzol-Gleys, however, the whole profile is depleted of iron oxides and, with it, of heavy metals such as Mn, Cu, Zn, and Co. The iron leached by seepage water and dislocated in the landscape was partly accumulated in the oxidizing horizons of gleys elsewhere, especially near creeks. At places, the accumulation of iron oxides has led to the formation of **bog iron ore**, which once was used for iron foundry. Wide hollows of the podzol-gley landscape carry moors; first acid, nutrient deficient fens formed, which later mostly developed into acid and extremely nutrient deficient bogs.

Some Saalean moraines project through the sandur plain. With their elevated clay contents (as compared to the sands) more or less podzolized acid **Braunerden** (Cambisols) have developed. Also dry Podsole (Podzols) occur where the boulder sands are covered by Weichselian airborne (practically clay-free) sands, and where, after the clearing of the forests, heath vegetation has prevailed over centuries.

Especially because of the dominance of waterlogged soils, the Low Geest was not attractive to settlement. Only the above mentioned moraine islands were cultivated early, the manuring with heath litter over centuries led to the formation of **Plaggenesch** (Fimic Anthrosols) with thick topsoil layers enriched with organic matter. Today, after artifacial drainage, the soils of the Low Geest are in agricultural use: Histosols and podzolic Gleysols as grassland, gleyic Podzols, especially after deep-ploughing, as arable land. Due to their low nutrient contents the soils require heavy fertilization, also with micro-elements besides macro-elements. Fertilizers should only be applied during the vegetation period and in small amounts at a time to avoid groundwater contamination. The sandy gleyic Podzols need additional irrigation during dry summers, even with groundwater tables as high as 80 - 100 cm, because of the low water-holding capacity of the soils.

Soils of the High Geest

Also on the Saalean moraines of the High Geest **Luvisols** have developed. Since already during the Eemian interglacial soil forming processes have been going on, they are free of Ca-carbonate to depths of several meters today, strongly acidified and often podzolic. The clay depletion of the topsoil reaches often a meter deep, partly a consequence of clay translocation, but also due to sedimentation of airborne sands during the Weichselian glaciation. These sands have been mixed with the underlying material by cryoturbation. Many of the soils on the moraines contain frost wedges filled with sand to several meters deep. Often they form nets of 5 to 10 m grid size. They are formed when periglacial conditions prevailed in this landscape during the last glaciation. The sandy cracks have drier soils with somewhat poorer vegetation, and they can thus be recognized in aerial photographs. Where the loamy subsoil is nearer to the surface gley like soils have developed on level terrain, a tendency enhanced by a precipitation which is higher by 100 to 200 mm per year as compared to the Eastern Hills. Thicker covers of aeolian sand carry **Podzols** also here, depressions have **podzolic Gleysols** or **Histosols.**

Soils of the Marshland

The properties of the marshland soils derive from both geogenic and pedogenic processes. Their development starts seaward of the dykes, where sediments are being deposited. Depending on the flow velocity of the water, in Schleswig-Holstein they contain 3 - 60 % clay, 0.5 - 10 % organic matter, and 3 - 8 % total carbonates (0.5 - 2 % dolomite therein). A specific fauna and flora of the Wadden Sea settles, and the surface is slowly elevated above the level of the dayly tides: Salzmarsch (Gleyo-Salic Fluvisol, Halaquent) forms. It is only flooded by storm tides. The marshland soil profile is thus characteristically layered: layers of fine sand, silt and clay interchange, and - corrosponding to the history of the landscape (cf. chapter "Geology") - peat layers and fossile topsoil horizons occur. The soil forming processes of the young marshland outside the dykes and in freshly enclosed polders ("Koog") are: intensive redox processes, especially sulphide formation and -oxidation, structure formation, salt leaching and starting carbonate leaching. They lead to the formation of the fertile Kalkmarsch (Gleyo-Calcaric Fluvisol, Calcareous Fluvaquent) and are summarized under the term maturation. Subsequent degradation consists of the processes of carbonate leaching, clay migration and acidification. In Schleswig-Holstein it takes around 200 to 400 years of "Koog" development to complete carbonate leaching of the topsoil. Kleimarsch (no or little compaction, carbonate-free 40 cm, Gleyo-Eutric Fluvisol, Fluvaquent) is formed. Marshland soils which are carbonate free (40 cm), clay-rich, and compacted are called Knickmarsch (Fluvi-Dystric Gleysols, Epiaquic Haplaquepts or Haplaqualfs). The "Knick"-horizon consists of clay-rich sediments covered by sandier material deposited during storm tides, it is often additionally compacted by clay illuviation.

In cases, where marine sediments were deposited on former land surfaces, "Dwogmarsch" (carbonate-free 40 cm, Fluvi-Dystric Gleysols) formed: Humic "Dwogs" containing fossile Ah-horizons, and Iron "Dwogs" containing fossile iron-rich Go-horizons. Marshland soils over fen peat (sediment cover 40 cm) are called Moormarsch or Peat-Marsch. When much organic material (from old bogs or old Ah-horizons) was contained in the marine sediments, organic matter-rich Marshland soils derived: Humusmarsch (Fluvi-Humic Gleysols, humaqueptic Fluvaquents). In sedimentary environments of the latter three types the formation of "Maibolt" (Jarosite, $KFe_3(OH)_6(SO_4)_2$) was enhanced with long development under direct influence of the sea: here very acid (pH down to 2) Marshland soils formed.

Agriculture in Schleswig-Holstein

Agriculture and nutritional industries are important in Schleswig-Holstein's economy. Around 25 % of the working population are imployed in this sector. Agriculture's contribution to the gross national product is more than double the federal average here. More than half of the population live in places of less than 15000 inhabitants. In rural regions, agriculture is the supporting economic branch. The subdivision into the landscapes of Eastern Hills, "Geest", and Marshland has strong impacts on the patterns of agricultural production. Cropland on Marshland Soils and on Cambisols and Luvisols in the Eastern Hills is dominated by cereal and rape production. The permanent grassland of the marshland supports intensive cattle production. Efficient dairy production has developed in the "Geest", with its light soils and widespread peatsoil lowlands.

Agricultural economic structure is relatively healthy in Schleswig-Holstein. On 25000 of the total 31000 farms, agriculture alone supports the farms; animal production (especially dairy cattle) dominates.

1. Farm sizes

The total number of farms was 30993 at the end of 1984. Compared to 1960 and 1980 it declined by 43 % and 6.3 %, respectively. Mean farm size increased by 1.9 ha (1984 vs. 1980) to 35.2 ha. This is double the federal figure of 15.3. More than 15000 farms are larger than 30 ha, they cover almost 80 % of the agricultural area of Schleswig-Holstein.

No. of farms and %-coverage by size classes

Size classes	1960	1970	1980	1984
No. of farms	54,163	43,172	33,012	30,933
Percent area by size classes				
up to 10 ha	36.2	29.1	26.5	27.5
10 - 20 ha	24.3	18.4	11.9	11.0
20 - 30 ha	18.1	21.1	15.6	13.3
30 - 40 ha	9.4	13.7	15.1	13.9
40 - 50 ha	5.3	7.6	11.3	11.3
50 - 100 ha	5.7	8.5	16.4	19.1
more than 100 ha	1.0	1.6	3.2	3.9
mean farm size	21.0	25.9	33.3	35.2
mean size of farms greater than 30 ha	53.2	53.3	57.8	60.6

Land use in Schleswig-Holstein

	1960	1970	1980	1984
Total productive area	1569	1570	1327	1316
Agricultural area	1187	1153	1101	1091
%-ages of:				
Arable land	57.4	44.9	56.7	55.0
Horticulture, fruit-growing, nurseries	3.6	2.7	0.9	0.8
Permanent grassland	39.0	41.4	42.4	44.2
Forests (% of total production area)	8.6	8.5	10.5	10.6

2. Developments of culture and yields of principal crops

Cereals and rape are the dominant crops in Schleswig-Holstein. Winterwheat areas have approximately doubled between 1960 and 1984, those of winter barley and rape have increased 4-fold and 6-fold, respectively. Winter barley has replaced rye and spring cereals on sandy sites. Cereal yields have approximately doubled in this period. In favourable years, peak yields of 10 metric tons per hectare of wheat were harvested. Also for other crops, the yields have increased considerably.

Culture area of selected crops (1000 ha)

	1960	1970	1980	1982	1984
Winter wheat	74.4	81.1	161.2	136.4	149.7
Spring wheat	14.0	12.0	5.5	8.3	2.3
Rye	112.5	72.9	67.6	51.5	52.2
Winter barley	31.7	58.9	108.5	121.3	129.9
Spring barley	43.3	55.9	27.5	33.2	13.3
Oat	61.4	103.9	41.7	38.4	22.9
Cereals (total)	408.2	409.7	413.6	390.5	370.9
Winter rape	14.2	46.2	73.7	84.4	90.4
Potatoes	42.1	14.0	5.3	5.0	5.1
Sugar beet	13.7	15.0	18.7	19.4	18.8
Common beet	29.0	25.9	13.3	8.2	7.2
Green maize	0.3	5.3	39.8	46.2	49.6
Fodder crops (total)	121.3	100.6	88.7	96.0	96.4

Average yields of selected crops (dt/ha)

	1960	1970	1980	1982	1984	1985
Winter wheat	38.2	46.0	54.8	73.1	73.5	74.7
Spring wheat	33.9	39.8	41.4	51.2	49.8	51.8
Rye	26.9	25.4	38.9	45.3	43.4	42.8
Winter barley	36.2	34.8	58.0	65.3	62.5	56.9
Spring barley	32.0	26.6	36.5	42.8	40.0	45.9
Oat	31.2	31.5	40.0	50.5	49.7	51.3
Cereals (total)	31.4	32.9	50.1	61.8	62.5	-
Winter rape	24.1	22.3	29.4	31.8	25.4	34.2
Potatoes	411	599	548	864	713	-
Sugar beet	238	295	268	285	368	390
Common beet	357	376	386	458	442	442
Green maize (shoots)	365	434	393	431	380	-

3. Fertilization

Since 1979/80 the use of commercial fertilizers has been decreasing somewhat. The nutrient supply by farmyard manure (solid, semi-liquid, and liquid), soil nutrient balance, and crop demand are being increasingly considered.

Use of fertilizers (kg/ha) in Schleswig-Holstein

	N	P	K	CaO
1960/61	55	25	60	37
1970/71	106	35	73	56
1979/80	169	41	92	143
1981/82	162	27	68	141
1983/84	163	29	78	167

Mean nutrient addition in 1981/82 in Schleswig-Holstein

	N	P	K
Farmyard manure	53	26	95
Commercial fertilizer	162	28	68
Sum	215	54	163
Fertilizer recommendation	198	41	152

Fertilizer recommendations (calculated from soil analyses, average yields, and cropping patterns) show that a decrease of commercial fertilizer use is possible. The chamber of agriculture consults on fertilization (nitrate service).

4. Animal stocks in Schleswig-Holstein (in 1000)

	1960	1970	1980	1984
Horses	46	18	35	33
Cattle (total)	1219	1407	1552	1627
Dairy cattle	460	493	520	545
Pigs	1414	1774	1808	1768
Sheep	105	97	123	157

5. Forestry

Woods and forests cover 8.9 % of the area of Schleswig-Holstein, and 10.6 % of its productive area. Main tree species are Oak (11 %), beech (23 %), spruce (+ fir and Douglas fir) (37 %), pine (+ larch) (19 %), and miscellaneous deciduous trees of minor importance (10 %). 465000 m^3 of timber were cut in 1984. The forests are mostly rather young: 35 % less than 20 years, and only 3 % over 100 years. To cut down an overproduction, afforestation of agricultural areas is planned for the future.

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Excursion A, 9th day, route description

Elmshorn (38000 inhabitants), situated on the "Geest" margin against the marshland of River Elbe, old town with church of mid-14th century, south of Elmshorn rocks of Zechstein and Rotliegendes, lifted to the surfaces by salt tectonics.

Glückstadt (13000 inhabitants), port on River Elbe, founded as a fortified city in 1616 by Christian IV of Denmark, today small town with various industries. Centre of large vegetable cropping region of the Elbe Marshland, pastures on heavy "Knickmarsch" and moist sites.

Brunsbüttel (10000 inhabitants), port on the mouth of Kiel Canal, which connects Baltic (Kiel) and North Seas. Built in 1887-1895, length 98.7 km, ca. 100000 passages per year. Small town with various recently established industries, among them atomic power station and petrochemical plants. Surrounding marshland diked between 1573 and 1762. Due to bad drainage mostly permanent grassland (to get rid of excess water, land is vaulted between drainage ditches), also vegetable and cereal cropping.

Neufeld, village with small harbour in the Marner Neuenkoogsdeich (diked 1608); goose fattening, sheep production; soils 1-3; farm Heinrich Heesch.

Marne (6000 inhabitants) small town in southern Dithmarschen on a big sandy ridge in the marshland, on both sides of the first dike (built ca. 1000 a.D.), west of Marne old marshland with Dwogmarsch, Humusmarsch, and Moormarsch, pastures; younger marshland with vegetable cropping; soils 4 and 5.

Wilster (5000 inhabitants), situated in the Wilstermarsch which partly lies below sea level. Town since 1281, old town hall of 1585 and various other historic biuldings, centre of cattle breeding. Surrounding country with pastures, drainage by pumping stations.

Itzehoe (35 000 inhabitants), situated on the border of the "Geest" against the Marsh Lowlands, is the oldest town in Holstein, founded in 810 by Charlesmagne. Cretaceous limestone and Tertiary clays are the basis of cement industries in Lägerdorf nearby. "High Geest" with Cambisols, and Podzols on aeolian sands over Late Saalean boulder sand and -marl, covered by forest; then - at the margin of the Stör-Braunau-Valley - "Lower Geest" with Gley-Podzols and nutrient-poor Histosols covered mainly by grassland.

Bad Bramstedt (brine and moor watering place, 9000 inhabitants). After passing through the Segeberger Forest with acid Brown earth on sandy moraine ridges and Gley-Podzols on fluvio-glacial sands, the young moraine landscape is reached.

Bad Segeberg: brine watering place at the foot of the "Chalk Hill", 13 000 inhabitants. The "Chalk Hill" consists of Zechstein (Late Permian) gypsum which was lifted by salt tectonics; it contains stalactite caverns. Today it provides the scene for Western festivals with plays after the novels of Karl May. - Passage through the gently rolling young moraine landscape with sandy Cambisols and loamy Luvisols under cropland, and calcic Gleysols and Histosols under grassland to

Lübeck, the leading "Hanse" town of medieval times, situated on River Trave. Today a port and industrial town with 220 000 inhabitants. With its great number of historic buildings (Holsten Gate, 15th century, Town Hall, 13th-15th centuries, St. Mary Church, 13th/14th centuries, St. Jacobi Church, 14th century and Cathedral, founded by Henry the Lion) in aspect of a medieval town of trade is well preserved in the city in spite of major destruction during World War II.

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Marshland Soils of Southern Dithmarschen

by H. Finnern and G. Brümmer

The marshlands north of the mouth of River Elbe, Dithmarschen and Eiderstedt, have been formed in part already during the Atlantic Period (5500 - 2400 b.C.) when the sea level rose (Flandrian Transgression). The Pleistocene land surface, partly lying more than 20 m below sea level, was covered by a thick sheet of marine sediments rich in fine sand and silt, which formed very stable marshland. The area was populated already 2000 years ago, especially on the seward Kalk- and Kleimarsch areas; the lower parts of the marshland lying east towards the "Geest" were unfavourable swampy Humusmarsch, Moormarsch and fens.

When during the Dunkirk Transgression the sea level rose once more (about 2000 years ago), man protected himself against the attack of the sea by the building of earthern hills ("Warft") and, since 1000 a.D., dikes. Fig. 9.1 illustrates the history of colonisation and diking in Southern Dithmarschen since the year 1000.

The marshland soil types in the area of the field trip are shown on the enclosed soil map.

In the **Wadden** area outside the Neufelder Koog (diked 1924) which is not yet covered by higher plants, sedimentation continues. Reductive processes, especially sulphate reduction and sulphide accumulation, and the influence of salty seawater dominate (station 1).

The **Salzmarsch** (profile 2) has grown higher than sea level. It is only flooded during storm tides, with the sedimentation of coarser sediments. Aeration, the oxidation of reduced compounds of sulphur, iron, and manganese, dehydration, structure formation, starting salt- and carbonate leaching occur. These processes are summarized as **maturation.**

In the Neufelder Koog (profile 3), which was diked 1924, the processes of maturation have completed: the land was drained and aeration, salt leaching, structure formation, Ca-saturation of exchange sites have formed a **Kalkmarsch** soil. These soils are among the most productive soils of Schleswig-Holstein. In good years peak yields of more than 10 metric tons of wheat per hectare are reached. With ongoing carbonate leaching, **degradation** (silicate weathering, clay migration, structure deterioration, compaction, acidification) proceed.

In the older marshland east of the Neufelder Koog these processes have advanced, partly **Kleimarsch** soils have formed (carbonate leached > 4 dm). In the areas east of the 1000 year old dike, also Dwog- and Humusmarsh occur.

The **Dwogmarsch** near Auenbüttel (profile 4) shows the complex geo-pedogenesis of the Old Marshland; it contains several humus-rich "Dwogs". Often strong sulphur accumulation and - partly influenced by cultivation - marked clay migration are encountered.

The **Humusmarsch** at Behmhusen (profile 5) shows the typical sulphur accumulation of low-lying Old Marshland frequently flooded by the sea. It is strongly acidified after carbonate leaching, sulphide oxidation, and "Maibolt" (jarosite: $KFe_3(OH)_6(SO_4)_2$) formation.

Marsh Soils Dithmarschen

Dithmarschen 2, Salzmarsch

Location:	Salt marsh area in front of Neufelder Koog (diked in 1924); close to the Elbe estuary; about 1.20 m a.s.l. .
Parent material:	Marine sediments with additions of fluvial material.
Vegetation:	Salt marsh vegetation, mainly Pucinellia maritima.
Soil type:	Typische Salzmarsch (Gleyo-Saltic Fluvisol, Halaquent).
Site qualities:	Storm floods limit agricultural use, geese and sheep grazing.
Profile description:	Typische Salzmarsch

zGoAh	(Agzh)	0- 5 cm:	grayish brown to brownish gray (2.5 Y 4/2-6/2), storm flood layers, sandy silt, crumb to subangular, few mottles/concr., few sulphidic reduction zones, many roots.
zAhGo	(Ahzg)	5- 10 cm:	grayish brown (2.5 Y 4/2) to olive gray (5 Y 5/2), storm flood layers, loamy silt, crumb to subangular, some mottles/concr., many roots.
zGo	(Czg)	10- 24 cm:	olive gray (5 Y 5/2) to grayish brown (2.5 Y 4/2), storm flood layers, sandy silt, structureless to fine crumb, many mottles/concr. (7.5 YR 4/6), some roots, gradual boundary.
zGro	(Czrg)	24- 45 cm:	olive gray (5 Y 3/2-5/2), storm flood layers, loamy silt, structureless to fine crumb, some mottles/concr., some roots.
zGor	(Czgr)	45- 63 cm:	dark to olive gray (5 Y 4/1-2 to 3/2), loamy sand, storm flood layers, decaying roots, some mottles/concr., few sulphides, structureless.
zGrl	(Czrl)	63- 73 cm:	Gray (5 Y 4/1) to black (2.5 Y 2/0), sandy silt, spots of sulphides, decaying roots, rusty root channels, structureless.
zGr2,3	(Czr2)	73-200 cm:	black to very dark gray (2.5 Y 2/0-3/0), sulphides, decaying plant material, structureless.

Dithmarschen 1+2; Schlick, Salzmarsch vor Neufelder Koog (1924)

No	hor.	depth cm	text. in % humus/carb. free soil: sand f	silt c	silt m	silt f	silt Σ	clay	carbonates %: calc.	dol.	Σ	salts mS	salts g/l	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.1	zGr	4- 10	15.6	38.7	22.4	9.9	71.0	13.4	4.6	1.7	6.3	27.1	15.5	1.1
2.1	zGoAh	0- 5	39.9	46.6	4.8	2.9	54.3	5.8	4.3	1.7	6.0	20.7	11.5	-
2.2	zAhGo	- 10	19.5	54.4	12.2	4.5	71.1	9.4	3.7	1.5	5.2	21.9	11.8	148
2.3	zGo	- 24	32.7	51.2	6.2	2.8	60.2	7.1	3.6	1.7	5.3	20.7	11.5	52
2.4	zGro	- 45	37.4	37.0	9.5	4.6	51.1	11.5	2.8	1.5	4.3	23.7	13.7	0.7
2.5	zGor	- 63	54.3	28.4	4.3	4.6	37.3	8.4	2.1	1.4	3.5	24.2	13.3	-
2.6	zGr1	- 73	47.2	40.0	3.9	2.6	46.5	6.3	3.0	1.6	4.6	21.6	12.2	2.6
2.7	zGr2	- 88	52.6	18.8	8.7	6.9	34.4	13.2	3.6	1.4	5.0	26.1	16.1	1.3
2.8	zGr3	-120	76.3	10.3	3.5	2.7	16.5	7.2	4.0	1.5	5.5	26.2	15.5	-

No	bulk dens g/cm³	GPV %	water content at pF(%) 1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	redox E_h mV	FeII %	S^{2-} mg/kg	Fe_d mg/g	Fe_o mg/g	Fe_o/Fe_d	Mn_d mg/kg
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1.1	0.71	70.9	53.7	47.0	25.7	7.4	7.3	- 15	100	1130	7.4	7.2	0.97	838
2.1	-	-	-	-	-	7.7	7.6	+380	9	-	3.8	3.5	0.92	406
2.2	1.10	57.8	49.4	46.1	24.8	7.7	7.6	+430	7	-	5.9	5.2	0.88	725
2.3	1.27	51.7	44.4	37.3	19.3	7.8	7.6	+405	15	-	4.3	3.9	0.91	386
2.4	1.24	52.3	47.3	45.2	28.1	7.6	7.6	+415	18	-	4.7	4.4	0.94	577
2.5	-	-	-	-	-	7.6	7.6	+365	19	19	2.2	1.6	0.73	171
2.6	1.37	47.7	46.0	40.3	18.7	7.7	7.6	+250	60	62	1.5	1.2	0.80	128
2.7	1.13	56.3	54.5	51.7	30.9	7.3	7.2	+115	100	967	5.5	5.3	0.96	306
2.8	-	-	-	-	-	7.3	7.3	+ 20	100	1295	5.5	5.4	0.98	427

No	Corg %	N_t mg/g	C/N	S_t mg/kg	P lact mg/kg	CEC P	sol. + exch. cations meq/kg: Ca	Mg	K	Na	H+Al	Ca/Mg	V %	Al mg/g
1	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1.1	1.5	2.0	7.5	5220	44	162	74	66	16	183	0	1.1	100	0.4
2.1	1.5	1.2	12.5	481	33	85	51	19	7	68	0	2.7	100	0.2
2.2	1.2	1.7	7.1	627	31	87	69	29	6	73	0	2.4	100	0.2
2.3	0.9	1.0	9.0	456	22	74	60	27	6	79	0	2.2	100	0.1
2.4	0.9	1.1	8.2	594	26	96	77	22	8	77	0	3.5	100	0.3
2.5	0.6	0.8	7.5	496	22	64	45	16	4	63	0	2.8	100	0.2
2.6	2.1	0.8	26.3	567	17	60	43	15	4	60	0	2.9	100	0.2
2.7	1.8	1.5	12.0	5740	11	82	84	27	6	78	0	3.1	100	0.3
2.8	2.4	1.3	18.5	5500	15	62	59	16	6	64	0	3.6	100	0.2

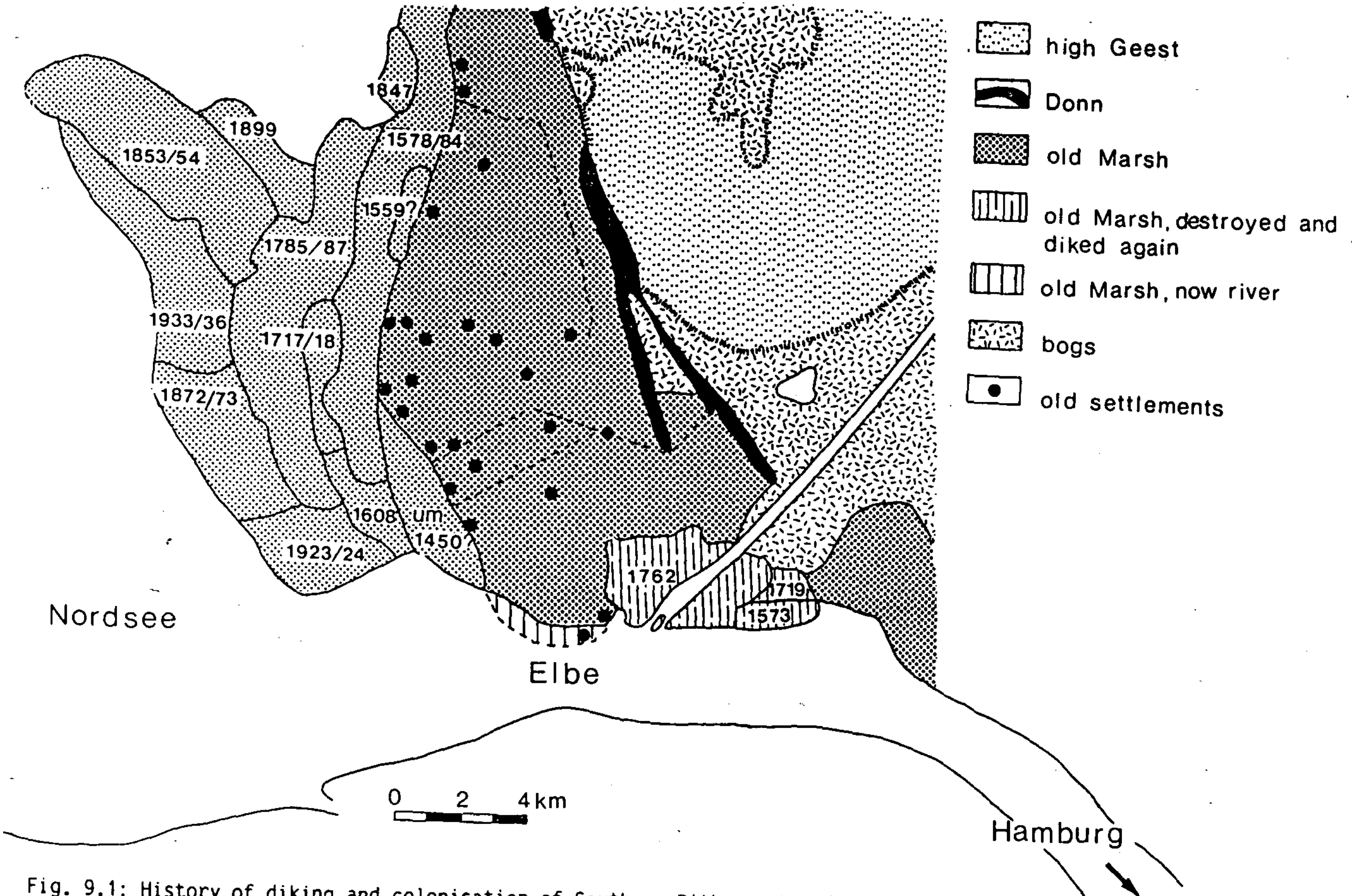

Fig. 9.1: History of diking and colonisation of Southern Dithmarschen (after Degn and Muuß, 1963)

Neufelderkoog, Kreis Dithmarschen (Schleswig-Holstein)

Diked 1924, area: 650 ha, 550 ha agricultural area, soil productivity indices sL 3 Al 53/53 to sL 1 Al 93/93.
1.2 - 1.5 a.s.l., depth to groundwater table (summer) 0.80 - 1.20 m.
Topsoil contains carbonate.
Mean annual temperature: 8.1° C, mean annual precipitation: 810 mm.

Farm Heinrich Heesch (1985)

1. Size:
   total : 23 ha (free hold land)
   arable land : 20 ha
   grassland : 2 ha
   farmyard : 1 ha
   soil fertility index: 70 - 93

2. Cultures:

		Ø yields
winter wheat	9 ha	85 dt/ha
winter barley	3 ha	74 dt/ha
sugar beet	4 ha	480 dt/ha
cabbage	4 ha	600 - 1200 dt/ha

3. Live stock:
   50 souws
   3 boars
   10 rearing cattle

4. Machinery:
   2 tractors, 50 and 45 PS
   1 fertilizer distributor
   1 turnover plough (2-share)
   1 Canadian
   The farm is joint to a machinery co-operative.

5. Labour: farmer and wife, 400 man-hours non-steady labourers

6. Fertilization: Soils contain carbonate, pH 7.4 - 7.6

Fertilizer amounts by crops
- kg/ha -

	N	P_2O_5	K_2O
winter wheat	200	100	120
winter barley	180	90	120
sugar beet	160	120	150
cabbage	300	150	200 +

7. Costs of plant protection: 400 DM/ha (1985)

8. Fertilizer costs : 500 DM/ha (1985)

Marsh Soils Dithmarschen

Dithmarschen 3, Kalkmarsch, Neufelder Koog, diked 1924.

Location:	Neufelder Koog, close to Elbe estuary, 1.5 m a.s.l., groundwater 0.80 - 1.15 m below surface.
Parent material:	Marine sediments with additions of fluvial material.
Vegetation:	Pasture (Shepherd Wolfgang Kuhrt).
Soil type:	Typische Kalkmarsch (Gleyo-Calcaric Fluvisol, calcareous Fluvaquent).
Site qualities:	Deep root zone in dry years and good supply of nutrients and water, waterlogged after periods of heavy rainfall, drained since 1927, drainage distance 15 m.

Profile description: Typische Kalkmarsch

Ap	(Ap)	0- 29 cm:	very dark grayish brown (10 YR 3/2), loamy sand, fine subangular to crumb, many roots.
GoAp	(Agp)	29- 35 cm:	dark to grayish brown (10 YR 3/3-5/2), loamy sand, fine subangular, many mottles/concr., some roots.
Go1	(Cg1)	35- 70 cm:	grayish brown (10 YR 5/2), loamy sand, storm flood layers, many mottles/concr. (7.5 YR 4/6), rusty worm and root channels, structureless.
Go2	(Cg2)	70- 91 cm:	grayish brown (2.5 Y 5/2) to strong brown (7.5 YR 5/6), loamy sand, some storm flood layers, mottles/concr., structureless.
Gor	(Cgr)	91-110 cm:	grayish brown (10 YR 5/2), silty sand, decreasing amount of mottles/concr., structureless.
Gr1	(Cr1)	110-115 cm:	Gray (2.5 Y 4/0-5/0), silty sand, reducing conditions, gradual boundary, structureless.
Gr2	(Cr2)	115-200 cm:	very dark gray (2.5 Y 3/0), silty sand, iron sulphides, structureless.

Dithmarschen 3; Kalkmarsch, Neufelder Koog (1924)

No	hor.	depth cm	text. in % humus/carb. free soil: sand f	silt c	silt m	silt f	Σ	clay	carbonates %: calc.	dol.	Σ	salts mS	salts g/l	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3.1	Ah	0- 5	48.9	25.0	8.1	2.5	35.6	15.5	2.0	1.2	3.2	0.86	0.21	-
3.2	Ap	- 29	48.4	25.9	8.9	3.4	38.2	13.4	2.7	1.2	3.9	0.63	0.18	2.7
3.3	GoAp	- 35	39.8	33.6	8.8	3.1	45.5	14.7	3.6	1.2	4.8	0.76	0.25	-
3.4	Gol	- 70	74.0	17.5	1.5	1.7	20.7	5.3	3.2	1.2	4.4	0.73	0.30	11
3.5	Go2	- 91	77.6	14.2	1.4	1.2	16.8	5.6	3.7	1.0	4.7	1.34	0.45	13
3.6	Gor	-110	63.8	24.3	2.8	2.4	29.5	6.7	3.5	1.4	4.9	0.64	0.30	-
3.7	Gr1	-115	80.6	12.4	1.1	1.7	15.2	4.2	2.9	1.0	3.9	1.61	1.07	-
3.8	Gr2	-130	71.8	19.4	1.3	2.0	22.7	5.5	4.0	1.1	5.1	3.65	2.84	-

No	bulk dens g/cm³	GPV %	water content at pF(%) 1.8	2.5	4.2	pH H_2O	$CaCl_2$	redox E_h mV	FeII %	S^{2-} mg/kg	Fe_d mg/g	Fe_o mg/g	$\frac{Fe_o}{Fe_d}$	Mn_d mg/kg
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29
3.1	-	-	-	-	-	6.8	6.5	+515	8	-	3.7	2.8	0.74	281
3.2	1.41	44.6	34.4	29.4	15.1	6.9	6.6	+550	7	-	4.0	2.8	0.71	281
3.3	-	-	-	-	-	7.2	7.2	+530	5	-	4.9	3.8	0.77	255
3.4	1.52	41.6	37.4	29.2	9.7	7.5	7.4	+538	8	-	2.5	2.1	0.84	85
3.5	1.46	44.3	39.7	28.1	6.8	7.7	7.6	+515	8	-	2.5	2.1	0.86	97
3.6	-	-	-	-	-	7.7	7.6	+513	7	-	2.6	1.8	0.67	146
3.7	-	-	-	-	-	7.7	7.5	+265	72	12	1.1	0.7	0.61	31
3.8	-	-	-	-	-	7.1	7.1	+105	99	338	1.7	1.6	0.94	73

No	Corg %	N_t mg/g	C/N	S_t mg/kg	P lact mg/kg	CEC P	sol. + exch. cations meq/kg Ca	Mg	K	Na	H+Al	Ca/Mg	V %	Al mg/g
1	30	31	32	33	34	35	36	37	38	39	40	41	42	43
3.1	2.1	2.2	9.5	513	109	145	135	7	3	0.5	0	19	100	0.3
3.2	1.5	1.8	8.3	456	98	133	126	5	2	0.5	0	25	100	0.3
3.3	0.6	1.0	6.0	328	33	92	87	3	2	0.5	0	29	100	0.3
3.4	0.3	0.3	-	306	26	41	39	1	1	0.5	0	39	100	0.2
3.5	0.4	0.3	-	262	22	34	32	1	1	0.5	0	32	100	0.2
3.6	0.3	0.4	-	356	22	51	47	2	2	0.5	0	24	100	0.2
3.7	0.5	0.2	-	502	22	23	20	1	2	0.5	0	20	100	0.1
3.8	0.5	0.3	-	1073	24	37	33	2	2	1.5	0	17	100	0.2

Marsh Soils Dithmarschen

Dithmarschen 4, Dwogmarsch, old marsh land, diked about 1000 a. Chr.

Location:	Between Auenbüttel and Ramhusen, 1.0 m a.s.l., groundwater 1.15 m below surface.
Parent material:	Marine sediments with additions of fluvial material.
Vegetation:	Pasture (Reimer Hedde, Auenbüttel).
Soil type:	Schwefelreiche Dwogmarsh (Fluvi-Thionic Gleysol, Sulfaqualf).
Site qualities:	Imperfectly drained, subsurface horizons of very low permeability, good supply of bases.

Profile description:

Ah	(Ah)	0- 10 cm:	very dark grayish brown (10 YR 3/2), silt loam, angular to crumb, many roots.
GoAp	(Agh)	10- 25 cm:	dark brown (10 YR 3/3), silt loam, angular, few mottles/concr., roots in cracks.
SwGo	(Bg)	25- 35 cm:	matrix strong brown (7.5 YR 4/6-5/6), many mottles/concr., yellowish red (5 YR 4/6), silt loam, angular, some roots, diffuse boundary.
SdfAh	(Aghb)	35- 43 cm:	black humic layers (10 YR 2/1) of 1-2 cm thickness (Dwog) and very dark grayish brown (10 YR 3/2) parts, many mottles/concr. (7.5 YR 4/6-5/6), silty clay loam, prismatic to platy, argillans, very dense, diffuse boundary.
fAhGoSd	(Ahb,Bg)	43- 56 cm:	very dark gray humic layers (10 YR 3/1) to very dark grayish brown (10 YR 3/2), many mottles/concr. (7.5 YR 4/6-5/6), silty clay, argillans, earth worm channels, very dense, angular to prismatic structure.
fAhSd	(Ahbg)	56- 60 cm:	black humic layers (10 YR 2/1), silty clay, some mottles/concr., angular, argillans, earth worm channels.
fAhGo	(Ahb,Bg)	60- 67 cm:	very dark grayish brown (10 YR 3/2), some mottles/concr. (7.5 YR 4/6-5/6) and spots of jarosite (2.5 Y 8/6), silty clay, angular, earth worm channels.
Gho	(Bhg)	67- 80 cm:	dark grayish brown matrix (10 YR 4/2), jarosite (2.5 Y 8/6) and many mottles/concr. (7.5 YR 4/6-10 YR 6/8), silty clay, angular (prismatic), fossil Phragmites rhizomes.
Gro	(Brg)	80-100 cm:	grayish brown matrix (10 YR 5/2), many mottles/concr. (7.5 YR 4/6-5/6), silt loam, structureless.
Gor1	(Bgr1)	100-114 cm:	gray matrix (10 YR 5/1), silt loam, many mottles/concr. (7.5 YR 4/6-5/6), structureless.
Gor2	(Cgr)	114-135 cm:	gray matrix (10 YR 5/1), sandy silt, some mottles/concr., carbonates, structureless.
Gr	(Cr)	135-200 cm:	dark grey to gray (10 YR 5/1), loamy sand, few sulphides, carbonates, structureless.

Dithmarschen 4; Dwogmarsch

No	hor.	depth cm	text. in % humus/carb. free soil: sand f	silt c	silt m	silt f	silt Σ	clay	carbonates %: calc.	dol.	Σ	salts mS	salts g/l	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4.1	Ah	0- 10	21.1	35.7	12.7	5.4	53.8	25.1	-	-	-	0.95	0.34	-
4.2	GoAp	- 25	24.2	33.0	15.6	8.6	57.2	18.6	-	-	-	0.62	0.23	3.6
4.3	SwGo	- 35	12.1	43.0	15.6	6.2	64.8	23.1	-	-	-	0.48	0.24	2.3
4.4	SdfAh	- 43	10.9	30.9	17.8	9.4	58.1	31.0	-	-	-	0.40	0.16	0.3
4.5	fAhGoSd	- 56	4.3	18.5	22.6	11.7	52.8	42.9	-	-	-		0.22	<0.1
4.6	fAhSd	- 60	6.4	19.9	16.2	12.0	48.1	45.5	-	-	-	0.89	0.37	-
4.7	fAhGo	- 67	5.1	21.7	16.2	9.6	47.5	47.4	-	-	-	0.62	0.32	-
4.8	Gho	- 80	3.1	21.9	21.9	11.6	55.4	41.5	-	-	-	0.85	0.40	0.4
4.9	Gro	-100	19.0	41.3	13.8	6.9	62.0	19.0	-	-	-	1.11	0.60	-
4.10	Gor1	-114	18.3	39.9	13.5	8.2	61.6	20.1	-	-	-	1.76	1.03	-
4.11	Gor2	-135	28.2	37.7	19.0	7.8	64.5	7.3	-	-	3.9	1.76	0.95	-
4.12	Gr	-160	71.6	15.9	2.9	1.6	20.4	8.0	-	-	4.3	1.89	1.13	-

No	bulk dens g/cm^3	GPV %	water content at pF(%) 1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	redox E_h mV	FeII %	S^{2-} mg/kg	Fe_d mg/g	Fe_o mg/g	Fe_o/Fe_d	Mn_d mg/kg
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29
4.1	-	-	-	-	-	5.4	5.1	+478	14	-	8.2	6.1	0.74	464
4.2	1.49	38.5	33.9	30.2	15.0	5.2	5.0	+564	11	-	8.0	5.4	0.68	233
4.3	1.52	38.9	33.5	30.1	19.9	5.3	4.9	+429	13	-	14.0	4.6	0.33	182
4.4	1.30	48.6	45.9	43.1	35.3	5.4	5.1	+429	14	-	13.2	5.5	0.42	135
4.5	1.32	48.0	46.2	43.1	32.6	5.6	5.2	+424	14	-	9.4	5.3	0.56	57
4.6	-	-	-	-	-	5.6	5.2	+435	13	-	11.5	10.0	0.87	215
4.7	-	-	-	-	-	5.5	5.2	+381	18	-	7.7	5.7	0.74	77
4.8	1.13	55.7	53.1	50.8	38.3	5.8	5.5	+362	17	-	19.5	9.0	0.46	56
4.9	-	-	-	-	-	6.4	6.2	+377	14	-	12.4	5.0	0.40	86
4.10	-	-	-	-	-	7.1	6.9	+332	9	-	9.6	5.8	0.60	137
4.11	-	-	-	-	-	7.6	7.4	+355	10	-	7.6	5.1	0.67	148
4.12	-	-	-	-	-	7.9	7.5	+355	19	41	3.5	2.2	0.63	61

No	Corg %	N_t mg/g	C/N	S_t mg/kg	P lact mg/kg	CEC P	sol. + exch. cations meq/kg Ca	Mg	K	Na	H+Al	Ca/Mg	V %	Al mg/g
1	30	31	32	33	34	35	36	37	38	39	40	41	42	43
4.1	4.5	3.4	13.2	832	76	217	113	14	14	0.5	76	8.1	65	0.4
4.2	2.1	2.0	10.5	502	22	148	79	11	10	0.5	48	7.2	68	0.4
4.3	0.7	1.0	7.0	393	4	114	61	12	9	0.5	32	5.1	72	0.4
4.4	0.9	1.3	6.9	446	4	219	137	21	11	0.5	50	6.5	77	0.7
4.5	1.3	1.4	9.3	675	4	230	142	26	10	0.5	52	5.5	77	0.7
4.6	4.2	4.0	10.5	2180	4	529	435	35	9	1	49	12.4	91	1.6
4.7	2.1	3.1	6.8	1882	2	342	198	29	9	0.5	106	6.8	69	1.3
4.8	0.7	1.7	-	2933	2	233	151	26	8	0.5	48	5.8	79	0.6
4.9	0.5	0.8	-	470	4	130	96	16	6	0.5	12	6.0	91	0.4
4.10	0.6	0.8	-	452	17	127	96	17	6	1	8	5.6	94	0.3
4.11	0.6	0.9	-	460	17	132	111	15	6	1	0	7.4	100	0.3
4.12	0.3	0.4	-	475	9	50	43	4	3	1	0	10.8	100	0.2

Marsh Soils Dithmarschen

Dithmarschen 5, schwefelreiche Humusmarsch, old marsh land, diked about 1000 a. Chr.

Location:	South-west of Behmhusen, 0.3 m a.s.l., groundwater 0.60-1.00 m below surface.
Parent material:	Marine sediments with additions of fluvial material.
Vegetation:	Meadow/pasture (Cornelsen, Behmhusen).
Soil type:	Schwefelreiche Humusmarsch (Thionic-Humic Gleysol, Humasulfaquept).
Site qualities:	Extremely acid subsurface horizons, waterlogged after periods of heavy rainfall.

Profile description:

GoAh1	(Agh1)	0- 26 cm:	very dark grayish brown (10 YR 3/2), silt loam, crumb to subangular, many mottles/concr., many roots.
GoAh2	(Agh2)	26- 34 cm:	very dark brown (10 YR 2/2), silty clay loam, subangular to angular, some mottles/concr., some roots.
Gho	(Bhg)	34- 50 cm:	grayish brown matrix (10 YR 4-5/2), silty clay loam, small layers of fine sand and of organic material, angular, jarosite (5 Y 8/4-2.5 Y 8/6) and many mottles/concr. (7.5 YR 4/4), earth worms.
Ghro	(Bhrg)	50- 66 cm:	grayish brown matrix (10 YR 5/2, 2.5 Y 5/2), silt loam, angular, jarosite, mottles/concr. of different colour (10 YR 3/2-5/8), Phragmites rhizomes, earth worms.
Ghor1	(Bhgr1)	66- 84 cm:	gray to olive gray matrix (5 Y 5/1-2), silt loam, angular, few jarosite, some mottles/concr. (10 YR 3/2-5/8), Phragmites rhizomes.
Ghor2	(Bhgr2)	84-103 cm:	gray matrix (5 Y 5/1), silt loam, angular to coherent, few jarosite, mottles/concr., Phragmites rhizomes.
Ghr	(Cr)	103-120 cm:	gray matrix (2.5 Y 5/0-5 Y 5/1) with black spots of sulphides (5 Y 2.5/1), silt loam, layers of fine sand, angular to coherent, carbonates.
Gr	(Cr)	120-200 cm:	greenish gray to dark gray, silty sand, few sulphides, carbonates.

Dithmarschen 5; schwefelreiche Humusmarsch

No	hor.	depth cm	text.in % humus/carb. free soil sand f	silt c	m	f	Σ	clay	carbonates % calc.	dol.	Σ	salts mS	g/l	kf cm/d
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5.1	GoAh1	0- 26	30.1	31.5	12.2	3.6	47.3	22.6	-	-	-	0.69	0.25	0.8
5.2	GoAh2	- 34	12.6	24.0	16.9	8.4	49.3	38.1	-	-	-	0.67	0.36	-
5.3	Gho	- 50	6.2	31.1	19.3	8.8	59.2	34.6	-	-	-	0.70	0.44	0.7
5.4	Ghro	- 66	16.1	36.9	16.2	6.3	59.4	24.5	-	-	-	1.39	0.73	9.5
5.5	Ghor1	- 84	28.9	34.5	11.6	4.8	50.9	20.2	-	-	-	2.39	1.51	7.8
5.6	Ghor2	-103	4.6	40.5	19.5	9.4	69.4	26.0	-	-	-	5.66	4.20	43
5.7	Ghr	-120	24.3	39.7	14.1	6.5	60.3	15.4	-	-	<1	4.07	2.05	-

No	bulk dens g/cm³	GPV %	water content at pF(%) 1.8	2.5	4.2	pH H_2O	$CaCl_2$	redox E_h mV	FeII %	S^{2-} mg/kg	Fe_d mg/g	Fe_o mg/g	$\frac{Fe_o}{Fe_d}$	Mn_d mg/kg
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29
5.1	1.31	47.7	42.6	38.0	22.9	5.1	5.0	+490	20	-	7.9	7.3	0.92	279
5.2	-	-	-	-	-	5.4	5.2	+490	22	-	11.3	9.2	0.81	194
5.3	1.13	56.3	48.7	45.2	27.4	4.2	3.9	+530	16	-	24.9	9.7	0.39	45
5.4	0.90	65.0	55.9	51.1	29.4	3.7	3.4	+610	12	-	11.9	7.9	0.66	17
5.5	0.98	61.9	52.0	43.6	(20)	3.2	3.2	+670	14	-	5.3	3.9	0.74	19
5.6	0.84	67.2	58.2	52.5	22.2	3.5	3.5	+410	83	60	5.9	5.2	0.88	40
5.7	-	-	-	-	-	6.5	6.2	+120	91	130	1.9	1.9	1.00	96

No	Corg %	N_t mg/g	C/N	S_t mg/kg	P lact mg/kg	CEC P	sol. + exch. cations meq/kg Ca	Mg	K	Na	H+Al	Ca/Mg	V %	Al mg/g
1	30	31	32	33	34	35	36	37	38	39	40	41	42	43
5.1	4.2	2.5	16.8	584	20	204	126	16	2	1	59	7.9	71	0.6
5.2	4.2	1.7	24.7	2110	7	350	198	32	2	2	116	6.2	67	1.0
5.3	0.9	1.3	-	4260	9	188	70	18	4	1	95	3.9	49	0.6
5.4	0.6	0.9	-	2090	11	104	16	6	2	1	80	2.7	23	0.6
5.5	0.6	0.8	-	1580	26	84	13	8	2	1	61	1.6	27	0.8
5.6	1.5	1.0	-	6400	17	238	83	47	4	2	101	1.8	58	0.9
5.7	1.2	0.5	-	3110	15	130	90	27	5	1	8	3.3	94	0.3

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Chemical Methods of Soil Analysis

Carbonates: a) Gas volumetric determination of total CO_2 after HCl treatment. b) Destruction of calcite by stirring a ground soil sample with Na_2-EDTA (pH 4.5) for 30 min. and determination of dolomite-CO_2. c) Total CO_2 minus dolomite-CO_2 gives calcite-CO_2.

Salts: Electrical conductivity of saturation extract in mS. Sum of Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_3^- and SO_4^{2-} in saturation extract in g/l.

Redox potential: Measurement in fresh soil material with or without additions of de-aerated destilled water.

FeII %: Extraction of the fresh soil sample with 0.5 m HCl (1:5) by vigorous stirring for 5 min., colorimetric determination (o-phenanthroline) of the extracted Fe^{2+} and Fe^{3+}.

$$\text{FeII \%} = \frac{\text{FeII} \cdot 100}{\text{FeII} + \text{FeIII}}$$

S^{2-}: Monosulphides and instable Polysulphides; determined as H_2S after HCl dissolution.

Fe_d, Mn_d = dithionite-citrate-bicarbonate extractable Fe and Mn.

Fe_o, Al_o = oxalate extractable Fe and Al.

CECp = potential CEC, determined by Sr^{2+} adsorption at pH 8.1.

Excursion A, 10^{th} day, route description

Lübeck, most important "Hanse" town on the Baltic in the Middle Ages, today industrial (shipyards, metal processing) and university (Faculty of Medicine) town. With

Travemünde, largest Baltic seaport of the Federal Republic (Ferries to Danmark, Sweden, Finland and Poland) and elegant seaside resort.

Herrmannshöhe with Brodten Cliff. 4 soils of the moraine landscape.- Ride to the

Evershof Farm, cropping without livestock; ride over

Lübeck in the Trave Valley, through the Lübeck Basin with Pleistocene basin clays under grassland;-passing

Reinfeld, and through the hilly moraine landscape with Luvisols under cropland and Gleysols and Histosols under grassland to

Hamburg.

Mitteilungen Dtsch. Bodenkundl. Gesellschaft, 46, 277-287 (1986)

Young Moraine Landscape near Lübeck Bight

by H.-P. Blume and H.-K. Siem (Kiel), H.J. Betzer and B. Meyer (Göttingen)

The Brodten young moraine region lies between the Hemmelsfjord and the Trave Fjord, two valleys formed by glacier lobes (Fig. 10.1). The Herrmannshöhe (H) is formed of boulder sands and fluvio-glacial sands of a later ice protrusion and surmounts the surrounding moraines. During the early Holocene lakes developed in the depressions of the hilly moraine landscape, later they developed into bogs. With the rise of the sea level (by about 30 m) the material eroded and the cliff of Brodten was formed. The residual sediment of stones (stone reef) erxtends into sea down to 20 m b.s.l., marking the coastline of 7000 years ago. The annual retreat of the cliff by erosion is about 1 m today. Sand deriving from the boulder marl has been, and is being, deposited on the beaches of the seaside resorts of Timmendorfer Strand and Travemünde.

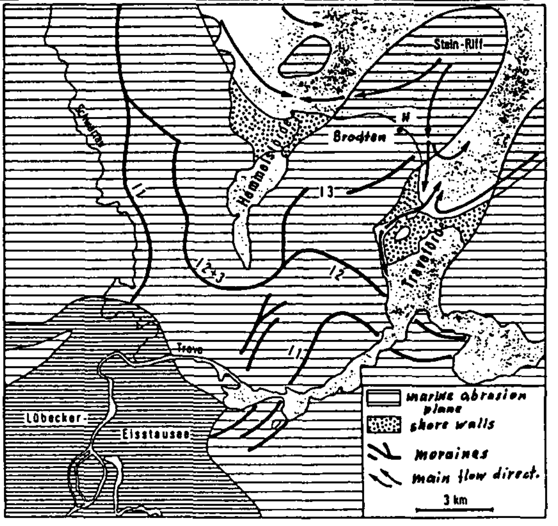


Fig. 10.1: Geology of the moraine landscape near Travemünde (after Ch. Degn and U. Muuß 1979)

The woodlands of Brodten were cut and agriculture started probably already during the Bronze age. This promoted hillslope erosion. Today the depressions are covered by thick sheets of colluvium.

Parabraunerde - Gley-Kolluvium - Niedermoor - Catena
Location: Cliff of Brodten, near Travemünde

Brodten I

Location: 14 m a.s.l., plateau, groundwater 3 m below the soil surface
Parent material: boulder marl above fluvioglacial silt
Vegetation: Grases of a field balk
Soil type: Pseudovergleyte Parabraunerde (Orthic Luvisol)
Site qualities: deep root zone, water supply moderately moist, well to imperfectly drained, good supply of bases

Profile description:

Ap (Ap)	0- 29 cm	dark brown (10YR3/3), sandy loam, crumb to subangular blacky, soft, many roots, gradual boundary
Al (E)	- 46 cm	dark yellowish brown (10YR4/5), sandy loam, coarse subangular blacky, some humic worm channels, soft, common roots, gradual boundary
Bt (Bt)	- 60 cm	brown (7.5YR4/4), loam, prismatic, dark brown argillans, humic worm channels, few small black concretions, common roots, diffuse boundary
SBt (Bt)	-105 cm	yellowish brown (10YR5/6), few rusty mottles, loam, prismatic, dense, few roots, clear boundary
CS (Cg)	-230 cm	yellowish brown (10 YR5/6) loam prismatic to coherent, bleached root channels and ped surfaces, but mottled cores, very fine lime coats, dense gradual boundary
CGo (Cg)	-290 cm	yellowish brown (10YR5/4), yell.red (5YR5/6) ped surfaces loam, coherent to platy, dense, clear boundary
CGr (Cr)	-385 cm	grey (5Y5/1), loam, coherent to platy, dense clear boundary
IIGr (Cr)	-400 cm	olive grey (5Y5/2), silt loam, coherent to platy, dense.

Interpretation

Parent material dense (platy structure due to strong ice pressure) dark grey boulder marl with quartz, feldspars, micas, clay minerals (mainly illites), carbonates and sulphides.

Deep oxidation of the sulphides (down to 2.9 m), formation of an oxidized horizon (2.3 - 2.9 m), above, a reduced horizon of a groundwater Gleysol. Carbonate leaching, acidification, and base depletion in the uppermost meter

Brodten I

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.1	Ap	0-29	3.2	4.3	17.9	34.2	56.4	14.9	12.6	4.9	32.4	11.2	950	
1.2	Al	- 46	2.1	3.9	14.3	32.9	51.1	13.8	12.7	5.3	31.8	17.1	230	
1.3	Bt	- 60	2.3	3.9	11.1	27.5	42.5	14.1	13.9	6.0	34.0	23.7	30	
1.4	SBt	-105	2.0	2.9	10.3	24.4	37.6	13.2	17.7	7.8	38.7	23.7	15	
1.5	CS1	-175	3.3	3.1	11.1	28.2	42.4	15.5	18.7	8.7	42.9	14.7	6.6	
1.6	CS2	-230		3.9	12.3	25.4	41.6	14.8	15.0	8.1	37.9	20.5	0.9	
1.7	CGo	-290		3.1	8.7	23.7	35.5	11.0	17.1	9.0	37.1	27.4	0.2	
1.8	CGr	-385		2.8	9.0	25.6	37.4	15.6	18.4	8.2	42.2	20.4	0.1	
1.9	IICGr	-400		0	0	29.1	29.1	40.3	21.0	3.1	64.4	6.5	17	

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_d mg/kg	S_t mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1.1	Ap	1.39	46	41	36	29	12	6.1	5.4	2.6	2.3	0.91	200	
1.2	Al	1.65	38	37	30	25	19	6.5	5.8	6.2	2.4	0.39	359	
1.3	Bt	1.69	37	36	34	30	23	7.1	6.4	7.6	2.9	0.39	518	
1.4	SBt	1.71	37	37	34	30	24	7.1	6.4	9.8	2.5	0.26	469	
1.5	CS1	1.74	35	35	32	28	18	8.2	7.5	6.4	0.9	0.14	168	
1.6	CS2	1.90	32		32 x	25 xx		8.2	7.5	5.6	0.5	0.09	202	<.1
1.7	CGo	1.92	29		29 x	28 xx		8.2	7.5	7.5	1.5	0.19	229	<.1
1.8	CGr	1.96	28		28 x	25 xx		8.3	7.6	2.3	1.3	0.53	160	0.9
1.9	IICGr	1.65	39		35 x	31 xx		8.2	7.4	2.5	1.5	0.59	176	2.6

x pF 2 xx pF 3

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon, %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1.1	Ap	0.84	1.0	8	0	132		74	4	8	1	45		66
1.2	Al	0.52	0.54	10	0	133		86	4	11	<1	32		76
1.3	Bt	0.46	0.49	9	0	196		145	3	16	7	25		87
1.4	SBt	0.26	0.37	7	0	176		137	3	16	<1	20		89
1.5	CS1	<1			17.5	165		151	2	12	<1	0		100
1.6	CS2	<1			18.1	118		98	3	16	1	0		100
1.7	CGo	<1			18.8	104		83	4	16	1	0		100
1.8	CGr	<1			18.4			287	4	15	1	0		100
1.9	IICGr	<1			18.3	176		160	3	12	1	0		100

followed by clay migration and humus accumulation in the topsoil. Water stagnation over the argillic horizon and the densely packed boulder marl; redistribution of iron: bleaching of the aggregate surfaces and mottling inside the aggregates.

Restoration of carbonate and base contents by liming and fertilizing.

Brodten II

Location: 13 m a.s.l., small depression, groundwater 2 m below the soil surface
Parent material: colluvial layer above solifluction deposits of boulder marl
Vegetation: Shrubs and grases of a field balk
Soil type: Gley Kolluvium or degraded Gley-Schwarzerde (Gleyic Phaeozem, Humaquept)
Site qualities: deep root zone, moist, well to imperfectly drained, good supply of bases

Profile description:

MAp (Ap)	0- 80 cm	grey brown (10YR4/2) to yellowish brown (10YR5/4), few rusty spots (2.5YR2.5/4), sandy loam, crumb to laminar, loose, many roots, clear boundary
GofAh (Ah)	-137 cm	black (N2), rusty (7.5YR5/6) root channels, sandy loam, crumb to subangular blacky, loose, few roots, clear to lobed boundary
Gro (Bg)	-180 cm	light olive grey (5YR6/2), rusty (2.5YR4/8), ped sufaces and root channels, loam prismatic, few dark brown argillans, dense, few roots, gradual boundary
Gor (Br)	-200 cm	greyish brown (2.5YR5/2), few yellowish red mottles, few root channels, loam, coherent, dense.

Interpretation

Boulder marl re-distributed by solifluction, accumulation in hollows.

Under the influence of carbonate-rich lateral groundwater input and intense bioturbation (mostly by earthworms) a gleyic Chernozem developed. Carbonate leaching later. With tillage of the landscape (probably since the Bronze Age) onset of strong erosion of the Luvisols on neighbouring slopes and accumulation of a thick (80 cm) colluvium over the gleyic Chernozem.

Brodten II

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2.1	MAp	0-80	<1	1.9	24.5	40.7	67.1	13.5	7.6	3.4	24.5	8.4	24	
2.2	GofAh	-137	<1	7.0	44.9	27.4	79.3	5.6	3.9	1.9	11.4	9.3	27	
2.3	Gro	-180	0	0.2	6.2	40.0	46.4	25.5	11.1	4.0	40.6	13.0	16	
2.4	Gor	-200	<1	1.0	29.0	48.4	78.4	9.9	3.2	3.9	17.0	4.6	22	

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
2.1	MAp	1.60	40	37	32	20	9.3		6.0	4.7	2.4	0.51		
2.2	GofAh	1.38	46	44	32	23	10		5.9	2.2	1.9	0.86		
2.3	Gro	1.81	32	32	24	18	6.4		6.2	3.3	1.6	0.49		
2.4	Gor	1.71	34	32	25	17	3.4		6.9	1.4	0.1	0.07		

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
2.1	MAp	0.84	0.8	11	0	111		85	1	6	2	28		75
2.2	GofAh	6.36	4.3	15	0	422		342	1	12	1	68		84
2.3	Gro	0.28	0.2	14	0	138		107	2	9	1	19		86
2.4	Gor	<0.1	<0.1		0	51		44	1	3	1	3		94

Brodten III

Location: 17 m a.s.l., slope of a bag
Parent material: boulder sand above fluvial glacial sands
Vegetation: Shrubs and grases
Soil type: Bänderparabraunerde (Orthic Luvisol)
Site qualities: very deep root zone, moderately moist to dry, well drained, good to moderate supply of nutrients

Profile description:

Ap (Ap)	0- 22 cm	dark greyish brown (19YR4/2), black and yellowish brown spots, loamy sand, singular to fine crumb, loose, many roots, clear boundary
Bv (Bw)	- 52 cm	brownish yellow (10 YR 4/3), light brownish grey crotowinals, loamy sand, singular to very fine crumb, loose, common roots, gradual to lobed boundary
Cbt (Bt)	- 92 cm	light yellowish brown (10 YR 6/4), brown clay pans (1 - 40 mm Ø), loamy sand, few roots, few small blackish brown concretions, clear boundary
SwC (C)	-120 cm	very pale brown (10YR7/4), few mottles, medium to fine sand, singular, few roots, clear boundary
IICSw	-150 cm	light yellowish brown (10YR6/4), many rusty mottles, and small (0.1 mm Ø) dark brown concretions, sandy loam, coherent to subangular, slightly dense, clear boundary
IIICSw	-180 cm	light yellowish brown (10 YR6/5), few rusty mottles, medium sand, singular, abrupt boundary
IVSd	-200 cm	very pale brown (10YR7/3)/ strong brown (7.5YR5/7), mottled, loam, coherent, dense, many black concretions.

Interpretation

The ground moraine base was covered by fluvio-glacial sediments and these in turn covered by boulder sand of minor thickness by a later glacier protrusion.

Soil development predominantly during the Holocene, it lead to the removal of carbonates, acidification, base leaching and humus accumulation, also clay migration, the clay accumulated in bands in the subsoil. Agricultural use lead to a rise in pH and secondary lime enrichment in the topsoil.

Brodten III

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3.1	Ap	0-22	4.1	5.7	28	43	77	15	2.0	1.7	19	4.4	170	
3.2	Bv	-52	0.8	1.0	21	50	72	21	2.9	1.7	25	3.1	200	
3.3	Cbt	-92	0.2	0.6	28	52	81	14	2.2	1.0	17	2.4	210	
3.4	SwC	-120	0.2	1.1	51	41	93	5.2	0.4	0.4	6	1.1	200	
3.5	IICS	-150	0	0.4	12	38	51	38	4.2	2.3	44	5.1	18	
3.6	IIICS	-180	0	0.1	56	39	95	2.0	0.8	0.3	3	2.0		
3.7	IVCS	-200	0	0.2	6.4	46	52	27	5.5	1.3	34	14		

No	hor.	bulk dens. g/cm^3	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_d mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
3.1	Ap	1.53	42	42	31	11	7.1	7.5	6.9	3.23	1.23	0.38	143	
3.2	Bv	1.61	39	36	28	13	5.3	7.3	6.6	2.44	1.49	0.61	169	
3.3	Cbt	1.60	39	35	16	7.5	5.8	7.4	6.8	1.05	0.70	0.38	85	
3.4	SwC	1.68	37	34	5.5	4.4	1.7	7.2	6.7	0.90	0.28	0.31	56	
3.5	IICS	1.74	34	31	25	18	8.8	7.1	6.3	2.18	1.04	0.48	112	
3.6	IIICS							6.9	6.3	1.10	0.39	0.35	73	
3.7	IVCS							6.8	5.9	5.90	2.50	0.42	245	

No	hor.	$C_{org.}$ %	N_t mg/g	C:N	carbon. %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
3.1	Ap	0.92	0.63	15	0.4	57	53	51	0.4	0.8	0.96	4.0		93
3.2	Bv	0.28	0.24	12	0.2	40	33	32	0.3	0.2	0.3	7.0		83
3.3	Cbt	0.09	0.09	10	0	29	20	19	0.3	0.3	0.2	9.0		69
3.4	SwC	0.01	0.01	10	0.1	16	12	11	0.2	0.2	0.1	4.0		75
3.5	IICS	0.03	0.05	6	0.1	36	30	26	1.0	1.5	0.2	7.0		81
3.6	IIICS	0.02			0.1	14	10	8	0.4	0.5	0.1	5.0		64
3.7	IVCS	0.04			0	81	74	53	2.1	7.9	0.7	17		79

Brodten IV

Location: 9.5 m a.s.l., small depression, (former) groundwater near soil surface
Parent material: lake sediments above boulder marl
Vegetation: shrubs of a small wood
Soil type: Niedermoor above Kalkgyttja (Eutric Histosol)

1 (H)	0- 38 cm	black (N2), strongly humified peat, mixed with colluvial deposits, some very small mottles, many roots, clear boundary
F1	- 41 cm	black (N2), humic mud with dark red spots (2.5YR4/8)
F2	- 53 cm	very dark grey (10YR3/1) lime mud with snail-shells, few red (2.5YR2/5) spots, light grey (10YR8/4) ped surfaces, carbonates
F3	- 59 cm	black (5YR2.5/1) humic mud, root channels with red (2.5YR4(7) surfaces, carbonates
F4	- 61 cm	very dusky red (2.5YR2.5/2) mud
F5	- 72 cm	very dark grey (5YR3/1) clayey mud, carbonates
F6	- 81 cm	black (5YR2.5/1) humic mud with carbonates
F7	- 86 cm	black (N2.5) humic mud
F8	- 89 cm	pale yellow (2.5Y8/4) lime mud with yellowish red (5YR5/8) spots
H2	- 90 cm	black (10YR2/1) peat, carbonate
Gor	-113 cm	olive grey (5Y5/2) loamy sand above stone layer, brownish yellow (10YR5/8) mottles, carbonates
IIGor	-173 cm	olive (5Y5/3) loam, reddish yellow (7.5YR6/8) channels, coherent to laminar, cabonates
Gr	-200 cm	pale olive (10Y6/3) loam, coherent, dense, carbonates

Interpretation

In a hollow of the ground moraine landscape, wind erosion in the late Glacial Period and -sedimentation formed a stone layer covering the boulder marl (deeper than 113 cm), later covered by eolian layered sand (90 - 113 cm). Probably since the Alleröd limnic conditions prevailed and mud of varying limecontents was deposited, partly containing peat (38 - 90 cm); later the lake landed up, a fen formed (o - 38 cm). When the hollow was opened by cliff erosion, the fen fell dry, mottling of the under lying sands and boulder marl.

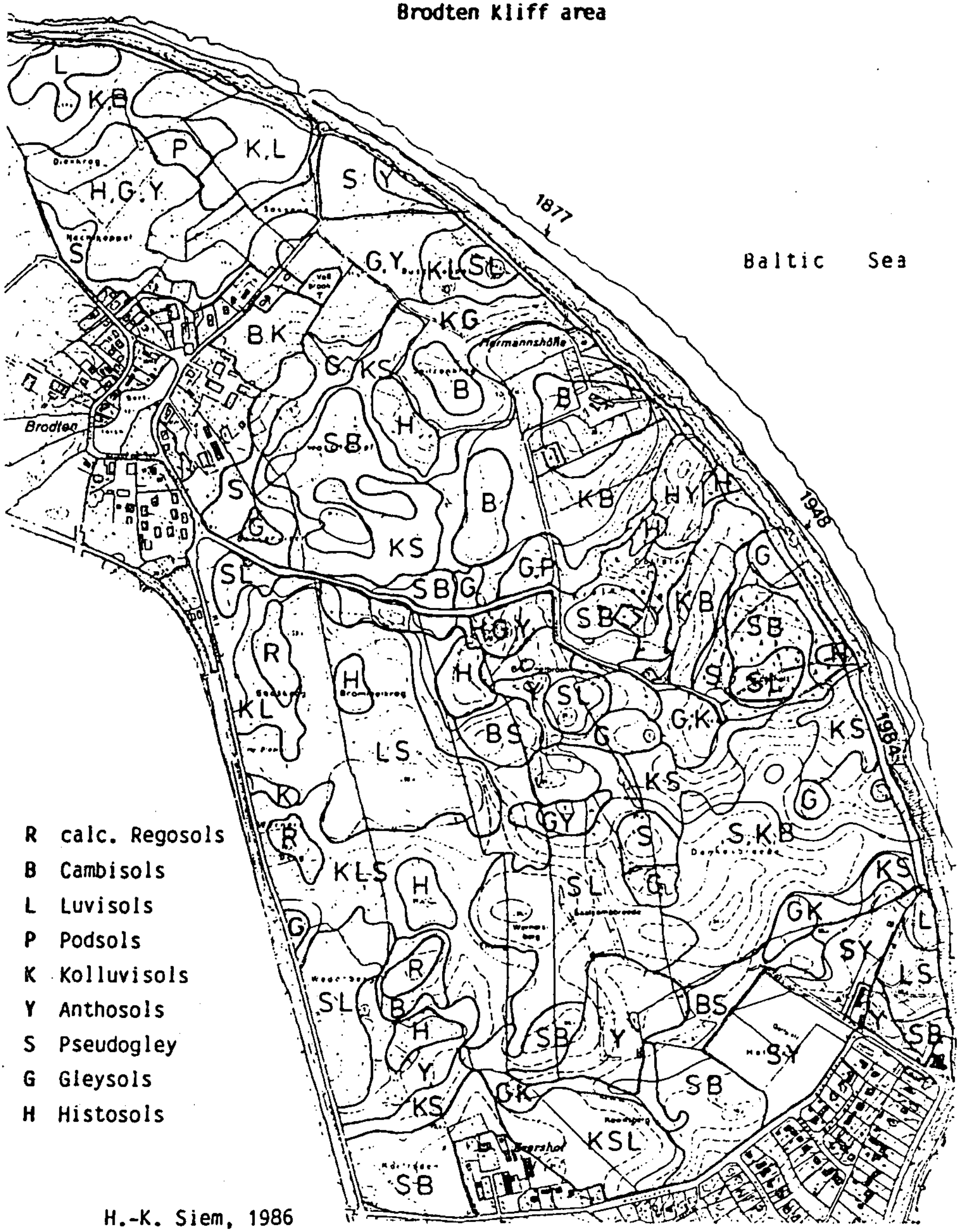
Brodten IV

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4.1	H1	0-38		1.6	12	31	44	17	18	11	45	11	181	
4.9	F8	86-89		0	1.7	6.7	8.4	15	4.4	2.6	22	70		
4.11	Gor	90-113		3.2	29	53	85	4.8	1.7	2.7	9.2	5.3		
4.12	IIGor	-173		4.8	13	27	45	14	17	7.8	39	16	0.1	
4.13	Gr	-215		4.4	13	26	43	11	13	8.1	32	25	0.3	

No	hor.	depth cm	bulk dens. g/cm³	GPV %	water content in % at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	$C_{org.}$ %	N_t mg/g	C:N	carbon. %
1	2	3	16	7	18	19	20	21	22	23	29	30	31	32
4.1	H1	0-38	0.58		74	47	45	36		6.4	24.0	20.0	12	0
4.2	F1	-41								7.0	37.2	23.3	16	9.0
4.3	F2	-53	0.52		81	61	58	36		7.6	11.5	9.3	12	66
4.4	F3	-59								7.4	18.7	14.5	13	20
4.5	F4	-61								7.3	15.7	9.4	17	9.0
4.6	F5	-72	0.64		71	61	59	34		7.3	29.4	8.8	33	7.8
4.7	F6	-81								6.6	21.6	15.6	14	1.8
4.8	F7	-86								7.5	19.6	16.2	12	11
4.9	F8	-89								7.7	11.2	13.5	8	77
4.10	H2	-90								7.1	26.7	14.3	19	4.1
						pF 2.0	pF 3.0							
4.11	Gor	-113								7.4	0.1			5.4
4.12	IIGor	-173	1.78	33		30	24			7.3	0.32			17
4.13	Gr	-215	1.82	31		30	24			7.6	0.30			19

No	hor.	Fe_d mg/g	Fe_o mg/g	Fe_o:Fe_d		CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	24	25	26		33	34	35	36	37	38	39	40	41
4.1	H1					2540		1520	2	50	6	66		98
4.11	Gor	1.8	0.5	0.26		46		42	1	1	2	0		100
4.12	IIGor	5.5	3.9	0.69		129		122	3	3	1	0		100
4.13	Gr	5.3	4.9	0.93		72		59	4	8	1	0		100

Soil association map of the Brodten Kliff area



R calc. Regosols
B Cambisols
L Luvisols
P Podsols
K Kolluvisols
Y Anthosols
S Pseudogley
G Gleysols
H Histosols

1000 m

H.-K. Siem, 1986
Geologisches Landesamt Schleswig-Holstein

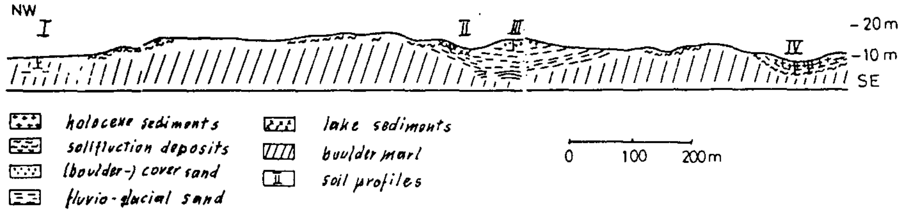


Fig. 10.2: Sediment composition of the Brodten Cliff (after H.J. Betzer 1982)

Luvisols free of carbonate down to 0.8 - 1.5 m have formed on the boulder marl. Since the material is very dense (compacted by ice sheets), stagnating water is common. The hills are covered by banded Luvisols on glacio-fluvial sand, the depressions contain thick colluvia, bogs and humic Gleysols. The latter have a thick mollic epipedon and may also be called aquic Phaeozems.

Literature

Betzer, H.J. (1982): Die Bodengesellschaft der jungweichselzeitlichen kuppigen Grundmoränenlandschaft Ostholsteins unter besonderer Berücksichtigung der periglazialen Oberflächenschichtung, am Beispiel einer Bodensequenz des Brodtener Kliffs bei Travemünde. Diss. Göttingen.

Degn, Ch. and U. Muuß (1979): Topographischer Atlas Schleswig-Holstein und Hamburg. K. Wachholtz, Neumünster.

Mitteilgn. Dtsch. Bodenkundl. Gesellsch. 46, 288-290 (1986)

Natural and economical resources of Evershof-Farm

by E.SCHNUG and J.LAMP (University Kiel)

1. Topography, geology and soils

The Evershof farm is situated 3 km north of Travemünde (20 km north-east of Lübeck) in the "Brodten-Kliff" area at the Baltic Sea.As part of the Eastern Hill landscape of Holstein the farmland was formed during the Weichselian glaciation and shares typical soils of the region described previously (see also fig.1). Cambisols and mainly Luvisols occur on hilltops, Pseudogleys on mid slopes, Gleysols and Histosols in depressions.
Slopes, often between 3 and 10 %, favour water erosion and caused decapitated soils during eight hundred years of cultivation. On one hilltop ploughlayers enriched with marl from parent material are found. Colluvisols or colluviated soils often occur at hillfoots and in levelled depressions at upper slopes. In some depressions anthropogenic soils, partly developing in dumped materials from the shoreline, are mapped and some soils with lower pH-values in their upper horizons have been detected at places where hedges were removed.

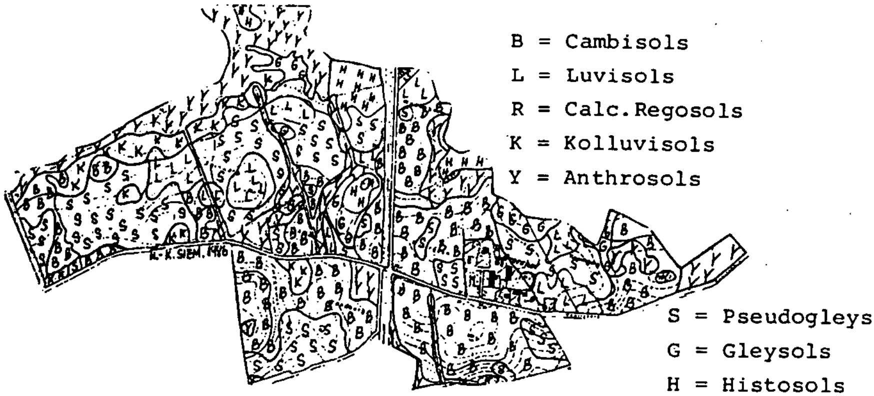


Figure 1: Locality and soil map of the Evershof farm (prepared by K. SIEM)

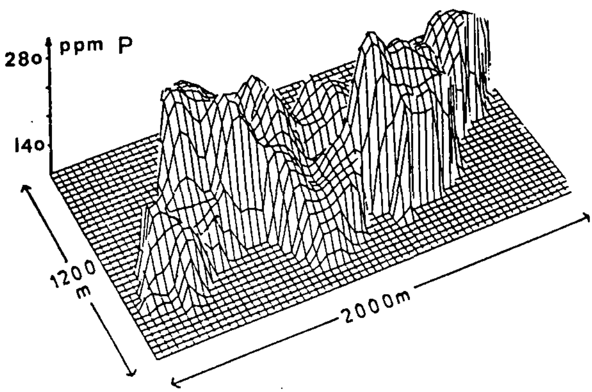


Figure 2: 3D-graphic of P-nutrient status in soils of Evershof fields
(interpolated from 70 sample points by Surface II program)

2. Economical resources and farm management

Real estate: The Evershof farm has 100 ha arable land (half of the area is leased, fig. 1). There exist three dwelling houses, five farm buildings for the storage of machines and farm products and stables for up to 10000 laying-hens. All fields contain drainage systems (7 to 20 years old).
Labour: The farmwork is statistically done by 3.9 labourers: field work is carried out by two persons, the others are responsible for the hens. The farmer's family execute labour for 1.5 persons.
Egg production: 10000 laying-hens are kept in 3 stables. Hens are bought when they are 20 weeks old and slaughtered after 12 to 13 months. The eggs are sold to private customers yielding an average margin of 2310 DM/ha yearly.
Plant production: Oilseed rape, winter wheat and winter barley grow on nearly 90 % of the fields, sugar beets amount to 10 % only.
Fertilizer: Basic fertilization is carried out in autumn (50 kg/ha P, 165 kg/ha K, 15 kg/ha Mg). Liming is done every second year with 1,6 t/ha $CaCO_3$. The farm receives additional nutrient inputs of 45 t/a N, 20 t/a P, 20 t/a K and 100 t/a $CaCO_3$ via the fodder of laying-hens bought from special firms. The overall nutrient balance for several crops is shown in table 1.
Margin: The plant production itself yields an average margin of 1890 DM/ha.

Table 1: Nutrient balances of the Evershof farm in 1985

kg/ha	Cereal			Oilseed rape			Sugar beet		
	N	P	K	N	P	K	N	P	K
Supply by:									
organic manure	+ 10	+20	+ 18	0	0	0	+ 60	+120	+110
mineral fertilizer	+200	+50	+165	+200	+50	+165	+140	+ 50	+165
Removal	-200	-35	-100	-140	-45	-150	-200	- 35	-335
Difference	+ 10	+35	+ 83	+ 60	+ 5	+ 15	0	+135	- 60

(yields (dt/ha) in 1985: rape 35, wheat 85, barley 75, sugar beets 450)

3. Nutritional status of soils and plants

The nutritional status of soils, partly derived from natural resources,partly from fertilizer inputs, is demonstrated by soil and plant analyses of seven fields represented in tables 2 and 3. The pH-value often exceeds the advisable limit of 6.5 due to enforced liming. High concentrations of available P are found after excessive manuring with poultry sludge (critical value in soils: 100 ppm P, tab. 2). A procedure named "Kriging"-interpolation stresses the fact of over-supply with P (endangering surface waters by eutrophication). P-concentrations in plants, however, are not influenced (tab. 3).
The S-supply seems to be sufffîcient for plant growth, but may become a critical factor in future (low S-immission). There exist no problems concerning the K-supply of cereals. Mg(exch.)-content in soil is sufficient (50ppm Mg) in contrast to Mg-concentrations in cereals, which are too low (1.5%, tab. 3). Cl-, Fe-, Mn- and Zn-supply are not limiting plant growth, but B-supply is for rape. Cu-concentrations are more than twice as high as necessary (critical value 0.5 ppm Cu).

Table 2: Results of soil analysis of Evershof fields in 1985
(average of 10 plots at each field; see fig.1)

Field	pH-value	ppm P	ppm K	ppm Mg	ppm Fe	ppm Mn	ppm Zn	ppm Cu
1	6.7	174	148	71	58	9.8	2.3	1.2
2	7.0	183	140	70	73	10.0	2.0	1.3
3	7.0	148	164	75	75	9.0	1.9	1.2
4	6.9	134	121	83	64	10.3	1.5	1.1
5	6.7	158	170	80	75	12.8	1.9	1.2
6	6.9	215	186	68	56	12.5	2.2	1.2
7	7.0	151	173	65	55	12.4	1.8	1.3
Optimum	6.5	100	120	50	50	10	1.5	0.5

Methods: pH: CaCl2; P and K: Double-Lactat Acc. Egner-Riehm; Mg: Exchangeable acc. Schachtschabel; Fe, Mn, Cu: DTPA-extract acc. Lindsay and Norvell

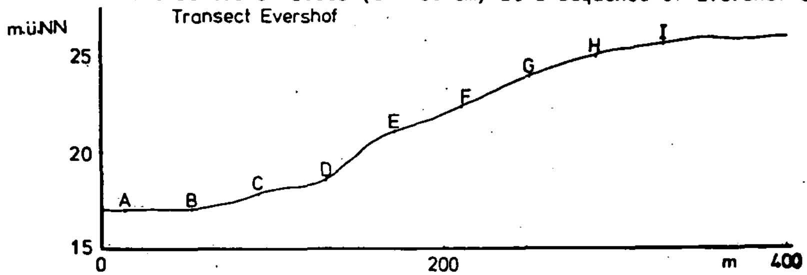
Table 3: Results of plant analysis of crops grown on Evershof 1985
(average of 10 plots of each field; see fig.1)

Field	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu	Cl	B	Si
	%o						ppm				%	ppm	%
1	29	2.9	2.2	30	3.9	0.6	67	35	21	9.0	2.1	4.0	6.2
2	32	2.9	2.4	30	4.0	0.7	72	41	19	8.7	2.8	3.65	6.8
3	38	2.9	2.4	30	4.1	0.7	79	28	19	8.0	2.5	3.27	6.2
4	40	5.0	4.9	19	23.8	1.9	94	44	37	10.4	0.6	19.7	0.1
5	47	5.2	5.1	20	24.8	1.9	91	49	34	9.6	0.6	18.1	0.1
6	25	3.3	2.1	32	4.0	0.6	70	20	21	6.5	1.5	3.1	4.9
7	40	4.0	4.4	20	19.9	2.0	77	38	30	7.8	1.0	17.4	0.1
Approximate critical value													
Cereals	30	3.0	4.0	25	3.0	1.5	50	30	23	3.5	-	3.0	-
Rape	40	3.0	6.5	25	10.0	1.5	50	30	23	3.5	-	28.0	-

Sampling:
Cereals (Fields 1 - 3 + 6): whole plant tops at shooting stage
Oilseed rape (field 4 + 5): younger differenciated leaves at shooting stage
Sugar beets (field 7) : younger fully differenciated leaves

Tables 2, 3 and fig. 1 present average values of 10 plots from each field, but a noticable microvariability of nutritional parameters caused by the relief is demonstrated in table 4. Following the catena some "depressions" of nutrients indicate demands in fertilizer, but at many places manuring could be reduced.

Table 3: Nutrient status of soils (0 - 30 cm) at a sequence of Evershof soils



	A	B	C	D	E	F	G	H	I
pH-CaCl2	7.1	6.9	6.7	6.8	6.9	7.0	6.9	6.9	6.7
" 60-90cm	7.5	7.2	7.3	7.0	6.9	6.9	6.8	6.6	6.3
Mg (ppm,+)	92	84	92	90	98	83	108	86	82
P (ppm,++)	270	190	100	183	81	212	189	241	204
K (ppm,++)	185	50	130	145	95	165	153	205	225

(+ exchangable, ++ Egner-Riehm)

Methods for analytical procedures

The field and laboratory data compiled within this tour guide book have been collected (partly) from different research projects and authors. Therefore it is possible that different analytical procedures are followed. In some cases original publications of data are cited. In these cases please refer to the cited papers. In the following only the generally used procedures are explained.

Particle-size distribution: Organic matter was oxidized by heating with hydrogen peroxide (DIN 19683), pretreatment with tetrasodiumpyrophosphate (LOTTMER & JUNG 1955); fraction >2 mm: dry sieving; fractions 2-0.02 mm: wet sieving; fractions 0.02-0.002 mm: pipette method (KOHN 1928).

Hydraulic conductivity (k_f): undisturbed soil samples in 250-cm³-rings (HANUS 1965).

Air conductivity (k_{oo}): air permeameter by KMOCH & HANUS (1965) at pF 2.0.

Pore-size distribution: undisturbed soil samples in 100-cm³-rings on ceramic pressure plates (pores >10µm); PWP (at pF4.2) with disturbed soil samples (HARTGE 1965).

pH values: in H_2O and 0.02 N Ca Cl_2 solution (10.0 g soil: 25 ml solution), glass electrode (SCHLICHTING & BLUME 1966).

Dithionite soluble iron oxides (Fed): "free" iron according to MEHRA & JACKSON (1960).

Oxalate soluble iron and manganes oxides (Fe_o and Mn_o): according to SCHWERTMANN 1959).

Citric Acid soluble phosphorus (Pa): 1% citric acid extract.

Total carbon (Ct): with WÖSTHOFF apparatus (SCHLICHTING & BLUME 1966).

Calcium carbonate (Ca CO_3): with SCHEIBLER apparatus (SCHLICHTING & BLUME 1966).

Total nitrogen (Nt): according to KJELDAHL (SCHLICHTING & BLUME 1966).

Cation exchange capacity (CEC_p and CEC_a) and base saturation: percolation with barium chloride/triethanolamine (CEC_p) or unbuffered barium chloride (CEC_a) according to MEHLICH (1948, 1961).

MITTEILUNGEN
DER
DEUTSCHEN BODENKUNDLICHEN
GESELLSCHAFT

13th
Congress

International Society of Soil Science

Hamburg
August 1986

Alterations and Additions for
Tour E

Alteration of Nomenclature according to Field Discussion (1), additional analytical data (2) and own corrections (3)

p. 25 US Soil Taxonomy: ..., coarse loamy, ... (3)

p. 28 US Soil Taxonomy: ..., mixed, acid, frigid (1)

p. 36 Soil classification; FAO: humic Podzol(3)
US Soil Taxonomy: entic Haplohumod, sandy, mixed, frigid (3)

p. 40 Soil classification; FAO: placic Podzol (1)
US Soil Taxonomy: Placorthod (1)

p. 52 US Soil Taxonomy: umbric Dystrochrept, coarse loamy, mixed, frigid (1)

p. 56 US Soil Taxonomy: umbric Dystrochrept, ... (1)

p. 61 US Soil Taxonomy: umbric Dystrochrept, ... (1)

p. 65 US Soil Taxonomy: ..., frigid, Ortstein (1)

p. 70 US Soil Taxonomy: umbric Dystrochrept (1)

p. 76 US Soil Taxonomy: aquic Hapludalf, ... (1)

p. 79 US Soil Taxonomy: ... mixed, non acid, mesic (1)

p. 86 US Soil Taxonomy: ... mixed, non acid, mesic (1)

p. 90 US Soil Taxonomy: aquic Eutrochrept, ... (1)

p. 92 US Soil Taxonomy: typic Humaquept, fine, mixed, non-acid, frigid (1)

p. 94 US Soil Taxonomy: ..., mixed, (non calcareous), frigid (3)

p. 99 Soil Classification; FAO: eutric Gleysol (1)
US Soil Taxonomy: aeric Haplaquept, very fine, mixed, non-acid, frigid (1)

p. 102 US Soil Taxonomy: udic Haploboroll, ... (1)

p. 105 US Soil Taxonomy: vertic Hapludoll, ... (1)

p. 108 Soil classification; FAO: calcaric Gleysol (1)
US Soil Taxonomy: aeric (3) Haplaquept, fine, illitic, non-acid (1), frigid

P. 111 Soil Classification; FAO: gleyic Cambisol (3)
German: Pseudogley*)-Braunerde, ... (3)
US Soil Taxonomy: aquic Dystrochrept, ... (3)
Sd1: ..., angular blocky to coherent, slickensides, ... (1)
*) most of the features are relics

p. 120 Soil Classification; FAO: orthic Podzol (3)
US Soil Taxonomy: typic Haplohumod, ... (3)

p. 124 Soil classification; FAO: ferric Acrisol (2)
US Soil Taxonomy: typic Hapludult, ... (2)

p. 128 Soil classification; FAO: humic Gleysol (3)
US Soil Taxonomy: histic Humaquept (3), clayey, mixed, acid (1), mesic

Additional Data

	No	hor.	depth cm	sto. %
	1	2	3	4
p.37	9	Cv2	-100	41

	No	hor.	clay
	1	2	13
p.125	7	SdBv	42

	No	hor.	kf cm/d	kf var.
	1	2	14	15
p.29	8	Cv	49	
p.77	1	Ah1	344	
	2	Ah2	1533	
	3	Al1	8662	
	4	Al2	623	
	5	Bvt	34	
	6	BtSd1	33	
	7	BtSd2	197	
	8	BC	119	

	No	hor.	bulk dens. g/cm³	GPV %	water content in % at pF 0.6	1.8	2.5	4.2
	1	2	16	17	18	19	20	21
p. 26	1	L/Of	0,09					
	2	Ah1	0,49	82	63	40	31	8
29	1	hHOf	0,08					
	2	Oh	0,18					
	8	Cv	1,55	44	44	42	41	25
32	1	Of	0,06					
	2	Oh	0,08					
37	1	Of	0,14					
	2	Oh	0,25					
41	1	Of	0,26					
	2	Oh	0,32					
44	1	Ofh	0,20					
	2	Oh	0,33					
117	1	Ofh	0,07					
121	1	Ofh	0,1					

	No	hor.	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
	1	2	22	23	24	25	26	27	28
p.29	8	Cv	3,9	3,5	9,0	2,6	0,29	0	<2
30	8	Cv				0,08	14,1		
37	9	Cv2	4,6	4,3	1,0	0,42	0,43	12	<2
41	1	Of	3,6	3,2	1,90	0,77	0,41	25	47,8
	2	Oh	3,6	2,9	1,96	1,28	0,65	34	56,2
44	1	Ofh	3,6	3,2	1,2	0,7	0,55	15	150,1
	2	Oh	3,5	3,1	1,8	1,3	0,73	20	50,0

	No	hor.	$C_{org.}$ %	N_t mg/g	C:N	$CaCO_3$ %	CEC p meq/kg	CEC a meq/kg	exchang. cations in meq/kg Ca	Mg	K	Na	H	Al	V %
	1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
p.29	8	Cv	0,1	0,3	4	0	156	52	2,8	3,1	1,7	1,2	120		7
30	8	Cv											0	43	
37	9	Cv2	0,2	0,1	20	0	54	11	0,3	0,8	0,2	0,1	38		4
41	1	Of	40,5	6,2	65	0	356	86	10,0	6,4	4,2	0,3	380		5
	2	Oh	30,4	13,6	22	0	1040	119	7,6	5,6	5,2	0,3	1130		2
44	1	Ofh	47,0	11,3	42	0	650	164	27,3	28,2	13,7	1,4	665		10
	2	Oh	37,3	12,6	30	0	854	93	8,9	4,6	4,5	1,0	905		2
84	6	(Bt)Sd				0	164	77	49	14,4	2,0	1,1	113		37
112	1	Ah													18
	2	Bv													11
	3	IISw													53
	4	Sd1													63
	5	Sd2	0,19	0,18	11	0	258	156	104	35	0,8	0,7	71		66
125	1	Ah													31
	2	Alv1													5
	3	Alv2													2
	4	Bt1													2
	5	Bt2													4
	6	SdBt													12
	7	SdBv				0	111	-	8,0	4,0	0,6	0,5	67		16
129	1	hH1	56,4	14,5	39										
	2	hH2	55,9	8,4	67	(due to charcoal ?)									
	3	Aha	12,8	2,9	44										

	No	hor.	depth	minerals in % clay Kao	Ill	Mont		Chl
p.107	1	Ah	0-5	5	40	25	25	5
	2	BvP1	-30	5	40	25	25	5
	3	BvP2	-55	5	40	25	25	5
	4	BvP3	-80	5	40	25	25	5
	5	C	-100	5	35	20	30	10

	No	hor.	Fe_p ‰	C_p ‰	Al_d ‰
p.38	9	Cv_2	0,52	1,6	
45	1	Ofh	0,65	11,0	1,3
	2	Oh	1,08	31,2	

	No	hor.	NH_4Cl me/kg H	Al
p.38	9	Cv2	0	10
p.42	1	Of	50	15
	2	Oh	42	58
p.45	1	Ofh	80	13
	2	Oh	34	40
p.85	6	(Bt)Sd	1	9
113	5	Sd2	0	15

	No	hor.	Ti %	Zr %	Ti: Zr	P_v ‰	K_v ‰	Ca_v ‰	Mg_v ‰
p.38	9	Cv2				0,10	0,91		
78	1	Ah1	3,26	0,29	11,2				
	2	Ah2	3,28	0,29	11,3				
	3	Al1	3,42	0,28	12,2				
	4	Al2	3,48	0,27	12,9				
	5	Bvt	3,58	0,22	16,3				
	6	BtSd1	3,57	0,23	15,5				
	7	BtSd2	3,44	0,25	13,8				
	8	BC	3,22	0,30	10,7				
81	1	Ah	4,51	0,22	20,5				
	2	AhBv	4,69	0,21	22,3				
	3	PSd	4,90	0,19	25,8				
	4	1CSd	3,84	0,17	22,6				
85	1	Ofh							
	2	Ah	4,20	0,29	14,5				
	3	Sew	4,52	0,32	14,1				
	4	Skw	4,56	0,31	14,7				
	5	Skd	4,23	0,28	15,1				
	6	(Bt)Sd	4,85	0,30	16,2				
	7	BvSd	4,08	0,25	16,3				
88	1	Ah	3,50	0,23	15,2				
	2	Go	3,44	0,25	13,8				
	3	Gor	3,34	0,26	12,9				
	4	Gr	3,79	0,28	13,5				
	5	IIGr	2,35	0,16	14,7				
101	1	Ah	7,79	0,17	45,8	1,61	6,96		
	2	AhSw	8,33	0,17	49,0	1,77	4,08		
	3	PSd	6,97	0,16	43,6	1,09	4,22		
	4	SdP	6,60	0,15	44,0	1,10	6,06		
	5	PC	6,64	0,14	47,4	1,50	5,37		
	6	C	6,42	0,15	42,8	1,44	6,16		
103	2	Ah1	5,77	0,16	36,1				
	3	Ah2	5,98	0,17	35,2				
	4	BvP	5,98	0,17	35,2				
	5	Cv	4,80	0,15	32,0				
107	1	Ah	3,96	0,12	33,0	0,49	22,3	32,7	52,5
	2	BvP1	4,44	0,15	29,6	0,59	22,0	20,5	43,4
	3	BvP2	5,73	0,18	31,8	0,39	19,8	6,9	31,9
	4	BvP3	5,66	0,18	31,4	0,30	19,8	5,5	32,1
	5	C	4,21	0,11	38,3	0,19	24,8	6,4	52,5
110	1	Ah	6,32	0,21	30,1	0,40	11,8		7,7
	2	AhSw	6,51	0,21	31,0	0,34	13,3		7,8
	3	SdP	4,71	0,14	33,6	0,39	13,1		25,9
	4	SdPCc	3,90	0,12	32,5	0,47	11,3		43,0
	5	SdlCc	3,65	0,12	30,4	0,44	10,9		43,0
113	1	Ah	1,12	0,49	23				

	No	hor.	P_v ‰	K_v ‰	Ca_v ‰	Mg_v ‰
p.112	1	Ah	0,53	2,63	1,71	1,74
	2	Bv	0,23	3,15	0,44	2,25
	3	IISw	0,21	1,95	2,00	2,13
	4	Sd1	0,18	0,60	2,20	1,78
	5	Sd2	0,39	0,90	1,68	1,65
118	1	Ofh	0,92	1,60	0,89	2,55
	2	Ah	0,70	2,33	0,14	2,09
	3	Sew	0,38	2,40	0,09	3,32
	4	Sd1	0,44	3,15	0,48	5,39
	5	Sd2	0,46	4,65	1,67	4,97
122	1	Ofh	0,85	1,10	11,56	0,47
	2	Ah	0,28	0,68	3,28	0,40
	3	Ae	0,05	0,33	0,37	0,18
	4	Bh	0,13	0,75	0,12	0,46
	5	Bs	0,17	1,00	0,05	0,67
	6	Sd1	0,09	1,50	0,05	1,05
	7	Sd2	0,08	0,96	0,06	0,48
	8	IISd	0,17	3,13	3,28	2,00
	9	IIISrd1	0,17	4,45	5,87	3,96
126	1	Ah	0,67	1,35	0,95	0,85
	2	Alv1	0,37	1,20	0,03	0,87
	3	Alv2	0,46	1,63	0,02	1,21
	4	Bt1	0,50	1,60	0,01	1,16
	5	Bt2	0,56	1,08	0,01	0,63
	6	SdBt	0,58	1,45	0,02	0,81

K_t %	Fe_t %	Mn_t %	Al_t %	Si_t %
1,0	6,5	0,18	7,5	27