EUROSOIL 2008 – EXCURSION 3A-pre-post-congress

"FOREST SOILS AT THE EASTERN FOOTHILLS OF THE ALPS"

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1 THE FIELD TRIP AREA

The excursion sites are located in the forest subzone 5.2 (Bucklige Welt), according to KILIAN et al. 1994.

The forest districts are situated along the eastern foothills of the Alps and the south-western slopes of the Ödenburger mountain range, down to the Oberpullendorf Basin.

The Central European climate is mainly influenced by west-weather situations, although Pannonian and Subillyric weather-characteristics have an effect, too. At higher elevations, the annual mean temperature is 8°C, with an annual precipitation of 750 mm (Station Neustift at Rosalia, 570 m, 8.1°, 774 mm annual precipitation). In the lower parts of the district the temperature rises up to 9°C, whilst the annual precipitation drops to 650 mm (Station Kobersdorf, 320m, 8.8°C, 663mm). The monthly rainfall distribution shows a summer maximum, mostly due to convective thunderstorm-rainfalls (figure 1). Occasional dry summer periods (1976, 1983, 1992) can result in pronounced drought damage to the vegetation.

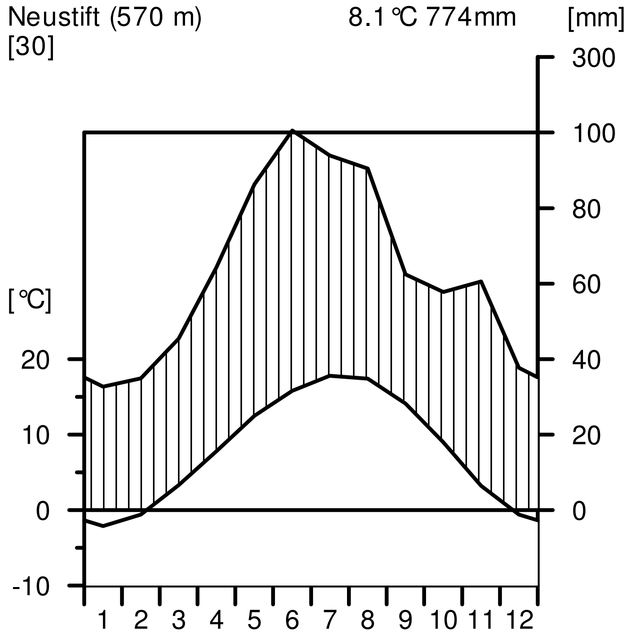

Figure 1: Climate diagram of the weather-station Neustift at Rosalia (Austrian Hydrographical Bureau 1994).

The long-term maximum daily mean temperature reaches 29°C, the minimum is -17°C. Snow falls on 15 - 20 days a year, a closed winter snow cover remains for 22 - 30 days. Due to low altitudes, there are regular wet snowfalls throughout the entire cold season. The predominant wind directions are N and W, though there are also frequent storms from southern directions.

Geologically, the area belongs to the Eastern descent of the Central Alps. The cristalline bedrock mainly consists of gneiss, mica-shist and Semmering quartzite. The Oberpullendorf Basin has been lowered in the tertiary along a NNW-SSE orientated tectonic line and filled up in the Miocene and Pliocene (25 to 1.5 mio years) with marine sediments (gravel, sand, clay-stone, coal deposits, limestone). Parts of the Pauliberg ranger district are dominated by basalts of early tertiary volcanic origin (figure 2).
During the Pleistocene, paleo-soils, loose sediments were partly translocated by solifluction. Especially in the Oberpullendorf Basin, but partly also in slope depressions of the highlands, the parent material for recent soil formations consists of Pleistocene solifluction-detritus. In the area of the forest enterprise there are shallow Podzolic Leptosols (rankers), Regosols and Podzols with a high content of coarse fragments on quartzite and gneiss, Cambisols (Brown Earths, partly waterlogged), Luvisols and Stagnic Gleysols on mica-shist, Gleysols and Gleyic Fluvisols along brooks or around springs and shallow soils derived from basalt to be found on Pauliberg. On a small scale, lime stones reach up to the surface on which chromic Cambisols are developed.

At 600 m a.sl. the altitudinal zone changes from a submontane into a montane zone. Oak-hornbeam forests and Scots pine-oak forests are typical of the submontane zone (KILIAN et al., 1994). Silver fir-beech forests with an admixture of oak, Sweet chestnut and Scots pine are natural forest types in the upper part of the submontane and the deep montane zone. The border to the mid-montane zone with fir-dominated Norway spruce - Silver fir - beech forests is specified at 800 m a.sl., i.e. above the highest elevations in this area (Pauliberg at 761 m a.sl. and Klosterberg at 745 m a.sl.). On shadowy slopes these altitude boundaries have to be set at lower positions.

Recently, secondary pine forests lower sites and secondary spruce forest at higher sites have stagnated.

Coppice und coppice-with-standards forests are distributed only in small areas.
Particularly in the proximity of settlement areas, the influence of intensive historical land uses (litter removal, forest pasture) is still clearly observable from the soil vegetation and the condition of the upper soil.

2 MATERIAL AND METHODS

Soil description and classification

Soil description was conducted on a soil pit according to the FAO Guidelines for Soil Description (2006a), the soil classification follows the Austrian soil classification system (NESTROY et al., 2001) and the World Reference Base for Soil Resources (FAO, 2006b).

Soil sampling and sample preparation

Soil samples were taken by means of a hollow drill (70 mm in diameter) with four to five repetitions per excursion site. One profile was used for display; the remaining profiles were used for analytics. The diagnosed horizons were combined into mixed samples. If the horizon length exceeded 20 cm, this horizon was geometrically divided into further parts.
The rock samples originate either from the coarse gravel of the soil profile or from separate drilling.
The roots were sorted out, the proportions of coarse and fine soil were separated by dry sieving (2mm) and the mass values of the compartments, as well as the conversion factors for the calculation of the oven dry masses, were determined.

At exkursion point 3 (Heidriegel) a sampling according to volume was possible. At this site the samples were taken from each soil horizon out of the profile wall.

Particle size distribution, mineralogical and chemical analysis

Table 1 and 2 show the parameters analyzed in the individual humus and soil fractions and the used methods of analysis. The pH values were principally measured in fresh fine soil samples. The total element contents of the humus layer were determined in oven-dry material. In the mineral soil C_{tot} and $CaCO_3$ were analyzed in oven-dry samples. Exchangeable cations in the H-horizon and in the mineral soil, as well as the total element content in the mineral soil were determined in air-dried samples. For the illustration, all the results were converted to an oven-dry base, and all area-related data were calculated from fine soil masses or volumes, respectively.

Table 1: chemical analysis (O…organic layer, M…mineral soil).

Parameter	*Extraction and analytical method*	*Norm*	*O*	*M*
pH-value	suspension in demineralized water and 0.01 m $CaCl_2$, electrometrically	ÖNORM L1083	*	*
$CaCO_3$	Scheibler with 10 % HCl	ÖNORM L1084		*
C, S	Leco S/C 444; $C_{org}=C_{tot} – C_{CaCO3}$	ÖNORM L1080	*	*
N	Microkjeldahl Kjeltec 2300	ÖNORM L1082	*	*
Total contents of Na, K, Ca, Mg, Mn, Al, Fe	Microwave, $HNO_3/HclO_4$ Element detection: simultaneous ICP-OES (Perkin Elmer Optima 3000 XL)	ÖNORM L1085	*	*
Exchangable cations (in carbonated soil, buffered to pH 8.2)	$_{0.1}$ m $BaCl_2$ extract, Element detection: simultaneous ICP-OES (Perkin Elmer Optima 3000 XL); Calculation of CEC_{eff} on the sum of ion equivalents	ÖNORM L1086		*
Pedogeneous oxides	Dithionitcitrate; Element detection: simultaneous ICP-OES	Mehra & Jackson, 1960		*

Table 2: Distribution of grain size, mineralogical analyses.

Param.	*Preparation, measurement procedure*
Distribution of grain sizes in fine soil	Wet sieving (> 40 µm), automatic sedimentation analysis (< 40 µm); Sedigraph 5000 ET (Micromeritics) after oxidation of organic components (15 % H_2O_2) and treatment of the sample with ultrasonic (0.5 ‰ Calgon as disperging medium); classification according to ÖNORM B 4412 (cS: 2000 – 630 µm, mS: 630 – 200 µm, fS: 200 – 63 µm, cSi: 63 – 20 µm, mSi: 20 – 6.3 µm, fSi: 6.3 – 2 µm, cC: 2 – 0.63 µm, mC: 0.63 – 0.2 µm, fC: < 0.2 µm)
Total mineral content	X-ray diffractioner device (Philips PW 1710, Bragg Brentano Geometrie, Cu Kα-radiation, 45 kV, 40 mA); 1° 2 Θ - 70° 2 Θ; Identification & semiquant. mineral determination)
Mineral content of the clay fraction (< 2 µm)	Decarbonaisation of the fine soil with EDTA ((Kohler and Wever, 1980); Oxidation of organic components (15 % H_2O_2) and treatment of the sample with ultrasonic; Wet sieving to 63 µm and extraction of the 2 µm fraction by sedimentation (Tributh, 1989); Cation covering with 4 M KCl or 2 M $MgCl_2$, respectively (shake for 12 hrs., absorb the texture samples on ceramic plates (Kinter & Diamond, 1956), dry over sat. NH_4NO_3-solution); radiogram of 2° 2 Θ to 40° 2 Θ in the diffractometer; Transfer of Mg-covered samples into glycerin- or ethylenglycole atmosphere (Differentiation. Smectite-Vermiculite), of K-covered samples into DMSO atmosphere (Differentiation. Chlorite/Kaolinite); Contraction tests at 375 °C and 550°C (Differentiation prim./se. chlorite); Identification of clay minerals according to BRINDLEY & BROWN, 1980, THOREZ, 1975, MOORE & REYNOLDS, 1989; semiquantitat. estimation of clay mineral groups according to RIEDMÜLLER, 1978, OTTNER et al., 1996

Due to the partially very complex clay-mineralogical composition, the semiquantitative estimation of the relative proportions of the individual groups of clay minerals was only possible for profile 4 (Roterd). For the remaining profiles diffractograms are represented.

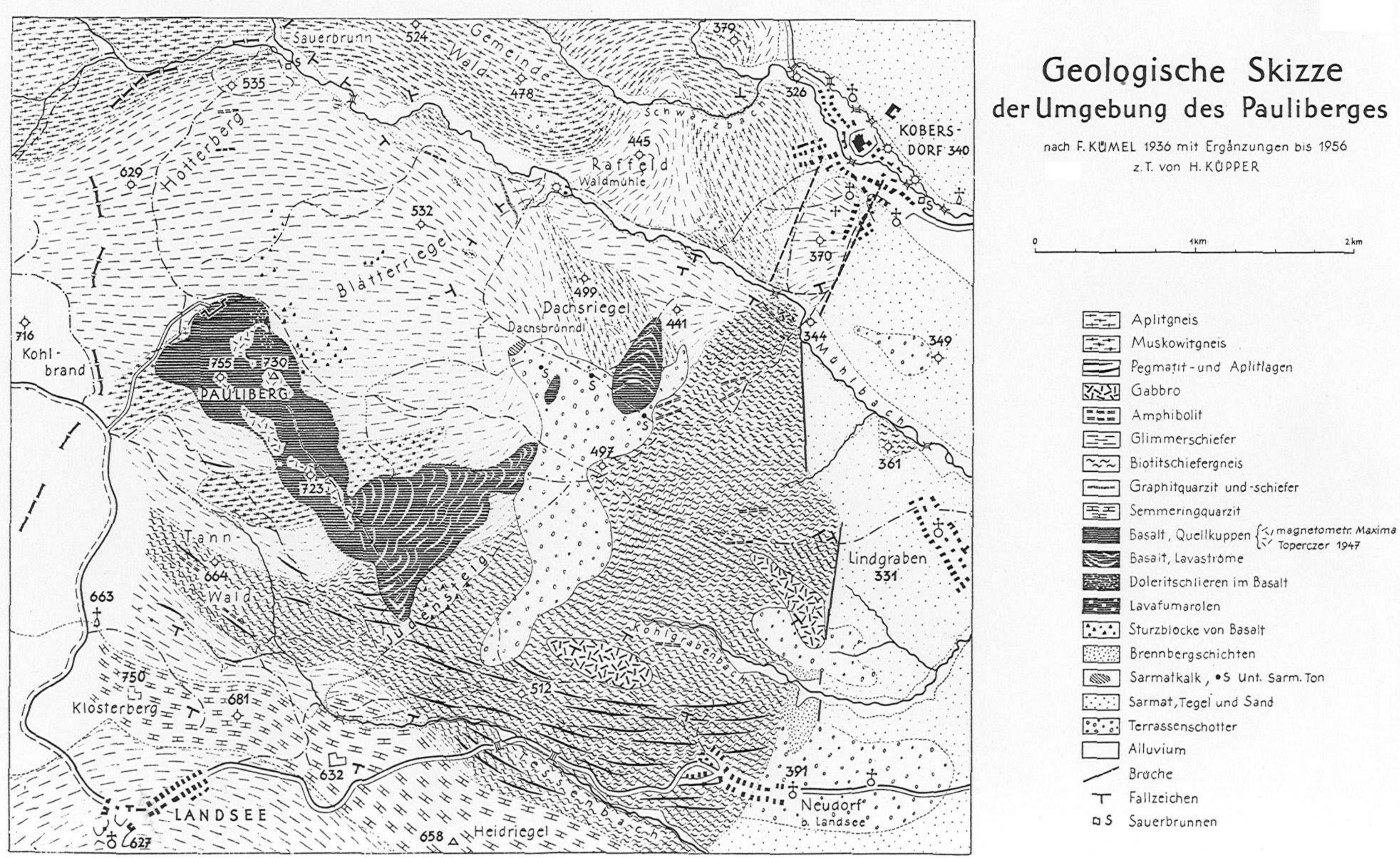

Figure 2: Geological map of the Pauliberg area (Küpper, 1957).

3 EXCURSION POINTS

Profile 1: Pauliberg

Location: 16°20’50“ E, 47°34’52“ N (MGI), 720 m a.sl.

Landform: plain to gently E sloping plateau

Site type: plain to slightly tilted, temporarily water-logged sites with skeleton-rich substrate soils on basalt

Land use: Forest (*Picea abies, Pinus sylvestris, Larix Europaea, Acer pseudoplatanus, Prunus avium, Ulmus glabra*)

Ground vegetation: Clearcut vegetation (*Calamagrostis epigejos, Rubus idaeus, Rubus fructicosus agg., Urtica dioica, Brachypodium sylvaticum, Cirsium sp., Galeopsis sp., Atropa belladonna* etc.)

Parent material for soil formation: Basalt

Table 1.1: Description of a representative profile.

Horizon			from – to [cm]	Description
AT		WRB		
L/F		Oie	0.5/1-0.3/0	slightly to moderately decomposed organic material, loosely bedded to weakly clotty grass- and leaf residues, spruce-twigs, branches; partly rhizome-felt
H		Oa	0/0.3-0	highly decomposed organic material, heavily rooted, many fine roots, gradually turning into A horizon
Ahb		A	0-9	soil structure: fine-crumbly to weakly blocky (granular to fine blocky soil structure with worm casts) soil texture: silty clay loam, medium to fine gravel soil colour: 10 YR 3/2 many fine roots, gradually turning into A/B
AhBv		A/B	9-39	soil sturcture: fine-blocky subangular soil texture: silt loam, fine to medium gravel soil colour: 10 YR 4/2

				many roots, gradually turning into B
Bv		B	39-80	soil structure: middle-blocky subangular soil texture: silt loam sands, fine to medium gravel, increasing gravel content downwards soil colour: 10 YR 4/3 few roots, gradually turning into C
Cv		C		basalt gravel

Humus form: Mull
Soil type: AT: Braunerde
WRB: Discussion: Endoskeletic Mollic Cambisol (Eutric) or Eutric Endoskeletic Regosol (if mollic horizon < 25 cm)

Trophic level: eutrophic
Hydrology: moderately fresh (1992: Dessication of a 14 ha, 80-years-old spruce stand)

Soil physical properties:

Coarse gravel increases continuously in a downward direction along the soil profile. In the fine soil the silt fraction dominates over the entire profile, only in Ah a slightly higher clay content is found. According to ÖNORM L1061, the fine soil in Ah is classified as silty loam, in Ah-BV and Bv-horizon as loamy silt. The bulk density of the fine soil in Ah is markedly low.

Table 1.2: Soil physical properties.

	Thickness [cm]	Coarse soil [v%]	Bulk density of fine soil [g.cm^{-3}]	Texture [%] of humus- and carbonate-free fine soil											
				cS	mS	fS	*ΣS*	cSi	mSi	fSi	*ΣSi*	cC	mC	fC	*ΣC*
O	0.7	0	0.1												
A	9	14	0.5	6.0	0.8	6.6	*13.4*	18.1	29.2	11.3	*58.6*	4.9	5.3	17.8	*28.0*
A/B1	10	24	1.0	3.5	1.3	8.1	*12.9*	28.0	29.2	10.9	*68.4*	4.0	6.1	8.9	*19.0*
A/B2	20	22	1.0	14.8	1.2	8.1	*24.1*	17.8	26.9	12.1	*56.8*	6.4	4.9	7.8	*19.1*
B	41	36	1.2	11.0	2.5	11.2	*24.7*	20.5	23.8	9.8	*54.1*	4.7	4.4	12.1	*21.2*

Mineralogical composition of the fine soil:

Main components: Diopside (Pyroxene) and Plagioclase (Anorthite);

Additional components: Olivine (Forsterite) some quartz, a little Analcime

In terms of total minerals, the individual horizons of the soil profile are evenly composed, there is no trend in the distribution of the minerals with increasing soil depth.

The coarse gravel has a similar mineralogical composition like the fine soil, but quartz is not detectable. Traces of biotite are present in the coarse gravel of the B.

Mineralogical composition of clay fraction:

The soil profile shows a very simple clay mineralogical composition (figure 1.1):
From 0 to 39 cm soil depth Chlorite is the dominant clay mineral. In the B the chlorite withdraws and Smectite, Vermiculite 14Å and Vermiculite 17Å gain considerable prominence.
Kaolinite is represented in the entire profile, but no trend is recognized. Illite is found in small portions/slight tracks down to 39 cm, in the B a slight increase is registered. Iron oxides are not detectable.

060 reflexes: Two clear reflexes with 1,490Å and 1,500 respectively, are visible, the first reflex comes from Kaolinite, the second reflex, however, is too strongly pronounced for the attested Illite traces. Most probably this reflex has to be assigned to secondary chlorite. Trioctahedral phases are not clearly detectable. A 1.537 Å reflex in the B2 can possibly be assigned to Vermiculite.

Annotation to Chlorite (figure 1.2): After heating up to 550°C the typical reflex of primary chlorite with ~14Å is there (except in A), but the relatively small intensity of this peak leads to the conclusion that apart from the primary chlorite also clear proportions of secondary chlorite must be present. After the heating, the 10Å reflex is too strong for traces of Illite and must be associated with secondary chlorite, too.

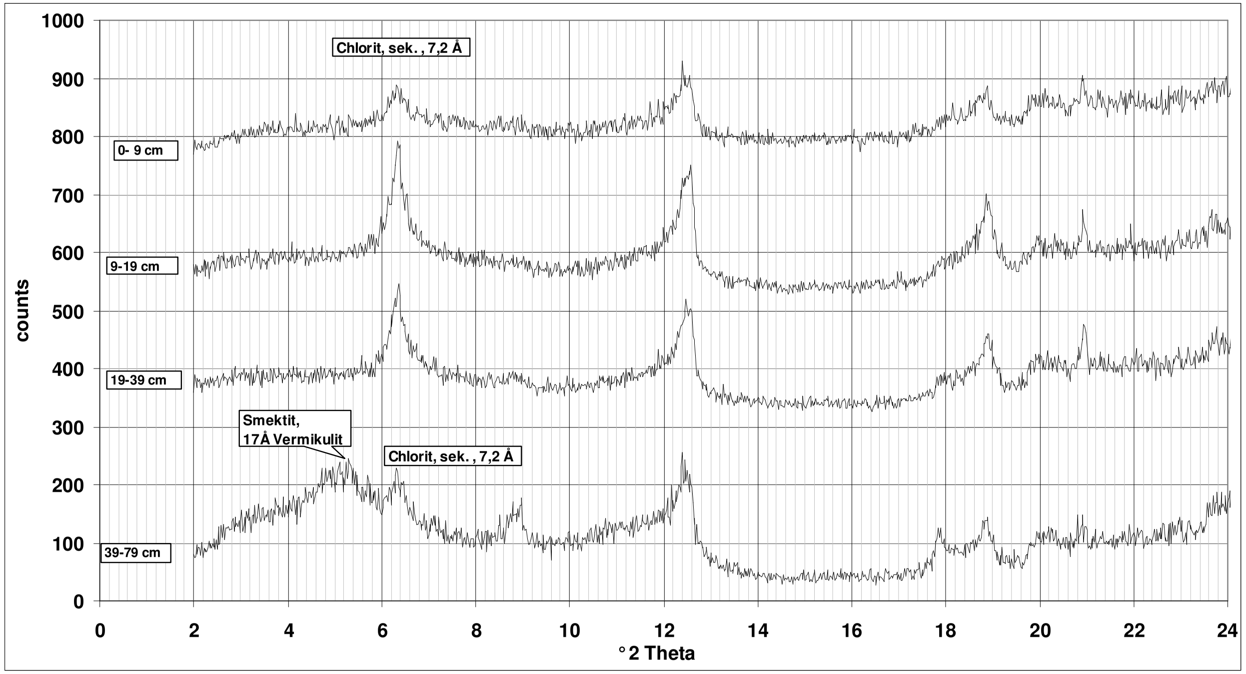

Figure 1.1: X-ray diffractograms of the clay fraction from soil horizons of the Pauliberg soil profile (saturated with Mg and glycolised).

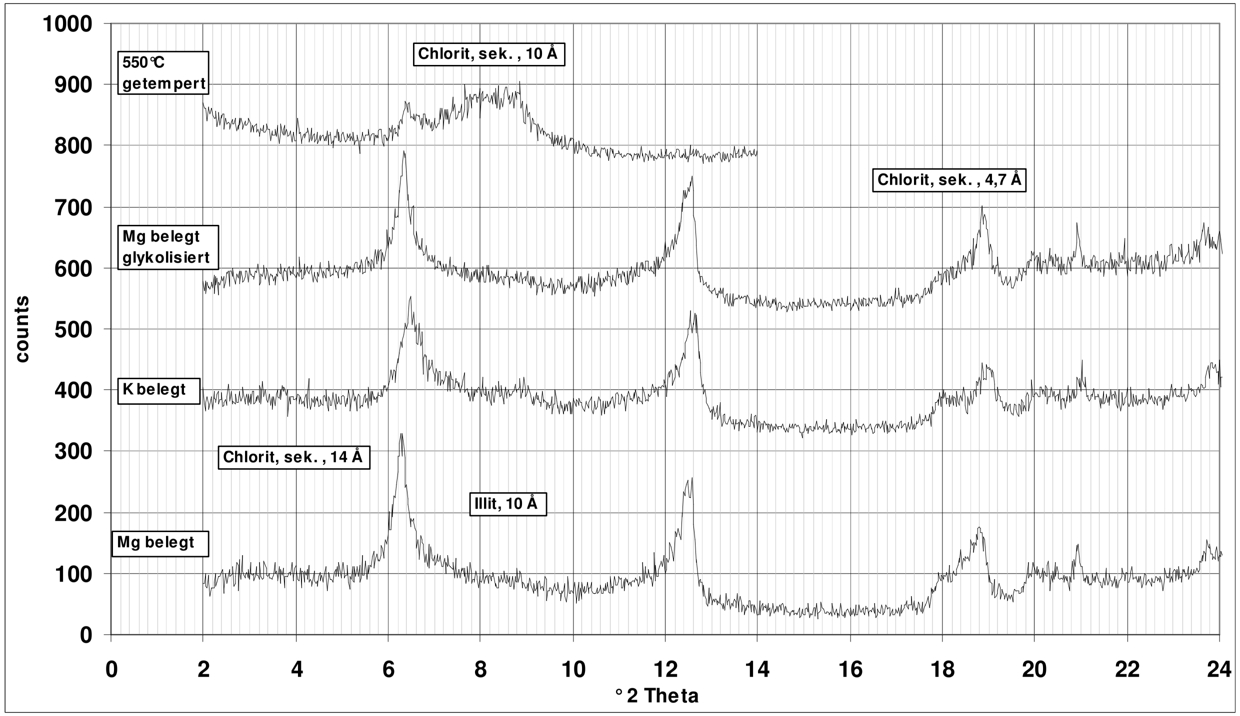

Figure 1.2: X-ray diffractograms of the clay fraction from B1 (9 to 19 cm) of the Pauliberg soil profile, after different treatments.

Soil chemical properties:

Table 1.3: Soil chemical properties of the Pauliberg soil profile.

pH-values, total C, N and P contents, and element ratios in profile

	from - to	pH H_2O	pH $CaCl_2$	C_{org} [$mg.g^{-1}$]	N_{tot} [$mg.g^{-1}$]	S_{tot} [$mg.g^{-1}$]	P_{tot} [$mg.g^{-1}$]	C/N	C/S	C/P
L/O	1 – 0			320.6	9.1	1.1	1.3	35	299	250
A	0 - 9	6.3	5.2	70.8	4.9	0.6	2.3	15	118	30
A/B1	9 – 19	6.2	4.9	35.0	2.7	0.3	2.2	13	103	16
A/B2	19 – 39	6.4	5	21.0	2.1	0.2	2.1	11	89	10
B	39 - 80	6.6	5.3	8.9	0.7	0.1	2.3	12	73	4

Total (t) element contents in the $HNO_3/HClO_4$-extract ($mg.g^{-1}$) and in the dithionite (d)-extract ($mg.g^{-1}$)

	Na_t	K_t	Ca_t	Mg_t	Mn_t	Mn_d	Mn_d [% Mn_t]	Al_t	Al_d	Al_d [% Al_t]	Fe_t	Fe_d	Fe_d [% Fe_t]
L/O	0.3	4.1	9.0	7.8	0.5			8.0			18.4		
A	0.7	3.0	8.3	8.5	1.3	0.9	65	26.7	2.7	10	72.7	13.5	19
A/B1	0.8	2.7	8.4	8.5	1.4	0.8	59	28.8	2.4	8	75.7	13.5	18
A/B2	0.7	2.6	8.4	8.2	1.4	0.6	45	28.7	2.1	7	76.8	10.3	14
B	0.7	2.6	8.1	8.1	1.2	0.5	43	29.5	1.0	3	76.6	9.4	12

Element contents in the 0.1 M $BaCl_2$-extract [$mmol_c.kg^{-1}$]

	Na	K	Ca	Mg	Mn	Al	Fe	H	CEC_{eff}	BS [% CEC_{eff}]
A	1.4	6.7	160.8	48.0	1.4	0.1			218	99.3
A/B1	1.9	1.1	88.6	33.3	0.7	1.4			127	98.4
A/B2	2.1	0.8	73.2	34.5	0.5	0.7			112	98.9
B	3.2	0.8	72.5	48.0	0.2				125	99.8

Element contents in the organic layer (O) and in the fine mineral soil (MS) down to 80 cm soil depth

	Total stocks [$g.m^{-2}$]						Exchangeable stocks [$g.m^{-2}$]		
	C	N	P	K	Ca	Mg	K	Ca	Mg
O	289	8	1	4	8	7			

MS (0-80 cm)	11430	974	1304	1549	4832	4827		27	920	295

The pH values are high across the entire profile, yet a clear difference between the values in aqueous and in 0.01 M $CaCl_2$-suspension is detectable. The humus content is relatively high across the entire profile, the C/N ratio is narrow. The nitrogen supplies/pools are high given, that this is a forest soil.

In the HNO_3/$HClO_4$ extract a high calcium and magnesium content is found, but only little potassium. The pedogeneous proportion of Al, Mn and Fe decreases downward the soil profile and is low, with the exception of Mn.

The effective cation exchange capacity is average, the base saturation is high across the entire profile. Traces of Mn^{2+} and Al^{3+} are detectable in the B1. The biogenous enrichment of K in the upper profile section can clearly be recognized.

Under the prevalent chemical conditions, the secondary formation of Chlorite in the A/B is hardly probable. The input of aeolian deposits might explain the chloritization.

Profile 2: Tannenallee

Location: 16°20’12“ E, 47°34’02“ N (MGI), 660 m a. sl.

Land form: gently NNE sloping middle slope

Site type: Shady slopes with moderately fresh to fresh brown earth on mica-shist

Land use: Forest (Profile A: *Fagus sylvatica*, 4th **age class**, Profile B: *Picea abies*, 5th age class)

Ground vegetation (general for the site unit): *Cyclamen purpurascens, Carex sylvatica, Dryopteris filix-mas, Fagus sylvatica, Festuca altissima, Galium odoratum, Galium rotundifolium, Mycelis muralis, Rubus fruticosus agg., Senecio ovatus, Viola sylvestris agg.;* in the case of Moder dynamics, additionally *Oxalis acetosella, Luzula luzuloides*

Parent material for soil formation: periglacial solifluction cover, coarse gravel and stones (predominantly quartzite, partly weathered mica-shist), oriented in parallel to the slope

With similar local conditions the influence of the tree species on morphological and chemical soil characteristics is comparable. The description of one characteristic soil profile each is represented in table 2.1.

Humus form: beech: mull

spruce: small-scale change of Moder and Hemimoder

Soil type: AT: pseudovergleyte Braunerde;

WRB: Dystic Regosol or Dystic Endostagnic Regosol

Trophy: mesotrophic, Hydrology: fresh

There is a clear difference in the humus and upper soil condition between the two profiles. While Mull-humus-dynamics prevail under beech, Moder dynamics dominate under spruce. The average ratio of the organic layer to the A-horizon amounts to 0.1 under beech and 0.7 under spruce. However, under spruce a higher spatial variability of the humus form is found. The bulk density of the A horizon is lower under beech than under spruce. The root distribution under spruce reaches a maximum between the H and the A-horizon, while the rooting of beech is clearly more balanced and deeper. In both profiles the difference in the bulk density from the Bg2 to the Bg3 is clearly recognizable. The light greyish colour in the Bg3 horizon under spruce could be due to longer wet phases than take place under beech. It cannot clearly be answered whether this shows primarily a local difference or a tree species effect.

Table 2.1: Description of one representative soil profile each, of the beech and spruce stand.

Profil A: Beech				*Profil B: Spruce*			
Horizon		from – to [cm]	Description	Horizon		from – to [cm]	Description
AT	WRB			AT	WRB		
L/F	Oie	0.5/1 – 0.3/0	loosely bedded, slightly decomposed beech leaves, branches and beechnuts	L	Oi	3/2.5 - 2.5/1.5	loosely bedded to weakly sticky, slightly decomposed spruce needles and twigs, gradually turning into Oe
				F	Oe	2.5/1.5 - 0.5/1.5	layered; clearly withered, partly decomposed spruce needles, only few roots
H	Oa	0/0.3 - 0	in pockets	H	Oa	0.5/1.5 - 0	loosely bedded to crumbly, soil colour: very dark grey-brown (10YR 3/2), many roots, gradually turning into A
Ahb	A	0 – 9	soil structure: granular (worm casts?), weakly blocky, half-openly layered soil texture: loam with few stones and coarse gravel soil colour: dark brown (7.5 YR 3/2) few small roots gradually turning into Bg	Ahib	A	0 - 4	soil structure: fine granular to blocky, partly weakly coherent, half-openly layered soil texture: loam, medium amount of coarse gravel soil colour: very dark grey-brown (10 YR 3/2) high amount of roots gradually turning into Bg
Bvg1	Bg1	9 - 21	soil structure: medium to coarse, subangular, half-openly layered soil texture: loam, medium amount of stones and coarse gravel soil colour: brown-yellow (10 YR 6/6) very fine and very few concretions medium amount of roots gradually turning into Bg	Bvg1	Bg1	4 – 19	soil structure: weakly medium blocky, half-openly layered soil texture: loam, medium amount of stones and coarse gravel soil colour: yellow-brown (10 YR 5/4) very fine and very few concretions few roots gradually turning into Bg
Bvg2	Bg2	21 - 44	soil structure: medium to coarse, subangular blocky, closed to half-openly layered soil texture: loam, medium amount of stones	Bvg2	Bg2	19 - 32	soil structure: very coarse subangular blocky to porous-blocky/massive? soil texture: loam, medium amount of stones and

			and coarse gravel soil colour: light yellow-brown (10 YR 6/4), several unclear corrosive spots at the root cavities (10 YR 6/6) very fine and very few concretions medium amount of roots gradually turning into B				coarse gravel soil colour: light yellow-brown (10 YR 6/4), a few unclear corrosive spots at the root cavities (10YR 6/6) many and very fine concretions very few roots gradually turning into B
P	Bg3	44 - 80	soil structure: very coarse subangular blocky to porous-blocky/massive? soil texture: loam, medium amount of stones and coarse gravel soil colour: light yellow-brown (10 YR 6/4), clear corrosive and bleached spots (10YR 6/3 & 10YR 6/6) many and very fine concretions very few to few roots	P	Bg3	32-80	soil structure: very coarse subangular blocky to porous-blocky/massive soil texture: loam, medium amount of stones and coarse gravel soil colour: pale brown (10 YR 6/3), clear corrosive spots (10YR 6/6), many and very fine concretions very few roots

Soil-physical properties:

The proportion of coarse gravel increases continuously downward the soil profile. In both profiles the bulk density of the fine soil clearly shows an increase in the subsoil (Bg3). A distinct body of congestion, however, is missing in the sampled soil profiles. The gravel size distribution in the fine soil is hardly differentiated over the entire soil profile, the portions of sand, silt and clay are relatively balanced, see table 2.2.

Table 2.2: Soil-physical properties.

Profile A: beech					*Profile B: spruce*			
	Thickness [cm]	Coarse gravel [v%]	Bulk density of the fine soil [g.cm^{-3}]			Thickness [cm]	Coarse gravel [v%]	Bulk density of the fine soil [g.cm^{-3}]
O	0.7	3	0.4		O	2	2	0.4
A	9	9	0.6		A	4	15	0.9
Bg1	12	13	0.9		Bg1	15	17	0.8
Bg2	23	13	1.1		Bg2	13	25	1.1
Bg	36	18	1.4		Bg	48	26	1.3

Texture [%] from humus- and carbonate-free fine soil (Profile B: spruce)													
Hor.	from- to [cm]	cS	mS	fS	*ΣS*	CSi	mSi	fSi	*ΣSi*	cC	mC	fC	*ΣC*
A	0 - 4	12.4	8.3	14.3	*35.0*	11.6	8.3	15.3	*35.2*	6.3	7.4	16.1	*29.8*
Bg1	4 – 19	10.5	8.9	15.7	*35.1*	12.0	13.5	10.8	*36.3*	7.3	8.6	12.7	*28.6*
Bg2	19 – 32	11.9	8.4	15.2	*35.5*	11.2	13.5	11.1	*35.8*	7.5	9.7	11.5	*28.7*
Bg	32 - 80	13.7	8.6	15.3	*37.6*	11.4	14.7	11.1	*37.2*	6.6	8.1	10.5	*25.2*

Mineralogical composition of soil profile B (spruce):

The fine soil consists of quartz/silica with proportions between 48 and 53 mass %, 43 to 46 mass % layer silicates, especially Muscovite and Kaolinite, as well as 5-6 mass % feldspar (Albite). No trend within the profile is observable in any of the mentioned mineral distributions, see table 2.3.

The coarse gravel is enriched in quartz, neither feldspar nor Kaolinite are found, and it has the least Muscovite content in the lowest profile part.

Table 2.3: Semiquantitative mineralogical composition of the fine soil in profile B.

Hor.	from - to [cm]	Quartz	Layered silic.	Feldspars
A	0 - 4	52	43	5
Bg1	4 – 19	52	43	5
Bg2	19 – 32	48	46	6
Bg	32 - 80	50	44	6

Mineralogical composition of the clay-fraction of soil profile B (spruce):

Kaolinite and a mixed layer mineral are dominant within the profile (figure 2.1). Kaolinite shows good cristallinity and is largely expandable with DMSO**.** The mixed layer mineral is complexly composed and consists of Illite, Vermiculite and Chlorite. If Mg-covered, in each sample of the profile the mineral shows a uniform d-value for the 002 reflex of 11,5 Å, whereas the K-covered samples show a clear contraction in the upper profile parts.

Especially the sample from the A horizon contracts completely at 10Å, in the lower horizons the contractivity decreases with increasing depth. This leads to a transition from a mixed layer with Illite/Vermiculite in horizons near the surface to Illite/Chlorite in deeper profile parts. Chlorite is represented across the entire profile, but shows a clear declining tendency near the soil surface.

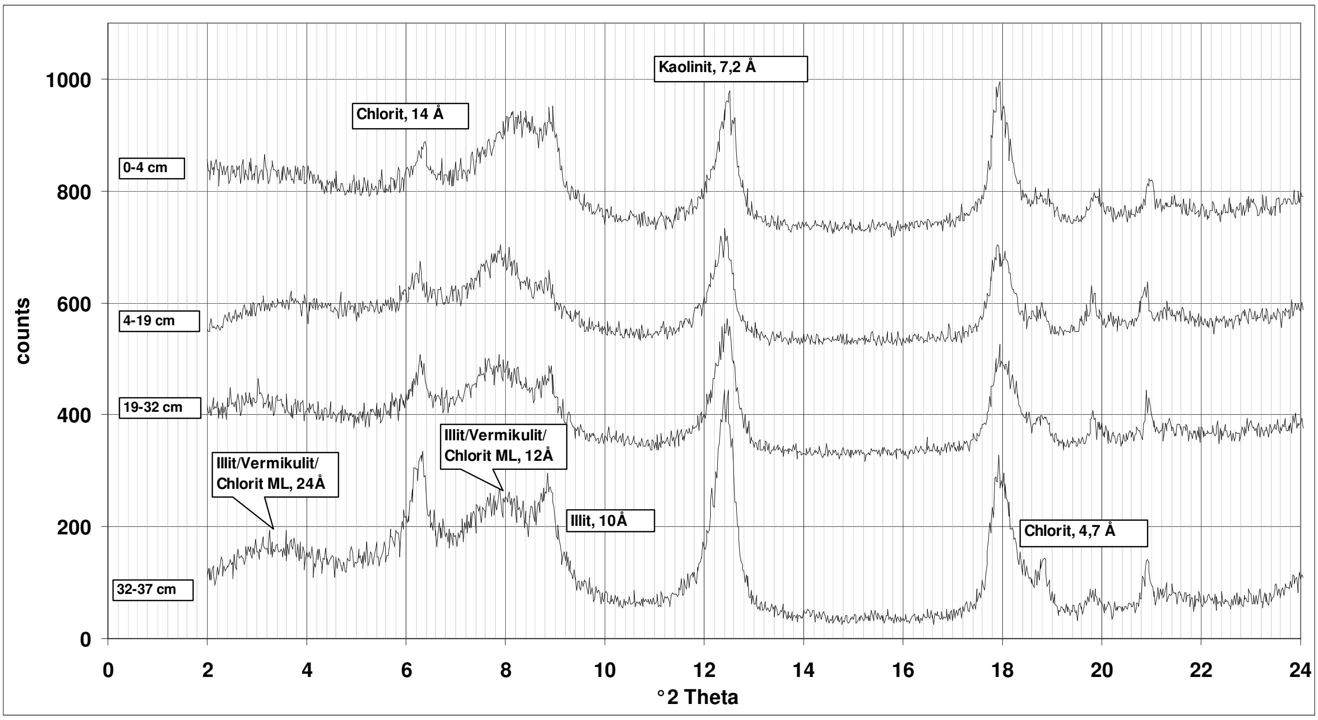

Figure 2.1: X-ray diffractograms of the clay fraction of the soil horizons in profile B (spruce) (Mg-covered and glycolised).

Smectite is not detectable in the entire profile, Illite plays a secondary role. The extreme increase in intensity up to the fivefold value is remarkable with the K-covered samples in the 10Å range, which cannot be explained by the contraction of the Vermiculites alone. The addition of potassium leads to a structural reorganization of the highly weathered silicate layers.

In the 060 range two dominant reflexes with 1,49 and 1,51Å, respectively, have to be assigned to dioctahedral minerals, a weak reflex with 1,56Å is derived from the trioctahedral phases Vermiculite and Chlorite, respectively.

The good crystallinity of the Kaolinite suggests older weathering formations (Tertiary period) and a relictic character of the profile. The transition from Vermiculite to chlorite in the ML can be explained by the strong decomposition procedures in the upper profile section.

Soil chemical properties

Table 2.4 shows a comparison of the soil-chemical characteristic values of the two stands. The element contents in the $HNO_3/HClO_4$ extract are similar for both soils, the dithionite-soluble portion of manganese, however, is higher in the subsoil of the spruce profile than under beech, whereas the relationship in the topsoil is vice versa. In the total digestion both profiles show a very low calcium but a rather high magnesium content. These values were tested for the Bg-horizon (32 - 80 cm) in the spruce stand by means of RFA (69,4 % SiO2, 0,80 % TiO2, 15,5 % Al2O3, 4,8 % Fe2O3, 0,13 % MNO, 1,61 % MgO, 0,08 % CaO).

Table 2.3: Soil chemical properties of the "Tannenallee" profiles.

pH-values, total C, N and P contents, and element ratios in profile A: beech

Hor.	from – to [cm]	pH H_2O	pH $CaCl_2$	C_{org} [mg.g^{-1}]	N_{tot} [mg.g^{-1}]	S_{tot} [mg.g^{-1}]	P_{tot} [mg.g^{-1}]	C/N	C/S	C/P
O	0.7 - 0			333.9	13.2	1.2	0.9	25	267	372
A	0 - 9	4.3	3.3	47.4	2.6	0.4	0.6	18	116	84
Bg1	9 – 21	4.2	3.3	19.1	1.9	0.3	0.4	10	73	45
Bg2	21 – 44	4.4	3.5	6.7	0.6	0.2	0.3	12	37	22
Bg	44 - 80	4.5	3.5	3.2	0.6	0.1	0.2	5	24	13

pH-values, total C, N and P contents, and element ratios in profile B: spruce

Hor.	from - to [cm]	pH H_2O	pH $CaCl_2$	C_{org} [mg.g^{-1}]	N_{tot} [mg.g^{-1}]	S_{tot} [mg.g^{-1}]	P_{tot} [mg.g^{-1}]	C/N	C/S	C/P
O	2 - 0			259.1	11.1	1.2	1.8	23	221	148
A	0 - 4	4.3	3.1	32.5	1.8	0.3	0.4	18	100	81
Bg1	4 – 19	4.4	3.3	14.3	1.1	0.2	0.3	13	59	47
Bg2	19 – 32	4.4	3.4	8.3	0.8	0.2	0.3	10	40	24
Bg	32 - 80	4.6	3.5	4.1	0.6	0.2	0.3	7	19	15

Total (t) element contents in the $HNO_3/HClO_4$-extract (mg.g^{-1}) and in the dithionite (d)-extract (mg.g^{-1}) Profile A: beech

Hor.	Na_t	K_t	Ca_t	Mg_t	Mn_t	Mn_d	Mn_d [% Mn_t]	Al_t	Al_d	Al_d [% Al_t]	Fe_t	Fe_d	Fe_d [% Fe_t]
O	0.4	6.2	4.7	2.6	2.5			16.0			14.6		
A	1.2	16.8	0.5	6.8	0.6	0.4	69.0	49.2	1.7	3.5	31.0	8.4	27.2
Bg1	1.1	16.9	0.3	6.3	0.5	0.4	78.7	50.5	1.7	3.4	31.7	8.6	27.2
Bg2	1.1	16.7	0.3	6.7	1.0	0.5	53.8	51.0	1.4	2.7	32.7	8.9	27.3
Bg	0.9	15.3	0.3	6.9	0.3	0.2	62.7	52.2	1.1	2.1	36.8	8.3	22.6

Total (t) element contents in the $HNO_3/HClO_4$-extract (mg.g^{-1}) and in the dithionite (d)-extract (mg.g^{-1}) Profile B: spruce

Hor.	Na_t	K_t	Ca_t	Mg_t	Mn_t	Mn_d	Mn_d [%Mn_t]	Al_t	Al_d	Al_d [% Al_t]	Fe_t	Fe_d	Fe_d [% Fe_t]
O	0.3	6.3	2.2	2.1	1.5			16.5			32.1		
A	0.7	16.9	0.5	6.3	0.5	0.3	56.7	42.5	1.3	3.0	25.0	7.1	28.6
Bg1	0.7	16.8	0.4	5.8	0.8	0.5	57.6	42.1	1.3	3.1	22.9	5.4	23.8
Bg2	0.7	16.7	0.4	5.5	0.9	0.9	95.1	42.6	1.3	3.1	23.5	7.2	30.8
Bg	0.6	15.9	0.3	5.4	0.7	0.6	95.7	39.8	1.1	2.7	23.5	6.9	29.2

Element contents in the 0.1 M $BaCl_2$-extract [mmol$_c$.kg^{-1}] Profile A: beech

Hor.	Na	K	Ca	Mg	Mn	Al	Fe	H	CEC_{eff}	BS [% CEC_{eff}]
A	1.0	1.9	11.0	3.5	3.1	68.0	0.1	19.7	108	16.0
Bg1	1.0	1.0	2.7	1.4	1.0	53.6	0.0	11.7	72	8.4
Bg2	0.9	0.9	1.8	1.0	1.0	37.5	0.3	9.3	53	8.7
Bg	0.9	0.8	3.3	1.9	0.5	29.8	0.0	7.9	45	15.5

Element contents in the 0.1 M $BaCl_2$-extract [mmol$_c$.kg^{-1}] Profile B: spruce

Hor.	Na	K	Ca	Mg	Mn	Al	Fe	H	CEC_{eff}	BS [% CEC_{eff}]
A	1.0	1.0	8.2	2.7	2.2	83.9	0.6	18.8	119	10.9
Bg1	1.0	0.6	2.3	1.3	2.0	68.7	0.1	14.2	90	5.8
Bg2	1.0	0.6	2.2	1.0	1.5	47.4	0.0	12.5	66	7.1
Bg	1.0	0.8	4.2	3.9	0.9	37.8	0.4	11.3	60	16.5

Table 2.3: continued

Element contents in the organic layer (O) and in the fine mineral soil (MS) up to 80 cm soil depth.Profile A: beech

Total stocks [g.m^{-2}]								Exchangeable stocks [g.m^{-2}]		
	C	N	P	K	Ca	Mg		K	Ca	Mg
O	515	20	1	10	7	4				
MS (0-80 cm)	6722	673	232	12131	218	5158		27	50	18

Element contents in the organic layer (O) and in the fine mineral soil (MS) down to 80 cm soil depth.Profile B: spruce

Total stocks [g.m^{-2}]								Exchangeable stocks [g.m^{-2}]		
	C	N	P	K	Ca	Mg		K	Ca	Mg
O	1854	79	13	45	15	15				
MS (0-80 cm)	5047	508	203	11101	245	3751		20	51	23

The pH($CaCl_2$)-values are slightly lower in the topsoil of the spruce stand than in that of the beech stand. C, N, S and p-contents in the topsoil to approx. 20 cm soil depth are clearly higher under beech than under spruce. The relations of these elements vary only slightly in the mineral soil. The poor C/N proportions in the humus layer of the beech stand can be explained by the fact that under Mull dynamics, predominantly cellulose-rich branches, beech nuts and leaf blades are accumulated on the soil surface, while easily convertible portions are integrated into the soil.

While the cation exchange capacity found under beech is smaller than under spruce, the effective base saturation is clearly higher in the topsoil of beech. Potassium and calcium are clearly, magnesium only slightly enriched. The exchanger of the spruce stand is substantially more protonised, particularly in the topsoil.

The distribution of carbon and nitrogen pools reflects the different humus dynamics. The nitrogen storage in the soil of the spruce stand is lower than that of the beech stand by around a ton per hectare.

The nutrient supplies bound in the humus layer are substantially higher under spruce than under beech. However, there are clear element-specific differences, as the phosphorus in the humus layer of the spruce stand is substantially more enriched than calcium, for example. There is a clear difference in the potassium level and distribution. With altogether similar total nutrient pools the exchangeable supplies in the mineral soil are substantially smaller under spruce than under beech. On the other hand the (rapidly mobilizable) potassium supply is four times high in the humus layer of spruce as under beech.

Since the differences were solely determined on the basis of a mixed sample from four profiles each, the found differences are by no means statistically proof. Yet some of the results correspond with results of a soil-scientific comparison of pairs of 60 pure spruce stands with mixed spruce-beech stands (NEUBAUER, 2000). There the accumulation of nutrients in the humus layer of spruce stands was statistically verified, only calcium was more enriched in the humus layer under beech. Neubauer's comparison could prove a significant lowering of the pH values only on base-rich substrates (Flysch). On base-poor substrates (tertiary gravel) these effects were small and statistically not verifiable. The effect of the tree species on base saturation was similar. In well base-supplied locations, the base saturation in the topsoil of beech was significantly higher than under spruce, on base-poor substrate this effect was only small. An increase of the effective cation exchange capacity in the topsoil of the spruce stand was also shown by Neubauer.

The influence of tree species choice on humus form, distribution of roots and structure of the topsoil is obvious. On meso- to oligotrophic locations, however, the influence of the tree species on soil-chemical parameters seems to be small. The pumping effect of beech for calcium, an effect of the water consumption from deeper horizons, seems to be clearly recognizable (GLATZEL et al., 2000).

Profile 3: Heidriegel

Location: 16°21'39" E, 47°33'26" N (MGI), 620 m a. sl.

Land form: steep SW declining middle slope

Site type: Podsolic brown earths and semipodsoles on sunny slopes on quartzite

Land use: Forest (Timber of 5th age grade, mixed forest: 0.5 scots pine, 0.3 sessile oak, 0.1 European larch, 0.1 silver fir)

Ground vegetation: *Avenella flexuosa, Vaccinium myrtillus, Leucobryum glaucum*

Parent material for soil formation: slope colluvium with Semmering quartzite; at 50 m above the sample point, in the slightly steeper slope area strongly cleft Semmering quartzite is found, on which partly podsolic rankers have developed. (Periglacial) cover layers have developed at the sample site. Gravel and stones are accumulated at the surface. A skeleton-rich layer of approximately 10 cm depth is followed by a skeleton-poorer layer of approximately 50 cm depth, see table 3.1.

Table 3.1: Description of a representative profile.

Horizon		from – to	Description
AT	WRB	[cm]	
L	Oi	8 – 7.5	loosely bedded oak leaves, needles of larch and pine, cones, branches, slightly decomposed, gradual transition
F	Oe	7.5 – 5.5	stickty to layered, moderately decomposed, many fine roots, gradual transition
H1	Oa1	5.5 – 2	compact to crumbly, high amount of roots, soil colour: dark brown (10YR 3/3), gradual transition
H2	Oa2	2 – 0	compact to fragile, ca. 50 vol % gravel, sharp boundary
Ahe	A	0 – 8	fine subangular weakly blocky soil type: loamy sand, high amount of gravel (ca. 50-60% fine- & medium) soil colour: light yellow-brown (10 YR 4/1), many roots, clear boundary
Bv1 (E)	B1	8 – 23	subangular fine-blocky soil type: loamy sand, high amount of gravel (ca. 30 % fine & medium coarse) soil colour: pale brown (10 YR 6/3), many roots, gradual transition
Bv2 (Bs)	B2	23 - 50	subangular medium-blocky, half-openly layered soil type: sandy loam, high amount of stones and gravel soil colour: light yellow-brown (10 YR 6/4), few roots, gradual transition
Bv3	B3	50 +	subangular medium-blocky, half-openly layered soil type: sandy loam, very high amount of stones and gravel soil colour: brown-yellow (10 YR 6/6), very few roots

Humus form: Morlike Moder

Soil type: AT: Podsol-Braunerde,

WRB: depending on slope position, either Hyperdystric hyperskeletic Leptosol or Hyperdystric episkeletic Regosol can be classified.

The podsolization is morphologically hardly detectable, but indisputable under consideration of soil-chemical analyses.

Trophy: oligotrophic, hydrology: moderately dry

Soil physical properties:

The soil texture of fine earth ranges from loamy sand in the topsoil (cover layer) to sandy loam in the subsoil**.** In the B2 horizon the clay content increases remarkably, the silt fraction marginally, see table 3.2.

Table 3.2: Soil physical properties.

Hor.	from – to [cm]	Texture [%] of the humus- und carbonate-free fine soil											
		cS	mS	fS	*ΣS*	cSi	mSi	fSi	*ΣSi*	cC	mC	fC	*ΣC*
A	0 – 8	29.8	8.7	13.2	*51.6*	12.8	13.4	7.4	*33.6*	4.8	3.8	6.2	*14.8*
B1	8 – 23	39.1	8.5	12.3	*60.0*	11.7	10.0	6.7	*29.2*	3.3	1.8	5.7	*10.8*
B2.1	23 – 35	19.9	10.7	13.8	*44.3*	14.7	13.1	9.1	*36.8*	5.4	5.7	7.6	*18.6*
B2.2	35 – 50	19.5	9.3	14.3	*43.1*	14.2	13.8	9.0	*37.0*	6.7	5.9	7.3	*19.9*
B3	50+	19.7	9.6	14.5	*43.8*	15.8	11.9	9.0	*36.7*	6.5	6.6	6.4	*19.5*

Mineralogical composition:

Table 3.3: Semiquantitative mineralogical composition of fine soil.

Hor.	from - to [cm]	Quartz	Layered silic.	Feldspars
A	0 – 8	71	27	2
B1	8 – 23	87	11	2
B2.1	23 – 35	77	22	1
B2.2	35 – 50	76	22	2

Silica occurs as a main part of the fine soil in this profile. The silica-rich raw material gives rise to values up to 87 mass %. The rest of the mineral proportion in the fine soil consists of layer-silicates, particularly Muscovite (11 to 27 mass %) and small quantities of feldspar (1-2 mass %) see table 3.3.

In the soil skeleton, as well as in the fine soil, silica is dominant, Muscovite gains some importance, while feldspars are not detectable at all.

Mineralogical composition of the clay fraction, see figure 3.1:

The main part of the clay fraction consists of a mixed layer mineral from Illite and Vermiculite with a D value (002) of 11,5Å if Mg-saturated. Under K-cover, there is a partial contraction of the Vermiculite portion in the mixed layer in the upper profile part. The contraction, however, is not complete, so that a d-value of 10Å is not reached. Starting from 35 cm soil depth, the vermiculite component changes into secondary chlorite. Discrete Vermiculite is detectable down to 35 cm soil depth, below that it is not present. Chlorite is found starting from this depth.

Kaolinite is represented in the entire profile, but detectable only in small quantities.

The profile is free from chlorite up to approximately 35 cm soil depth, below that it occurs as primary chlorite. The dominating mixed layer mineral shows a gradual change from Illite / Vermiculite into Illite / Secondary Chlorite at approximately 35 cm.

This could be interpreted as a hint towards a two-storey character of the profile. The dispersal pattern could also be explained by progressive weathering. In the upper profile section aluminium could have been extracted from the intermediate layers of the secondary chlorite portion, so that now vermiculite is present in the ML.

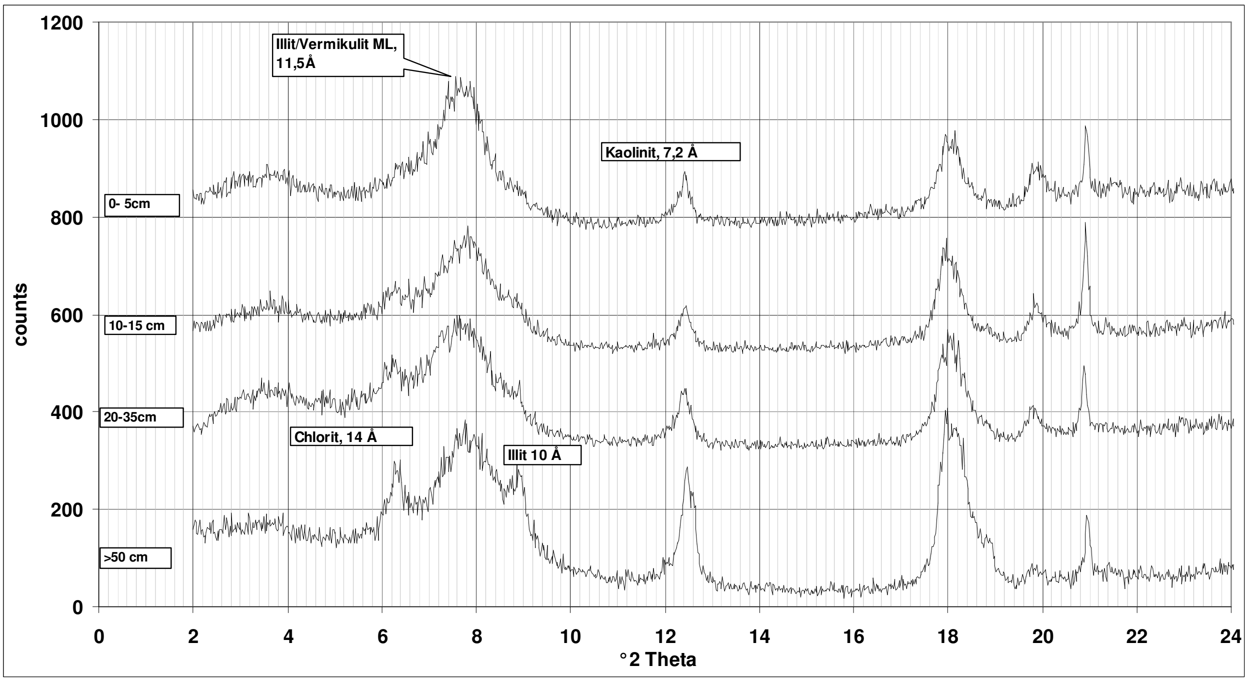

Figure 3.1: X-ray diffractogram of the clay fraction in the soil horizons of the profile (Mg-covered and glycolised).

Soil chemical properties, see table 3.4:

The upper profile part, particularly the A, is strongly acidic, the increase of pH $CaCl_2$ within the transition from A to B1 is relatively abrupt. C-N-ratios are relatively narrow over the entire profile, the C-P and C-S-ratios particularly in the topsoil. This reflects the inactive humus form.

In the total digestion, extremely low calcium and manganese contents are noticeable. In the A horizon, a breakdown of iron, aluminium and manganese contents, particularly of the dithionite-soluble portion, is recognizable. This is clearly seen at the clay-related dithionite-soluble iron contents, which suggests a certain podsolization. However, there is no clearly visible and pronounced Bs-horizon. Altogether the substrate is very poor in (coloring) manganese and iron compounds, which could explain the missing morphological development of a Bs horizon.

The effective cation exchange capacity is very low, just like the base saturation. The exchanger-complex is dominated by aluminum, iron is hardly detectable, manganese only in small portions. The portion of basic cations of the exchanger decreases continuously downwards the soil profile, which can be interpreted as an indication of a clear bio-accumulation.

Table 3.4: Soil chemical properties.

pH-values, total C, N and P contents, and element ratios

		pH H_2O	pH $CaCl_2$	C_{org} [mg.g^{-1}]	N_{tot} [mg.g^{-1}]	S_{tot} [mg.g^{-1}]	P_{tot} [mg.g^{-1}]	C/N	C/S	C/P
Oi/Oe	8 –5			367.6	13.1	1.3	1.1	28	277	349
Oa	5 – 0	4.6	3.2	457.5	14.7	2.1	1.2	31	221	397
A	0 – 8	4.2	2.9	112.1	5.0	0.8	0.5	23	140	218
B1	8 – 23	3.9	3.0	17.7	0.7	0.1	0.2	27	145	101
B2.1	23 – 35	4.2	3.5	14.7	0.4	0.1	0.3	36	130	49
B2.2	35 – 50	4.4	3.8	11.1	0.3	0.2	0.2	34	72	50
B3	50 +	4.4	3.7	9.7	0.3	0.1	0.2	33	72	47

Total (t) element contents in the $HNO_3/HClO_4$-extract (mg.g^{-1}) and in the dithionite (d)-extract (mg.g^{-1})

	Na_t	K_t	Ca_t	Mg_t	Mn_t	Mn_d	Mn_d [% Mn_t]	Al_t	Al_d	Al_d [% Al_t]	Fe_t	Fe_d	Fe_d [% Fe_t]
Oi/Oe	0.1	2.2	3.3	0.6	0.76			2.8			26.7		
Oa	0.2	3.9	1.8	1.0	0.45			8.1			7.4		
A	0.3	6.5	0.5	1.1	0.06	0.02	37	15.3	0.8	5	10.1	2.2	22 (14.8)
B1	0.3	6.9	0.4	1.1	0.04	0.01	19	14.6	0.4	3	9.0	1.7	18 (15.8)
B2.1	0.4	9.4	0.5	1.6	0.06	0.02	35	21.9	0.9	4	13.9	4.5	32 (24.0)
B2.2	0.4	10.1	0.5	1.8	0.06	0.02	28	23.8	1.1	5	14.8	3.4	23 (17.1)
B3	0.4	14.0	0.4	2.1	0.07	0.02	36	28.9	1.1	4	16.5	5.4	32 (27.6)

Element contents in the 0.1 M $BaCl_2$-extract [mmol$_c$.kg^{-1}]

	Na	K	Ca	Mg	Mn	Al	Fe	H	CEC_{eff}	BS [% of CEC_{eff}]
Oa	5.6	12.0	85.8	23.0	13.01	24.1	0.001	20.2	184	68.8
A	1.0	2.1	6.1	3.3	0.72	51.4	0.000	21.5	86	14.5
B1	0.8	0.9	1.0	0.7	0.05	34.1	0.001	11.4	49	6.9
B2.1	0.8	0.8	1.0	0.6	0.05	38.1	0.001	7.6	49	6.3
B2.2	0.7	0.6	0.7	0.4	0.03	20.8	0.000	4.0	27	8.7
B3	0.8	0.8	1.0	0.5	0.06	25.0	0.000	4.8	33	9.5

Profile 4: Roterd

Location: 16°20'15" E, 47°32'33" N (MGI), 580 m a. sl.

Land form: gently E sloping middle to lower slope

Site type: Degraded, water-influenced sites with relic soils in level positions

Land use: Forest (2- layered mixed forest, timber 5th age grade, first layer: 0.4 scots pine, 0.3 sessile- & turkey oak, 0.1 beech, 0.1 spruce, 0.1 fir, second layer: spruce, fir)

Ground vegetation: *Vaccinium myrtillus, Avenella flexuosa, Festuca altissima, Galium rotundifolium, Luzula pilosa, Dryopteris filix-mas, Rubus fruticosus agg.*

Parent material of soil formation: weak signs of solifluidal transport, relic soil material („red earth") and mica-schist

Table 4.1: Description of a representative profile.

Horizon		from – to [cm]	description
AT	WRB		
LF	Oi/Oe	2/3 – 0.5/0	loosely layered to sticky, beech leaves, spruce needles, beechnuts, twigs, slightly withered
H	Oa	0/0.5 – 0	partly in pockets, many roots, gradual transition
Ahb	A	0 – 3	granular, weakly blocky, openly layered soil texture: loam, low amount of gravel soil colour: dark red-grey (5 >R 4/2), many roots, gradual transition
ABvrelg	ABg	3 – 13	granular to medium subangular blocky, half-openly layered soil structure: loam, medium amount of stones and gravel soil colour: yellow-red (5YR 4/6) many, very fine concretions, many roots, gradual transition
Bvrel1g	Bg1	13 – 33	coarse subangular blocky, spongy, half-openly layered soil structure: loam, medium amount of stones and gravel soil colour: yellow-red (5YR 5/6) many fine concretions, medium amount of roots, gradual transition
Bvrel2g	Bg2	33 – 80+	coarse subangular blocky, closed to half-openly layered soil structure: loam, high amount of stones and gravel soil colour: yellow-red (5YR 5/6) very few roots

Humus form: Dysmull

Soil type: AT: pseudovergleyte Reliktbraunerde;
WRB: Chromic endoskeletic Cambisol (hyperdystric) or, depending on content of coarse soil, Chromic episkeletic Cambisol (hyperdystric)

Trophy: mesotrophic

Hydrology: fresh, temporarily waterlogged

Soil physical properties:

Down to approx. 30 cm soil depth the bulk density is very low and increases in the Bg1 horizon, see table 4.2.
The coarse gravel proportion continuously increases with depth.

Table 4.2: Soil physical properties.

Hor.	Thickness [cm]	Coarse gravel [v%]	Dry bulk density [g.cm^{-3}]	Texture [%] of humus- and carbonate-free fine soil											
				cS	mS	fS	*ΣS*	cSi	mSi	fSi	*ΣSi*	cC	mC	fC	*ΣC*
L/O	2	1	0.1												
A	3	13	0.7	8.9	3.8	11.2	*23.9*	9.7	14.6	14.0	*38.3*	10.4	8.0	19.4	*37.8*
ABg	10	11	0.9	9.3	3.2	11.2	*23.7*	12.1	17.4	13.9	*43.4*	11.2	10.4	11.3	*32.9*
Bg1	20	24	1.1	7.7	4.0	13.6	*25.3*	12.0	17.6	15.0	*44.6*	10.3	9.6	10.2	*30.1*
Bg2.1	30	34	1.4	5.5	3.7	19.1	*28.3*	14.3	20.5	13.8	*48.6*	6.7	6.2	10.2	*23.1*
Bg2.2	20	32	1.4	3.9	4.9	11.5	*20.2*	13.8	25.3	16.1	*55.2*	6.7	6.3	11.6	*24.6*

The soil type across all profile parts is loam, the clay portion decreases downward in favour of the middle silt. Altogether, the silt component dominates the entire profile.

Mineralogical composition:

Table 4.3: Semiquantitative mineralogical composition of fine soil.

Hor.	from – to [cm]	Quartz	Layered silic.	Feldspars
A	0 – 3	22	78	nn
ABg	3 – 13	22	78	nn
Bg1	13 – 33	21	79	nn
Bg2.1	33 – 63	20	80	nn
Bg2.2	63+	13	87	nn

In terms of total minerals, the fine soil of this profile is dominated by layer silicates (Muscovite and Kaolinite) with portions between 78 and 87 mass %. Feldspars were not detected. The Silica portion declines with depth from 22 mass % in the upper sample to 13 mass % in the Bg2.2, see table 4.3.

In the coarse soil silica shows similar values, whereas Muscovite is represented in higher portions. Kaolinite is also detectable. For the mica-schist from this area, Kuepper (1957) indicates chlorite as the main constituent. This is no longer detectable in the examined rock samples. Feldspars are not detectable in the coarse gravel, nor in the fine soil. This could be a result of intensive weathering. The mica-shist underneath is likely to be poor in fieldspars, too.

Mineralogical composition of the clay fraction:

Kaolinite is the dominating clay mineral (table 4.4) in this profile. The major part is well crystallized; almost the entire Kaolinite is expandable with DMSO, only small quantities of poorly crystallized portions are present. This hints at a relictic character of the soil.

Table 4.4: Semiquantitative mineralogical composition of the clay fraction < 2 µm.

Hor.	from – to [cm]	Kaolinite	Illite	Vermiculite	Chlorite
A	0 – 3	73	24	2	1
ABg	3 – 13	77	21	1	1
Bg1	13 – 33	79	18	1	2
Bg2.1	33 – 63	86	11	1	2
Bg2.2	63+	88	10	-	2

Illite is the second most frequent clay mineral. Due to the Illite-content in the upper profile part, a loess-influence can be clearly recognized. Vermiculite and chlorite are represented in very small quantities; chlorite shows an increase with depth, whereas Vermiculite shows the opposite trend.

The very high portions of well crystallized Kaolinite prove the relictic character of the profile. Chlorite is weathered in the upper profile parts and replaced by Vermiculite.

Soil chemical properties, see table 4.5:

The fine soil of the profile is extremely poor in calcium but rather rich in potassium. The total contents of iron are high, with a high dithionite soluble proportion. The aluminum content is high, the pedogenous portion with approximately 5 % rather low. The portion of pedogenous manganese decreases from 80 % in upper soil to approximately 50 % in the lower soil parts.

The C/N, C/S and C/P relations are relatively close, in accordance with the humus form. The pH values continuously increase over soil depth, while the difference between pH H2O and pH $CaCl_2$-values is very large. The cation exchange capacity in the Bg1 and in the Bg2 is extremely low. Only in the A horizon somewhat higher values can be found, due to the higher humus portion. The base saturation in the upper soil part is low but it increases abruptly from the Bg1 to the Bg2. Exchangeable potassium shows a minimum between 13 and 63 cm soil depth, a slightly distinct bio accumulation is recognizable.

Apart from the intensive weathering of the soil profile, the litter-raking that has been practiced for centuries is likely to have led to depletion. Another indication for this are the carbon and nitrogen contents, which are rather low for a profile that is rich in fine soil. The pools of exchangeable bases and the total pools of calcium of this soil are extremely low.

Table 4.5: Soil chemical properties.

pH-values, total contents of C, N and P, and element ratios

Hor.	von – bis [cm]	pH H_2O	pH $CaCl_2$	C_{org} [mg.g^{-1}]	N_{tot} [mg.g^{-1}]	S_{tot} [mg.g^{-1}]	P_{tot} [mg.g^{-1}]	C/N	C/S	C/P
L/O	2 - 0			327.9	9.1	1.0	0.9	36.2	331	382
A	0 – 3	4.3	3.4	55.4	3.3	0.5	0.7	16.8	118	75
ABg	3 – 13	4.2	3.4	19.8	1.4	0.3	0.6	14.6	57	33
Bg1	13 – 33	4.2	3.6	10.9	1.2	0.3	0.5	9.3	34	22
Bg2.1	33 – 63	4.6	3.7	8.3	0.8	0.3	0.4	10.9	27	19
Bg2.2	63+	5.1	3.8	3.5	0.5	0.3	0.4	6.6	13	8

Total (t) element contents in the $HNO_3/HClO_4$-extract (mg.g^{-1}) and in the dithionite (d)-extract (mg.g^{-1})

	Na_t	K_t	Ca_t	Mg_t	Mn_t	Mn_d	Mn_d [% Mn_t]	Al_t	Al_d	Al_d [% Al_t]	Fe_t	Fe_d	Fe_d [% Fe_t]
L/O	0.9	6.4	3.3	1.3	3.2			20.1			15.3		
A	2.2	20.3	0.4	2.2	2.2	1.8	81.9	67.9	3.4	5.0	41.0	17.1	41.7
ABg	2.1	20.4	0.2	2.2	0.9	0.6	64.9	73.9	3.7	5.0	46.9	18.4	39.2
Bg1	1.6	15.3	0.2	2.0	0.9	0.6	69.3	62.6	3.3	5.2	44.5	18.3	41.1
Bg2.1	1.3	12.3	0.1	1.8	0.5	0.3	48.9	59.9	3.3	5.5	53.4	20.5	38.3
Bg2.2	1.4	14.4	0.1	1.5	0.7	0.3	47.8	68.4	3.2	4.6	50.2	22.5	44.8

Element contents in the 0.1 M $BaCl_2$-extract [$mmol_c.kg^{-1}$]

	Na	K	Ca	Mg	Mn	Al	Fe	H	CEC_{eff}	BS [% CEC_{eff}]
A	1.2	2.5	15.7	3.5	11.4	37.8	0.1	15.7	88	26.0
ABg	0.9	0.8	2.6	1.0	1.6	33.4	0.0	9.4	50	10.5
Bg1	0.9	0.5	1.6	0.8	1.3	22.7	0.0	6.1	34	11.2
Bg2.1	0.9	0.4	2.2	2.1	0.5	12.6	0.0	2.6	21	26.0
Bg2.2	0.7	1.2	4.8	2.8	1.0	15.7	0.0	4.0	30	31.3

Element contents in the organic layer (O) and in the fine mineral soil (MS) down to 80 cm soil depth

	Total stocks [$g.m^{-2}$]						Exchangeable stocks [$g.m^{-2}$]		
	C	N	P	K	Ca	Mg	K	Ca	Mg
O	1016	28	3	20	10	4			
MS (0-80 cm)	7087	655	336	10271	107	1279	19	42	22

Profile 5: Tschurndorf

Location: 16°'" E, 47°'" N (MGI), m a. sl.

Land form: middle ESE sloping middle slope, non-uniform small relief (windbreak plane, skid trails)

Land use: Forest (Timber: Turkey oak 5th age grade, scattered basswood; former coppice with standards; degree of canopy 0.6)

Weed cover & woody plants < 1 m: *Ligustrum vulgare, Cornus sanguinea, Berberis vulgaris, Crataegus sp., Rosa sp., Juniperus communis, Rubus fruticosus agg., Sorbus torminalis, Acer campestre, Fragaria sp., Cyclamen purpurascens, Primula sp., Galium rotundifolium*

Parent material for soil formation: loamy, polluted Leitha-lime, carrying fossils with enclosures of quartz minerals (Quartz gravel can be identified within the insoluble remnant after the dissolution of calcite with 10 % HCl)

Table 5.1: Description of a representative soil profile.

Horizon		From – to	Description
AT	WRB	[cm]	
L	Oi	0.5 - 0	loosely layered oak leaves, bark, twigs
Ahb	A	0 – 12	fine granular to weak blocky, openly to bulkily layered texture: loamy clay, low amount of stones (10 % calcium), very low amount of fine gravel (1 % Quarz) colour: dark brown (7.5 YR 3/2) many roots, gradual transition
AhbBvrel	AB	12 – 25	granular to fine subangular blocky, half-openly layered texture: loamy clay, medium amount of stones, low amount of fine gravel colour: dark brown (7.5 YR 4/3) many roots, gradual transition
Bvrel1g	Bg1	25 – 45	fine to medium (sub-)angular blocky, closed to half-openly layered texture: clay, high amount of stones and gravel colour: brown (7.5 YR 4/4) many fine mottles, high amount of roots, gradual transition
Bvrel2g	Bg2	45 + (in Spalten)	medium blocky – angular, closed to half-openly layered texture: loam, very high amount of stones and gravel colour: bright brown (7.5 YR 5/6) many fine mottles, medium to low amount of roots
C	C		Heavily karstic limestone, including fossils and enclosures of quartz

Humus form: Mull

Soil type: AT: pseudovergleyter Kalkbraunlehm;
WRB: Mollic endoleptic Cambisol (Calcaric); if criteria for mollic are not met: Calcaric endoleptic Cambisol (endoskeletic); if the increase in clay content from A/B to B is taken into account, a Cromic endoleptic Luvisol has to be classified.

Trophy: eutrophic; Hydrology: dry, temporarily waterlogged

Soil physical properties:

The A horizon is very loosely layered, in the Bg1 the bulk density increases rapidly. The soil texture in the upper two horizons is loamy clay, in the Bg1 clay. From the Bg1 to the Bg2 the clay portion decreases in favour of fine sand and a coarse silt fraction. Here the soil type can be defined as loam, see table 5.2.

Table 5.2: Soil physical properties.

Hor.	Thickness [cm]	Dry bulk density [g.cm^{-3}]	Texture [%] of humus- and carbonate-free fine soil											
			cS	mS	fS	*ΣS*	cSi	mSi	fSi	*ΣSi*	cC	mC	fC	*ΣC*
Oi	0.5 - 0	0.4												
A	0 – 12	0.7	6,8	5,1	11	*22,9*	13,0	12,2	8,2	*33,5*	6,7	9,8	27,0	*43,6*
AB	12 – 25	0.9	9,8	4,7	9,8	*24,4*	9,4	9,4	8,3	*27,1*	7,0	9,2	32,3	*48,5*
Bg	25 – 45	1.5	6,2	3,3	6,5	*16,0*	5,7	7,2	13,1	*26,0*	14,7	19,2	24,1	*58,0*
Bg	45 +	1.4	5,0	4,0	12,4	*21,5*	7,1	13,6	20,8	*41,4*	18,2	12,9	6,1	*37,1*

Mineralogical composition:

In the upper section of the profile silica is found with 48 mass % and is reduced in the Bg1 to 29 mass % (table 5.3). In the Bg2 only 3 mass % of silica are detectable. The layer silicates show an opposite trend with increasing soil depth, with values from 43 (A) to 65 mass % (Bg1). Feldspars appear in the top sample with a proportion of 10 mass %, which decreases in the lowest sample to the value of 5 mass %. Feldspars are not detectable in the Bg2. Calcite is found in the Bg1 with 1 mass %, while in the Bg2 it amounts to the proportion of 50 mass %, see table 5.3.

Table 5.3: Semiquantitative mineralogical composition of the fine soil.

Hor.	from – to [cm]	Quartz	Layered silic.	Feldspars	Calcite	Dolomite
A	0 – 12	48	42	10	nn	Nn
AB	12 – 25	48	47	5	nn	Nn
Bg	25 – 45	29	65	5	1	Nn
Bg	45 +	3	47	nn	50	Nn

The portion of fine gravel in the coarse soil up to the Bg1 is dominated by silica; furthermore, traces of feldspar are detected. Larger stones, as well as the coarse skeleton in the Bg2, consist entirely of calcite, with traces of silica.

Silica was also detected in the insoluble residue of limestones, which confirms an in-situ enrichment in the fine soil due to weathering.

Mineralogical composition of the clay fraction:

The clay mineralogical compositon of this profile differs considerably from all the other previously discussed soil samples (figure 5.1)

Its main component is an expandable clay mineral of the smectite group with a d-value 001 of 14 Å under Mg-cover. After K-cover an incomplete contraction of the samples close to the surface can be observed, the bottom sample remains at 14 Å. The Mg-covered samples expand to 17 Å after glycol treatment, whereas the samples with K-cover show only a very incomplete tendency to re-expansion (with the exception of the Bg2 sample).

The upper samples contain a clay mineral in the transition area from Vermiculite to Smectite; the sample from the Bg2 clearly contains low-charged Smectite.

Small quantities of Vermiculite, Kaolinite (for the most part poorly crystallized) and an Illite/Chlorite mixed layer are present in the entire profile. Illite occurs only in traces.

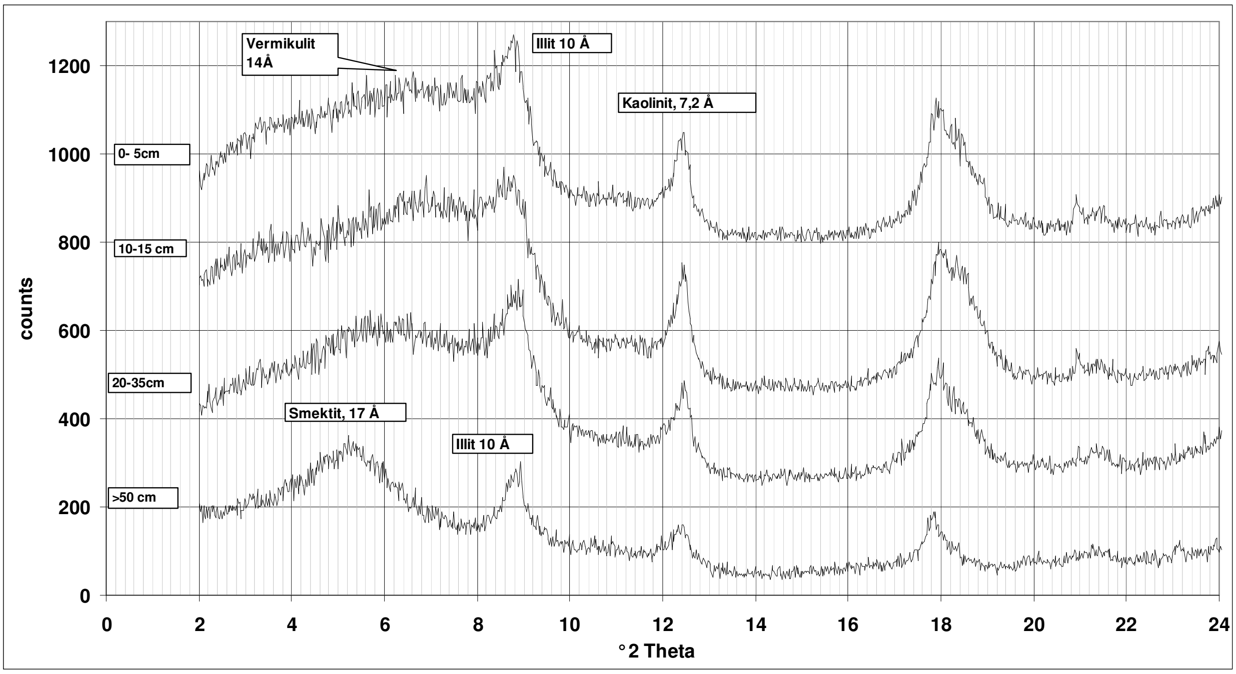

Figure 5.1: X-ray diffractogram of the clay fraction of the soil horizons in the profile (K-covered and glycolised).

Soil chemical properties, see table 5.3:

The profile is already carbonate-free in the upper soil, the pH values in A and A/B are surprisingly low. In the Bg-horizons, however, the finely distributed lime portion (predominantly in the gravel and sand fraction) leads to neutral pH values and a base saturation of 100 %. The effective cation exchange capacity in the upper soil is rather low for a carbonate-influenced soil, compared to the Austrian Forest Soil Condition Inventory (Kilian et al., 1992), yet it is average in the lower soil and high in the Bg2.

The Mn, aluminium and iron contents in the total digestion are relatively high and show a peak in the Bg1. The dithionite-soluble portion of manganese drops continuously from 80 % in the upper soil to 60 % in the lower soil. The dithionite-soluble portion of iron is relatively constant over the whole profile. The potassium contents in the total digestion are very high, the Calcium-contents increase continuously with soil depth. Free calcite causes a “dilution” of other elements in the Bg2.

Whether the profile emanates from relictic or recent weathering will be discussed as soon as the mineralogical analytical results of the insoluble residues of the basic rock are available.

Table 5.3: Soil chemical properties.

pH-values, total contents of C, N and P, and element ratios

		pH H_2O	pH $CaCl_2$	$CaCO_3$ [mg.g^{-1}]	C_{org} [mg.g^{-1}]	N_{ges} [mg.g^{-1}]	S_{ges} [mg.g^{-1}]	P_{ges} [mg.g^{-1}]	C/N	C/S	C/P
Oi	0.5 - 0				383.3	9.0	0.9	0.8	43	417	457
A	0 – 12	5.3	4.6	0	38.7	2.9	0.3	0.8	13	130	50
AB	12 – 25	5.3	4.2	0	16.9	0.9	0.1	0.7	20	116	26
Bg	25 – 45	6.6	6.2	12	12.0	0.7	0.1	0.7	17	109	19
Bg	45 +	7.5	6.7	463	35.5	2.4	0.3	1.4	15	102	28

Total (t) element contents in the $HNO_3/HClO_4$-extract (mg.g^{-1}) and in the dithionite (d)-extract (mg.g^{-1})

	Na_t	K_t	Ca_t	Mg_t	Mn_t	Mn_d	Mn_d [% Mn_t]	Al_t	Al_d	Al_d [% Al_t]	Fe_t	Fe_d	Fe_d [% Fe_t]
Oi	0.2	4.0	20.4	1.6	0.9			10.6			9.6		
A	0.6	10.7	4.8	5.6	1.0	0.8	80	46.3	1.5	3.3	31.4	10.4	33
AB	0.7	10.4	3.8	5.9	0.7	0.5	77	48.7	1.6	3.3	32.6	10.4	32
Bg	0.8	14.7	7.7	7.2	0.8	0.6	66	70.8	1.7	2.4	48.5	14.8	31
Bg	0.5	8.4	66.6	3.4	0.7	0.4	58	40.2	0.9	2.2	19.2	6.9	36

Element contents in the 0.1 M $BaCl_2$-extract [$mmol_c.kg^{-1}$]

	Na	K	Ca	Mg	Mn	Al	Fe	H	CEC_{eff}	BS [% CEC_{eff}]
A	1.0	3.2	201.5	13.0	2.0	4.2	0.0	0.4	225	97.1
AB	1.2	1.7	136.7	7.7	1.4	36.1	0.0	2.0	187	78.8
Bg	1.8	1.4	345.5	8.3	0.1				357	100.0
Bg	1.3	2.5	423.1	2.4					429	100.0

Element contents in the organic layer (O) and in the fine mineral soil (MS) down to 60 cm depth

Total stocks [g.m^{-2}]								Exchangeable stocks [g.m^{-2}]		
	C	N	P	K	Ca	Mg		K	Ca	Mg
O	541	13	1	6	29	2				
MS (0-60 cm)	8500	540	320	5200	5100	2600		30	2200	40

The nutrient pools can be estimated only very roughly, due to the high small-scale variability and the high proportion of rock. However, the nutrient pools are relatively high for such a shallow profile. Particularly the quite high potassium pool in the fine soil is remarkable. The exchangeable potassium portion, however, is small.

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