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Pedological and geochemical investigations at the "Red Outcrop" of Langenlois (Lower Austria)

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Abstract: In an outcrop of loess-paleosol sequences over amphibolite, six soil profiles (Lois 1 to Lois 6) were sampled and analysed for pedological, mineralogical, and geochemical characteristics. A second outcrop (Lois 7) was investigated for soil micromorphology. Two soil profiles (Lois 1 and 2) have developed over amphibolites, two over an amphibolite/marble-body (Lois 5 and 6) and three polycyclic paleosol profiles with several fossil horizons have no visible underlying bedrock (Lois 3, 4 and 7). In the profiles Lois 1–4 and Lois 7 intense carbonate illuviations occur. These high amounts of carbonate cannot result from recent pedogenesis, but are interpreted as being derived from carbonate-rich sediments (loess) overlying the present outcrop in the past which were eroded. Furthermore, a layer of calc-sinter was found in the profile Lois 2. It is assumed, that this sinter could come from the weathering of the marble which can be found in the profile Lois 6. The sinter layer seems to inhibit the exchange of chemical elements between rock and soil in the profiles Lois 1 and 2, which is emphasized by the geochemical results. The clay cutans on aggregates in the fossil horizons also indicate that the clay eluviation has already taken place in former periods. Furthermore, weakly developed stagnic properties can be found in the fossil horizons. The paleosol profiles show several polycyclic sedimentation stages and thus several generations of fossil horizons. The results of the soil micromorphological analysis allow for an age classification of the soil profiles in the "Red Outcrop" and can thus be placed in Middle to Lower Pleistocene or older.

[Bodenkundliche und geochemische Untersuchungen am „Roten Aufschluss" in Langenlois (Niederösterreich)]

Kurzfassung: In einem Aufschluss von Löss-Paläoboden-Sequenzen über Rehberger Amphibolit NW von Langenlois wurden sechs Bodenprofile (Lois 1 bis Lois 6) beprobt und pedologisch, mineralogisch und geochemisch analysiert. Am Profil Lois 7 wurden bodenmikromorphologische Untersuchungen durchgeführt. Zwei Bodenprofile (Lois 1 und 2) haben sich über Amphibolit entwickelt, zwei über einer Amphibolit/Marmor-Wechsellagerung (Lois 5 und 6) und drei Bodenprofile sind Sequenzen von polyzyklischen Paläoböden mit fossilen Bodenhorizonten ohne unterlagerndes kristallines Gestein (Lois 3, 4 und 7). In den Profilen Lois 1–4 und Lois 7 konnten intensive Karbonatanreicherungen beobachtet werden. Diese hohen Mengen an Karbonat können nicht Produkt einer rezenten Bodenbildung sein, sondern sprechen für eine Infiltration von ursprünglich das Profil überlagernden kalzitreichen Sedimenten (Löss), die erodiert wurden. Zudem wurde in Profil Lois 2 ein Kalksinter angetroffen. Dieser Kalksinter könnte aus der Verwitterung der im Profil Lois 6 aufgeschlossenen Marmorlagen stammen. Die Kalksinter-Schicht scheint die Stoffflüsse zwischen unterliegendem Gestein und Solum in den Profilen Lois 1 und 2 mehr oder weniger zu unterbinden, was auch durch die Ergebnisse der geochemischen Analytik unterstrichen wird.

In den fossilen Horizonten wurden auch ältere Anzeichen von Tonverlagerung in Form von Tonkutanen über den Aggregaten und darüber hinaus leichte Pseudovergleyungserscheinungen angetroffen. Die mächtigen Profile ohne aufgeschlossenes Grundgebirge (Lois 3, 4 und 7) weisen mehrere polyzyklische Sedimentationsphasen und dadurch mehrere Generationen von fossilen Horizonten auf. Aufgrund der bodenmikromorphologischen Analyse können die Böden vom „Roten Aufschluss" altersmäßig im unteren bis mittleren Pleistozän oder älter angesiedelt werden.

Keywords: *Loess, Paleosol, Micromorphology, Amphibolite, Langenlois*

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1 Introduction

In the summer of 2007 a new vineyard was established NW of Langenlois at the so-called 'Schenkenbichl-Hill' (Fig. 1 and 2, Coordinates: R: 49808, H: 5371937; Allotment 4975). The opportunity was taken to investigate an outcrop which is fresh and uncovered by vegetation in a geologically and historically distinct and interesting landscape. At the U-shaped outcrop with a height up to 5 m, a loess/paleosol/colluvium-sequence on a dome-shaped amphibolite with layers of marble was investigated. The loess/colluvium-sediments were deposited in the Early to Middle Pleistocene, according to the results of Smolíková, Havlíček, Holásek and Vachek, which are described in the chapter "Profile Lois 7". However, a Pliocene age of the sediments cannot be excluded. Such very old pedocomplexes at the SE-margin of the Bohemian Massif and especially in the area around Krems and Langenlois were described several times (Fink et al. 1976; Havlíček

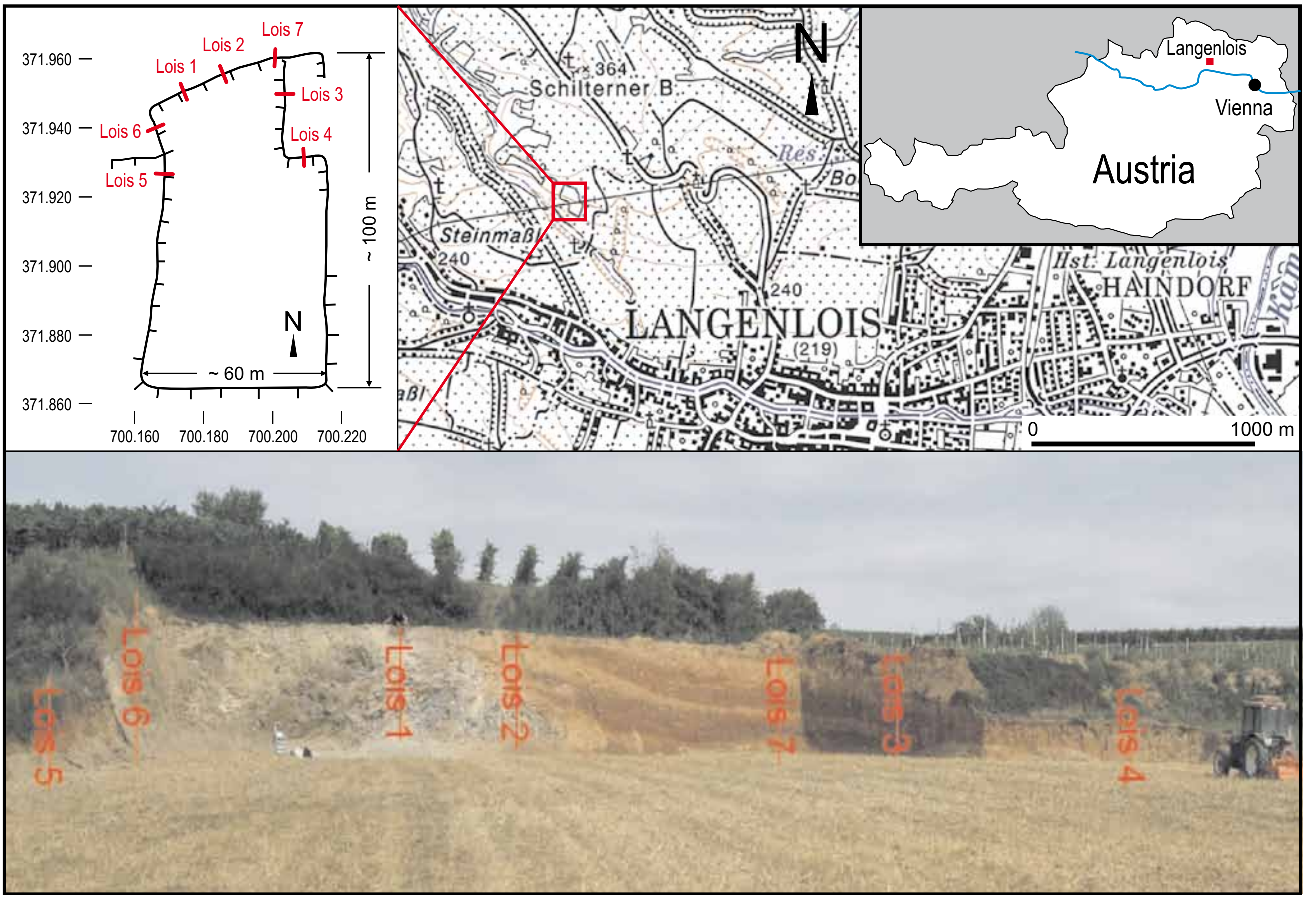


Fig. 1: Location of the outcrop (red circle) on a detail of the topographic map 1:50000 (© BEV – 2008, reproduced with permission of the BEV – Bundesamt für Eich- und Vermessungswesen Vienna, T2008/51914.), Overview of the outcrop with the sampled profiles Lois 1 to 7 and ground plot with coordinates (MGI_Austria_GK_M34; Projection: Transverse_Mercator) and positions of the profiles.

Abb. 1: Lage des Aufschlusses (roter Kreis) auf einem Ausschnitt der topographischen Karte 1:50000 (© BEV – 2008, Vervielfältigt mit Genehmigung des BEV – Bundesamtes für Eich- und Vermessungswesen in Wien, T2008/51914.), Übersicht über den Aufschluss mit den aufgenommenen Profilen Lois 1 bis Lois 7 und Grundriss und Koordinaten (BMN M34) des Aufschlusses und Positionen der aufgenommenen Profile.

et al. 1998; Havlíček et al. 2005; Havlíček et al. 2006). Due to the position of the area in the triangle between the SE-margin of the Bohemian Massif in the West, the river Danube in the South, and the river Kamp in the NE, these Lower Pleistocene to Pliocene sediments were protected from erosion. Young aeolian sediments, which covered the Middle to Upper Pleistocene sediments, additionally contributed to reduce the erosion.

The sediments are known in this area, for example from the 'Schießstätte' in Krems (Fink et al. 1976; Kovanda et al. 1995; Frank & Rabeder 1996b; Rabeder 1981), of the former brickyard 'Hammerer' in Langenlois (Fink et al. 1976; Jaburová 2009) or from outcrops in the hollow ways around Langenlois (Havlíček & Holásek 1998; Smolíková 1997, 1998; Havlíček et al. 2005; Smolíková & Havlíček 2007; Jaburová 2009). The sediments of the "Red Outcrop" are also comparable to the Plio-Pleistocene sediments of Stranzendorf (Fink et al. 1976; Kovanda et al. 1995; Frank & Rabeder 1996b; Döppes & Rabeder 1997; Rabeder 1981) or to soil sediments of the Middle Pleistocene in Neudegg (Frank & Rabeder 1996a; Döppes & Rabeder 1997; Havlíček et al. 2004).

According to Fuchs et al. (1984), the amphibolite on the Schenkenbichl-Hill belongs to the 'Rehberg-Formation'. The amphibolites are predominantly layered amphibolites, sometimes also gabbro-amphibolites, and locally associated with serpentinite and marble. The amphibolites occur in the shape of elongated bodies in the area around Langenlois, which is dominated by paragneisses. The petrology and geochemistry of the 'Rehberg'-amphibolite was thoroughly investigated in the doctoral thesis of Högl (1985). The petrographic description of the 'Rehberg'-amphibolites can be found in Matura (1989). Höck (in Steininger 1999) points to the comparability of the sequence to ophiolites, which can be regarded as remains of the oceanic crust. In the 'Red Outcrop', no macroscopically visible fossils could be found in the examined profiles, therefore there was no further investigation in this respect.

In this study, the reconstruction of the landscape's history and the single pedogenetic processes in the outcrop was carried out for the first time with detailed geochemical and soil micromorphological analyses.

2 Methods

Field

Seven profiles (Lois 1–7) were investigated (Fig. 1):
Lois 1 and **Lois 2** on weathered amphibolite
Lois 3 and **4** in the loess/paleosol/colluvium-sequence
Lois 5 in a disturbed soil on amphibolite/marble with backfill material on top

Lois 6 on weathered amphibolite/marble, partially disturbed with backfill material on top

The profiles Lois 1–6 were pedogenetically described and composite samples (ca. 1 kg) were taken from the genetical horizons. Two samples per horizon were taken from layers with a depth of more than 50 cm.

The profile **Lois** 7 has to be considered separately, since it was sampled only for the analysis of soil micromorphology and climatic stratigraphy. The laboratory analyses, which are described in the following, therefore refer only to the profiles Lois 1–6, with the exception of the description of the micromorphology method.

Laboratory

Drying and Sieving

Half of the samples were dried at 40 °C until constant weight, in order to simulate air drying. The other samples were stored cool and dark as retain samples. The dried samples were sieved to 2 mm to obtain the fine soil fraction. A representative portion of each sample was milled in a Netzsch-agate mortar.

Dry weight and loss on ignition

The samples were dried/heated at 105, 430 and 1000 °C. After each drying/heating step the loss on drying/ignition was calculated.

Particle size analysis after wet sieving

100 g of the air-dried samples were wet-sieved with mesh-sizes 2000, 1000, 500, 250, 125, 63 and 32 µm. The particle size distribution of the fraction < 32 µm was determined with a sedigraph (Micromeritics, Sedigraph 5100 ET).

pH in H_2O and $CaCl_2$

The determination of the pH-values was carried out according to the Austrian Standard (ÖNORM) L 1083 (ON 2006).

C/S-Analysis (LECO)

For each sample, 2 x 200 mg milled powder was weighed in tempered LECO-crucibles. The contents of C_{tot} and S_{tot} was determined in a LECO 200IS.

Content of organic matter

For each sample, 2 x 500 mg milled powder was weighed in tempered LECO-crucibles and wetted with H_2O deion. 3 x 2 M HCl were then percolated through the samples in order to dissolve the carbonate (C_{anorg}). In the next step, the samples were rinsed 10 times with H_2O deion. to remove the free Cl^--ions, since they interfere with the analysis. The C_{org}-content of the samples was measured in a LECO 200IS. The content of C_{anorg} was calculated by subtraction of the measured contents of organic carbon from the measured content of total carbon ($C_{tot} - C_{org}$). The analyses were carried out on two replicate samples.

Pedogenic oxides in dithionite and oxalate extract

The dithionite-extraction was carried out at room temperature according to the method of Holmgren (1967). The oxalate extraction was carried out according to the methods of Tamm (1932) and Schwertmann (1964).

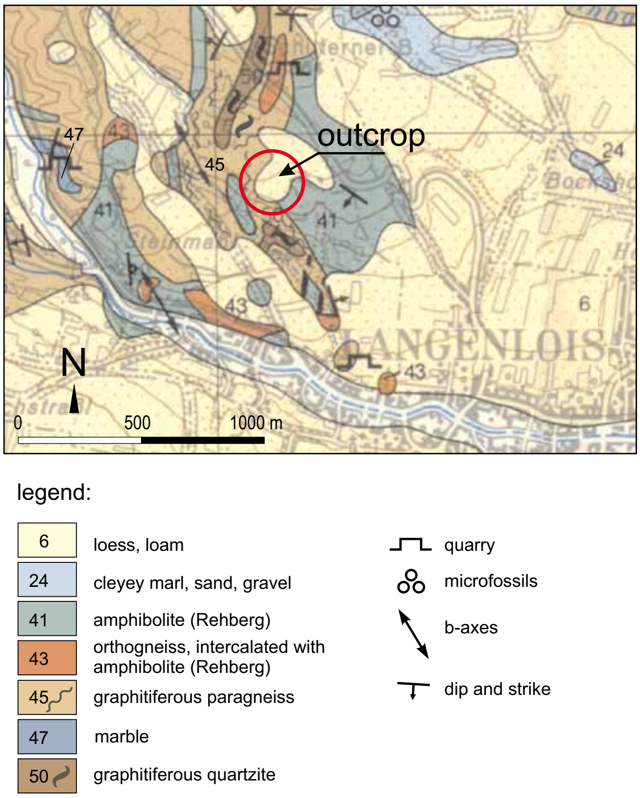


Fig. 2: Location of the outcrop (red circle) on a detail of the geological map 1:50000, Sheet 38 – Krems (Fuchs et al. 1984).

Abb. 2: Lage des Aufschlusses (roter Kreis) auf einem Ausschnitt der geologischen Karte 1:50000, Blatt 38 – Krems (Fuchs et al., 1984).

Total mineral content

The mineral phases were determined qualitatively and semi-quantitatively by X-ray diffraction in a Philips-XPert MPD Vertical Goniometer PW 3050 with the following measuring conditions: Measuring angle 2°– 65° 2 Θ, Cu-Kα-ceramic tube, automatic equatorial divergence, receiving slit 0.3 mm, continuous scan, step size 0.02°, 40 kV, 40 mA, measuring time 1 s/step, measuring program X'Pert Data Collector. The peak areas of the main reflections were determined with the X'pert-Data Viewer-Programme. Afterwards, the mineralogical composition of the samples was determined according to the method of Schultz (1964) with correction factors.

Clay mineral analysis (fraction < 2 µm)

The samples were dispersed with 15 % H_2O_2. After the reaction reached its equilibrium, the excess H_2O_2 was removed and the samples were treated in an ultrasonic bath for 15 minutes. The 2 µm-fraction was separated by centrifugation. Afterwards, 400 ml of the clay suspension of each sample was mixed with 100 ml 4 N KCl-solution or 4 N $MgCl_2$-solution, respectively, and shaken in a horizontal shaker for 24 h. The samples were prepared using the suction-on-ceramic-plate method. After X-ray diffraction, the K- and Mg-treated samples were treated with ethylene glycol and measured again. The Mg-treated samples were treated afterwards with glycerine for the distinction between smectite and vermiculite. The K-treated samples were treated with DMSO (Dimethyl sulfoxide) for the distinction between chlorite and kaolinite. Finally, the Mg-treated samples were tempered at 300°C und afterwards at 550° for 2 h for the determination of primary and secondary chlorite. The X-ray diffractometry for the clay samples was carried out in the same manner as for the total mineral composition. The correction factors were taken from Riedmüller (1978).

Determination of major and trace elements
4 g of the milled samples was mixed with 0.9 g wax (Merck, Hoechst Wax C Micropowder) in a planetary mill (Retsch MM200). The tablets were pressed with a Specac press. The analysis of major and trace elements was carried out by X-ray fluorescence (XRF) in a Spectro XLAB 2000.

Scanning electron microscopy (SEM) and microanalysis (EDX)
The SEM-analyses of the rock samples were carried out after C-sputtering on a Vega Tescan (CamScan, USA). The image capturing was carried out with the digital image capturing system analySIS (Soft Imaging Systems). The energy dispersive X-ray analysis (EDX) was carried out on a Link ISIS 200/300 (Oxford Instruments).

Soil micromorphological examinations on soil thin sections
The soil micromorphological analyses and description were carried out by Libuše Smolíková of the Karls-University in Prague.

Soil systematics
The determination of the soil types and their genetic horizons was carried out according to the Austrian Soil Classification System (Nestroy et al. 2000). However, in Table 1, there is a reference to the corresponding soil types according to *World Reference Base for Soil Resources* (WRB; IUSS Working Group WRB, 2006).

3 Results

The results of soil systematics, chemistry and physics, the mineralogical and geochemical analyses of the profiles Lois 1 to Lois 6, as well as the soil micromorphological analyses of Lois 7, are now shown and discussed. The chapters are divided into the sections 'Soil physical and chemical parameters', 'Mineralogy' and 'Geochemistry' for each profile. The soil micromorphological analyses of profile Lois 7 are discussed separately.

In Table 1 the soil descriptions as well as the most important soil chemical and physical parameters of the profiles Lois 1 to 6 are shown.

Profile Lois 1

Soil physical and chemical parameters
The examination of the chemical parameters of profile Lois 1 show that the pH-values in the whole profiles show no dynamics at all, with values between 7.2 and 7.5. The content of organic C is very low and decreases from 0.74 % in the uppermost (Ap-)horizon to 0.21 % in the lowermost (C-) horizon (Tab. 1). The pedogenic oxides decrease as well from top to bottom. The share of the pedogenic Fe compared to total Fe decreases from 7 to 4 %. The share of amorphous (active) Fe is low, which is a sign of low pedogenetical activity (Tab. 2). The texture of Lois 1 is relatively uniform throughout the profile. The gravel content (> 2 mm) is between 19 and 30 %, the sand content increases from 34 to up to 49 % through the soil profile. The silt and clay contents decrease from top to bottom (silt from 24 to 17 %, clay from 15 to 5 %) (Tab. 1). The soil texture of profile Lois 1 is loamy sand to sandy loam. The soil profile shows no significant dynamic behaviour and slow pedogenetical processes.

Mineralogy
The thin section of the rock sample (240 cm) shows that the amphibolite is very rich in hornblende with plagioclase and quartz as accessories. The quartz primarily occurs in lenses, which is typical for the 'Rehberg'-amphibolite. Chlorite could be identified as accessory by XRD. In the sample G1/2 (382 cm), the amphibolite shows alternate layering of finer and coarser grains. The feldspar occurs in small crystals. Clinozoisite, rutile and titanite as well as a chlorite vein could also be identified. The rock sample G1/3 (440 cm) is significantly coarser than the other two rock samples with paler amphiboles. The thin section also shows clinopyroxene and garnet. In addition, zoisite and chlorite could be identified as accessories by XRD.

The mineralogical analyses of the soil samples of profile Lois 1 show a predominance of quartz, calcite and hornblende (Tab. 3). The quartz content decreases from 26 to 3 % from top to bottom. Calcite shows a reverse behaviour. The content of hornblende is very constant throughout the soil profile (18–34 %). The feldspars are dominated by plagioclase with contents between 11–14 %. The sheet silicate content is low (up to 10 % in the Ap-horizon). Noticeable is the high content of calcite in the soil profile. The calcite covers the solum as well as the amphibolite and occurs as a thick, purely white crust which can be easily removed by hand from the fresh and only slightly weathered amphibolites. The, in places, intense carbonate enrichment can also be observed in the other soil profiles. These high amounts of carbonate cannot be derived from recent pedogenetical processes, but suggest an infiltration from eroded calcite-rich sediments (loess), which originally overlaid the soil profile. Furthermore, an occurrence of calc-sinter was found in profile Lois 2. This calc-sinter could be a weathering product from the marble of profile Lois 6. This hypothesis is also supported by the morphology of the outcrop. The outcrop slightly descends from the western flank (profiles Lois 5 and 6) towards the other soil profiles. Therefore, it is possible that weathering-induced calcite-rich solutions ran off laterally and then precipitated in the form of calc-sinter in the profiles on the northern and eastern flank of the outcrop (Lois 1–4). However, it is possible that both processes – decalcification of superimposed loess and precipitation of calcite-rich weathering products – were active in the 'Red Outcrop'. The calc-sinter layer apparently hinders material flows between the host rock and the solum, which is supported by the geochemical analyses.

The clay mineral composition is dominated by smectite with contents between 49 % in the uppermost horizon to 65 % in the lowermost horizon (Tab. 3). Illite shows a reverse distribution with 31 % in the uppermost and 12 % in the lowermost horizon. Kaolinite and chlorite occur only in small amounts (maximum contents: kaolinite 15 %, chlorite 16 %), whereas the chlorite only occurs as primary (detritary) chlorite.

Table 1: Soil description and most important soil chemical and physical parameters of profiles Lois 1 to Lois 6.

Tab. 1: Ergebnisse der Bodenbeschreibung sowie der wichtigsten bodenchemischen und -physikalischen Parameter der Profile Lois 1 bis 6.

Profile	Sample no.	Soil type (ASCS; WRB)	Horizon depth	Horizon	soil colour (moist)	soil colour (dry)	Structure	Horizon transition/ boundary	Roots	% > 2 mm	% Sand	% Silt	% Clay	pH H_2O	pH $CaCl_2$	C_{org} (%)
Lois 1	Lois 1/1	Karbonathaltige Braunerde aus grobklastischem Material - Haplic Calcisol	0 - 40	Ap	10YR/4/3	10YR/5,5/4	sab, gr	a, s	R3	26,3	33,7	24,7	15,4	7,5	7,2	0,74
	Lois 1/2		40 - 70	BwCv	10YR/5/3	10YR/6/2	sab	a, w	R1	19,0	44,7	24,1	12,2	7,7	7,3	0,48
	Lois 1/3		70 - 120	Cv	2,5Y/6/3,5	2,5Y/7/2,5	sab	a, w	R1	26,2	49,5	18,4	5,9	7,9	7,3	0,30
	Lois 1/4		120 - 140	C	2,5Y/6/3	2,5Y/7/3	sab	a, w	R1	30,1	47,1	17,1	5,7	7,9	7,5	0,21
Lois 2	Lois 2/1	Karbonathaltige Reliktbraunerde über Amphibolit - Endopetric Calcisol (Chromic)	0 - 45/50	Ap	10YR/4/3	10YR/6/3	ab, gr	a, s	R3	24,5	29,9	25,4	20,1	7,6	7,2	0,91
	Lois 2/2		45/50 - 170/180	Brel1	7,5YR/4,5/6	7,5YR/6/6	sab, gr	a, w	R2	6,1	17,2	33,3	43,5	7,8	7,5	0,22
	Lois 2/3			Brel1	7,5YR/4,5/6	7,5YR/6/6	sab, gr	g, w	R2	4,2	17,2	31,1	47,5	7,9	7,5	0,15
	Lois 2/4		170/180 - 220/230	Brel2	7,5YR/4/6	7,5YR/4/6	ab	g, w	R1	11,0	17,7	23,1	48,2	8,0	7,6	0,19
	Lois 2/5		220/230 - 310/340	BrelCv	7,5YR/4/6	7,5YR/4/6	ab	a, w	R1	14,0	23,3	20,0	42,6	8,0	7,6	0,18
	Lois 2/6			BrelCv	7,5YR/4/6	7,5YR/5/6	ab	a, w	R1	24,4	40,1	19,1	16,4	8,1	7,7	0,12
Lois 3	Lois 3/1	Karbonathaltige Parabraunerde aus reliktärem Lockersediment - Stagnic Hypercalcic Luvisol (Chromic)	0 - 25/30	Ap	10YR/3/2	10YR/4/3	ab, sab	a, s	R3	10,3	31,0	37,0	21,7	7,6	7,1	1,78
	Lois 3/2		25/30 - 60	Bh	10YR/4/3	7,5YR/5/4	sab, gr	a, w	R2	4,1	20,9	33,9	41,1	7,8	7,3	0,57
	Lois 3/3		60 - 120/130	B(t)	7,5YR/4/4	7,5YR/5/6	sab, gr	a, w	R1	1,4	11,4	32,3	54,9	7,8	7,4	0,33
	Lois 3/4			B(t)	7,5YR/4/6	7,5YR/6/6	sab, gr	a, w	R1	3,3	10,4	38,1	48,2	8,0	7,5	0,19
	Lois 3/5		120/130 - 190/200	Brel1	7,5YR/4,5/4	7,5YR/6/4	ab	g, w	R0	1,8	11,7	39,1	47,4	8,1	7,7	0,13
	Lois 3/6			Brel1	7,5YR/4/4	7,5YR/6/6	ab	g, w	R0	2,7	14,0	36,4	46,9	8,2	7,7	0,10
	Lois 3/7		190/200 - 290/300	Brel2	7,5YR/4/6	7,5YR/5/6	ab	g, w	R0	6,4	9,5	27,6	56,5	8,0	7,8	0,20
	Lois 3/8			Brel2	5YR/4,5/6	5YR/5/6	ab	g, w	R0	6,9	10,9	24,9	57,3	8,2	7,8	0,15
	Lois 3/9		290 - 409	Brel3	7,5YR/5/6	7,5YR/6/6	ab	g, w	R0	23,7	24,7	14,8	36,8	8,3	8,0	0,21
	Lois 3/10		409 - 460	Brel4	7,5YR/4/5	7,5YR/4/4	ab	g, w	R0	3,8	9,3	6,1	80,8	8,1	7,8	0,17
Lois 4	Lois 4/1	Karbonath. Parabraunerde aus reliktärem Lockersediment - Stagnic Hypercalcic Luvisol (Chromic)	0 - 20/25	Ap	10YR/4/3	10YR/5/4	gr	a, s	R3	7,2	23,3	32,2	37,3	7,6	7,2	1,01
	Lois 4/2		20/25 - 90/95	Brel1	5YR/4/6	5YR/5/6	ab	g, w	R1	2,3	10,1	25,0	62,6	7,8	7,4	0,25
	Lois 4/3		90/95 - 140	Brel2	7,5YR/5/6	7,5YR/6/6	ab	g, w	R1	9,9	33,8	24,1	32,2	8,1	7,6	0,13
Lois 5	Lois 5/1	Schüttungs-(Planie-)boden über skelettreicher karbonathaltiger Reliktbraunerde - Technic Cambisol (Chromic, Hypoepiskeletic)	30 - 0	Y	10YR/4/2	10YR/5/3,5				24,7	38,7	23,6	13,0	7,8	7,5	0,52
	Lois 5/2		0 - 15	Ap	10YR/4/3	10YR/4,5/3	sab, gr	a, s	R2	19,7	36,2	24,7	19,4	7,5	7,2	0,73
	Lois 5/3		15 - 120	BrelCv1	7,5YR/4/6	7,5YR/6/6	ab	g, s	R1	42,9	30,3	11,6	15,2	7,8	7,3	0,18
	Lois 5/4		120 - 200	BrelCv2	7,5YR/4/6	5YR/5/6	ab	g, s	R1	30,5	28,5	17,6	23,5	7,9	7,5	0,11
Lois 6	Lois 6/1	Schüttungs-(Planie-)boden über karbonathaltigem Grobmaterial-Rohboden - Technic Leptosol (Hypoepiskeletic)	+250 - 150	Y	10YR/4/3	10YR/5/3				18,1	42,0	26,7	13,2	7,5	7,2	0,84
	Lois 6/2		+150 - 0	YCv	10YR/4/3	10YR/5,5/3				25,5	37,5	23,0	14,0	7,7	7,5	0,56
	Lois 6/3		0 - 40	Cv1	2,5Y/6/3	2,5Y/7/2	sg	g, w	R0	54,9	32,5	8,8	3,8	7,8	7,6	0,36
	Lois 6/4		40 - 80	Cv2	2,5Y/4/3	2,5Y/6/3	sg	g, w	R0	45,1	43,0	10,1	1,8	8,2	7,6	0,40
	Lois 6/5		80 - 130	Cv3	2,5Y/5/3	2,5Y/6/4	sg	g, w	R0	29,4	52,6	15,6	2,4	8,2	7,6	0,10
	Lois 6/6		130 - 230	Cv4	2,5Y/4/4	2,5Y/6/4	sg	g, w	R0	52,6	31,7	13,2	2,5	7,9	7,6	0,15
	Lois 6/7		230 - 400	Cv5	2,5Y/5/4	2,5Y/6/4	sg	g, w	R0	25,3	48,8	18,7	7,3	8,1	7,7	0,23

Structure: sab = subangular blocky, ab = angular blocky, gr = granular, sg = single grain structure
Distinctness and topography of horizon boundaries: a = abrupt, g = gradual, s = smooth, w = wavy
Roots: R0 = none, R1 = few, R2 = moderate, R3 = many

ASCS = Austrian Soil Classification System; WRB = World Reference Base for Soil Resources

Table 2: Dithionite- and oxalate extractable fraction of the pedogenic oxides of profiles Lois 1 to 6.

Tab. 2: Dithionit- und oxalatlösliche Fraktion der pedogenen Oxide der Profile Lois 1 bis 6.

Profile	Horizon[1]/Depth	Fe_o (g/kg)	Al_o (g/kg)	Mn_o (g/kg)	Fe_d (g/kg)	Al_d (g/kg)	Mn_d (g/kg)	Fe_t (g/kg)	Fe_d/Fe_t	Fe_o/Fe_d
Lois 1	Ap - 40 cm	0,47	0,32	0,23	2,97	0,12	0,16	47,90	0,06	0,16
	BwCv - 70 cm	0,29	0,20	0,16	2,82	0,11	0,11	42,94	0,07	0,10
	Cv - 120 cm	0,11	0,09	0,05	2,51	0,08	0,04	48,16	0,05	0,04
	C - 140 cm	0,08	0,08	0,07	1,34	0,01	0,05	35,59	0,04	0,06
Lois 2	Ap - 25 cm	0,45	0,33	0,29	2,88	0,15	0,18	42,33	0,07	0,16
	Brel1 - 100 cm	0,27	0,28	0,31	2,29	0,11	0,19	33,53	0,07	0,12
	Brel1 - 170 cm	0,27	0,29	0,45	1,96	0,13	0,25	34,69	0,06	0,14
	Brel2 - 220 cm	0,30	0,33	0,46	2,91	0,19	0,32	49,72	0,06	0,10
	BrelCv - 270 cm	0,36	0,44	0,42	2,75	0,20	0,25	50,08	0,05	0,13
	BrelCv - 310 cm	0,35	0,50	0,28	2,37	0,17	0,15	55,43	0,04	0,15
Lois 3	Ap - 30 cm	0,68	0,56	0,38	2,87	0,18	0,19	38,40	0,07	0,24
	Bh - 60 cm	0,63	0,65	0,30	3,13	0,24	0,16	39,26	0,08	0,20
	B(t) - 90 cm	0,85	0,91	0,22	3,90	0,31	0,13	41,55	0,09	0,22
	B(t) - 120 cm	0,47	0,51	0,27	3,44	0,22	0,16	37,63	0,09	0,14
	Brel1 - 150 cm	0,32	0,28	0,24	2,21	0,11	0,13	30,26	0,07	0,14
	Brel1 - 190 cm	0,34	0,24	0,26	2,30	0,11	0,17	29,06	0,08	0,15
	Brel2 - 240 cm	0,67	0,47	0,23	3,65	0,24	0,16	41,84	0,09	0,18
	Brel2 - 290 cm	0,64	0,48	0,10	4,87	0,03	0,07	46,78	0,10	0,13
	Brel3 - 409 cm	1,01	0,60	0,88	2,85	1,21	0,41	62,40	0,05	0,35
	Brel4 - 460 cm	1,16	1,02	0,29	4,46	1,45	0,16	35,07	0,13	0,26
Lois 4	Ap - 20 cm	0,78	0,52	0,26	2,78	0,15	0,15	37,54	0,07	0,28
	Brel1 - 90 cm	0,80	0,59	0,07	4,83	0,33	0,05	45,84	0,11	0,17
	Brel2 - 140 cm	0,62	0,39	0,32	2,09	0,12	0,39	25,42	0,08	0,30
Lois 5	Y - +30 - 0 cm	0,51	0,31	0,20	5,55	0,13	0,16	54,04	0,10	0,09
	Ap - 15 cm	0,73	0,42	0,32	3,36	0,17	0,18	53,62	0,06	0,22
	BrelCv1 - 120 cm	0,44	0,31	0,46	5,23	0,29	0,31	61,24	0,09	0,08
	BrelCv2 - 200 cm	0,54	0,28	0,42	5,55	0,29	0,29	63,51	0,09	0,10
Lois 6	Y - +250 - 150 cm	0,73	0,40	0,27	3,36	0,17	0,17	51,11	0,07	0,22
	YCv - +150 - 0 cm	0,68	0,44	0,21	3,49	0,15	0,12	60,13	0,06	0,20
	Cv1 - 40 cm	0,19	0,16	0,10	6,10	0,06	0,11	69,44	0,09	0,03
	Cv2 - 80 cm	0,25	0,21	0,17	3,63	0,03	0,12	71,48	0,05	0,07
	Cv3 - 130 cm	0,09	0,10	0,07	2,76	0,06	0,06	61,57	0,04	0,03
	Cv4 - 230 cm	0,10	0,10	0,08	3,12	0,07	0,09	84,52	0,04	0,03
	Cv5 - 400 cm	0,47	0,18	0,26	3,21	0,02	0,14	36,60	0,09	0,15

[1] According to Austrian Soil Classification System

Table 3: Soil mineralogical and clay mineralogical composition of the rock and soil samples of the profiles Lois 1 to 6 in %.

Tab. 3: Gesamt- und tonmineralogische Zusammensetzung der Gesteins- und Bodenproben der Profile Lois 1 bis 6 in %.

Profile	Horizon[1]/Depth	Soil mineralogical composition							Clay minerals in the < 2 µm				
		Qu	K-Fsp	Plag	Calc	Sh.si.	Hbl	Acc	Verm	Smec	Illite	Kao	Chl
Lois 1	Ap - 40 cm	26	4	13	27	10	20		2	48	31	15	4
	BwCv - 70 cm	14	2	11	45	8	22		1	47	28	15	9
	Cv - 120 cm	3	0	14	43	3	36		Sp	55	17	12	16
	C - 140 cm	4	0	12	49	7	27		Sp	65	12	13	10
	G 1/1 - 240 cm	0	0	4	0	0	96	Zoi, Chl					
	G 1/2 - 382 cm	0	0	4	0	0	96	Zoi, Chl, Rut, Tit					
	G 1/3 - 440 cm	4	0	3	0	0	92	Zoi, Chl, Pyx, Gr					
Lois 2	Ap - 25 cm	32	2	13	28	9	16		3	48	30	12	8
	Brel1 - 100 cm	22	2	4	41	20	11		5	43	39	9	4
	Brel1 - 170 cm	32	2	5	38	21	2		8	47	37	6	2
	Brel2 - 220 cm	31	2	2	7	56	1		7	49	41	3	1
	BrelCv - 270 cm	22	2	2	13	52	9		0	51	47	2	0
	BrelCv - 310 cm	7	0	6	6	50	30		8	67	22	2	0
	G 2/1 - 280 cm	4	0	3	0	0	93	Zoi, Chl, Gr, Tit					
	G 2/2 - 382 cm	0	0	4	96	0	0	Hbl					
Lois 3	Ap - 30 cm	49	6	9	6	23	6		6	46	30	15	3
	Bh - 60 cm	51	4	12	6	24	2		3	40	37	18	2
	B(t) - 90 cm	51	3	6	1	39	0		7	38	18	38	0
	B(t) - 120 cm	49	3	6	13	29	0		9	38	21	31	0
	Brel1 - 150 cm	36	3	5	32	21	3		9	47	17	25	2
	Brel1 - 190 cm	48	3	5	17	27	0		8	41	23	26	1
	Brel2 - 240 cm	45	3	3	6	43	0		5	39	27	29	0
	Brel2 - 290 cm	34	2	3	11	50	0		9	24	29	38	0
	Brel3 - 409 cm	40	2	2	31	25	0		4	56	32	8	0
	Brel4 - 460 cm	17	2	0	2	80	0		5	55	36	4	0
Lois 4	Ap - 20 cm	43	4	9	9	25	11		0	39	36	25	Sp
	Brel1 - 90 cm	46	6	3	3	41	0		0	36	43	21	0
	Brel2 - 140 cm	62	2	1	13	21	0		0	55	35	10	Sp
Lois 5	Y - +30 - 0 cm	24	3	13	28	15	17		5	73	9	7	6
	Ap - 15 cm	30	2	15	19	14	20		8	56	20	9	7
	BrelCv1 - 120 cm	19	2	17	22	31	9		7	73	13	5	2
	BrelCv2 - 200 cm	33	2	11	2	45	8		9	54	26	7	4
Lois 6	Y - +250 - 150 cm	36	3	17	7	19	19		7	29	37	16	11
	YCv - +150 - 0 cm	26	2	15	17	17	23		9	54	17	0	20
	Cv1 - 40 cm	5	1	8	51	5	31		0	90	0	0	10
	Cv2 - 80 cm	12	2	15	36	9	26		0	87	0	0	13
	Cv3 - 130 cm	5	2	8	52	19	14		0	89	0	0	11
	Cv4 - 230 cm	52	3	6	20	12	7		0	97	0	0	3
	Cv5 - 400 cm	16	3	11	37	19	15		0	60	13	14	13
	G 6/1 - 330 cm	16	18	5	59	0	2						

[1] According to Austrian Soil Classification System

Qu = Quartz, **K-Fsp** = Kali Feldspar, P**lag** = Plagioclase, **Kalz** = Calzite, **Sh.si** = Sheet silicate, **Hbl** = Hornblende,
Akc = Akcessories, **Chl** = Chlorite, **Gr** = Garnet, **Pyx** = Pyroxene, **Rut** = Rutile, **Tit** = Titanite, **Zoi** = Zoisite
Verm = Vermiculite, **Smek** = Smectite, **Kao** = Kaolinite, **Chl** = Chlorite

Table 4: Major and trace elements in the soil profiles and the sampled rocks of the profiles Lois 1 to 6 in % (major elements) and ppm (trace elements); (H_2O^- = loss on drying at 105 °C; H_2O^+ = LOI-H_2O^--CO_2-Hydroxide-Phosphate-Sulfide).

Tab 4: Gehalt an Haupt- und Spurenelementen in den Horizonten und den entnommenen Gesteinen der Profile Lois 1 bis 6 in % (Hauptelemente) und ppm (Spurenelemente); (H_2O^- = Trocknungsverlust bei 105 °C; H_2O^+ = GV-H_2O^--CO_2-Hydroxide-Phosphate-Sulfide).

Profile	Horizon[1]/Depth	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	H_2O^-	P_2O_5	CO_2	SO_3	(H_2O^+)	Σ	Ba	Co	Cr	Cs	Cu	Ni	Pb	Rb	Sr	V	Y	Zn	Zr	Σ
Lois 1	Ap - 40 cm	46,5	0,80	12,23	6,85	0,14	3,69	13,63	1,45	1,57	1,69	0,35	10,77	0,14	0,10	99,90	361	12	103	5	138	51	23	64	311	152	25	112	137	1494
	BwCv - 70 cm	35,0	0,50	8,63	6,14	0,10	3,56	24,27	1,15	0,89	1,51	0,23	17,53	0,12	0,20	99,84	283	17	97	2	91	59	19	43	368	155	16	70	80	1299
	Cv - 120 cm	29,5	0,31	6,57	6,89	0,08	4,25	29,71	0,93	0,30	1,16	0,11	19,53	0,11	0,60	100,03	220	23	164	<1,5	82	79	6	14	449	189	9	45	24	1303
	C - 140 cm	29,0	0,31	6,55	5,09	0,08	3,80	31,49	0,93	0,33	1,13	0,13	20,46	0,11	0,60	100,00	213	21	244	<1,5	92	124	7	16	438	122	9	45	35	1365
	G 1/1 - 240 cm	48,0	0,54	15,37	8,48	0,12	10,51	12,05	2,28	0,20	0,37	0,04	0,26	0,00	1,50	99,72	129	18	776	3	81	102	2	7	294	317	9	55	18	1811
	G 1/2 - 382 cm	47,5	0,59	15,24	7,64	0,12	11,07	13,35	2,88	0,25	0,24	0,03	0,27	0,01	1,00	100,18	56	14	496	<1,5	34	40	4	7	331	405	10	57	19	1472
	G 1/3 - 440 cm	44,0	0,39	17,25	11,06	0,13	10,40	10,50	2,84	0,29	0,59	0,05	0,12	0,01	2,30	99,94	128	28	322	<1,5	284	195	2	10	321	265	7	60	15	1636
Lois 2	Ap - 25 cm	48,0	0,76	12,86	6,05	0,14	3,15	12,02	1,65	1,75	1,84	0,34	11,33	0,15	0,10	100,14	354	13	100	<1,5	127	47	27	77	262	135	27	104	164	1436
	Brel1 - 100 cm	40,0	0,54	12,00	4,79	0,12	2,43	18,58	0,97	1,91	2,28	0,28	13,61	0,04	2,30	99,84	375	9	79	<1,5	52	43	20	87	184	99	25	88	162	1224
	Brel1 - 170 cm	44,0	0,57	12,43	4,96	0,16	2,72	15,07	1,07	2,14	2,77	0,28	11,32	0,04	2,50	100,03	400	10	83	<1,5	54	45	23	97	192	112	27	103	159	1305
	Brel2 - 220 cm	52,0	0,67	16,73	7,11	0,17	2,91	4,21	1,32	2,83	4,56	0,12	3,29	0,03	4,00	99,95	413	9	118	3	65	57	25	130	140	153	22	151	137	1422
	BrelCv - 270 cm	47,0	0,59	16,74	7,16	0,17	3,49	7,23	1,15	2,45	4,59	0,13	4,28	0,03	5,30	100,32	364	9	141	2	68	72	19	113	203	142	19	133	109	1394
	BrelCv - 310 cm	47,0	0,50	19,24	7,93	0,13	3,90	6,71	1,37	1,82	5,35	0,11	1,90	0,02	4,15	100,12	254	10	327	<1,5	61	86	13	81	254	179	26	109	54	1454
	G 2/1 - 280 cm	46,5	0,42	20,11	7,21	0,10	7,26	11,05	2,36	0,43	1,74	0,50	0,45	0,01	1,90	100,03	332	15	450	<1,5	49	85	3	14	1051	162	14	51	17	2244
	G 2/2 - 382 cm	3,1	0,04	1,25	0,61	0,01	1,12	51,00	<0,15	0,04	1,87	0,14	39,98	0,14	0,45	99,74	351	3	41	<1,5	24	13	3	4	480	<10	2	16	<1	937
Lois 3	Ap - 30 cm	52,5	0,71	15,22	5,49	0,14	2,38	4,32	1,71	2,22	2,78	0,33	11,97	0,25	0,10	100,11	389	11	118	4	128	49	27	100	131	116	33	97	226	1428
	Bh - 60 cm	56,5	0,76	16,98	5,61	0,12	2,33	3,77	1,63	2,27	2,87	0,17	4,94	0,09	1,90	99,94	393	10	96	3	45	47	23	106	110	108	35	87	289	1353
	B(t) - 90 cm	57,5	0,81	19,04	5,94	0,08	2,13	1,29	1,73	2,42	3,59	0,08	1,65	0,08	3,70	100,05	425	10	101	3	42	44	25	120	93	120	35	89	329	1435
	B(t) - 120 cm	54,0	0,78	17,52	5,38	0,09	2,25	5,04	1,55	2,26	2,71	0,09	4,51	0,05	3,60	99,84	407	10	94	3	40	43	24	119	100	108	38	85	330	1401
	Brel1 - 150 cm	47,5	0,72	14,36	4,33	0,08	2,32	12,58	1,37	2,02	2,26	0,14	9,32	0,06	3,00	100,06	382	8	76	2	37	37	21	104	143	88	35	72	302	1304
	Brel1 - 190 cm	54,5	0,84	15,32	4,15	0,10	2,45	7,72	1,64	2,17	2,27	0,16	5,88	0,06	3,00	100,25	404	10	82	3	33	32	27	107	142	86	37	72	376	1410
	Brel2 - 240 cm	54,5	0,85	19,90	5,98	0,08	2,36	1,98	1,46	2,44	3,62	0,08	1,73	0,06	4,90	99,93	404	9	98	6	46	38	26	136	89	129	30	99	313	1421
	Brel2 - 290 cm	49,0	0,80	20,68	6,69	0,05	2,89	3,46	1,46	2,27	3,94	0,13	3,07	0,03	5,30	99,77	350	7	114	3	50	47	26	126	105	144	24	101	238	1334
	Brel3 - 409 cm	47,0	0,73	19,92	8,92	0,09	3,49	0,40	1,34	2,75	3,39	0,17	8,52	0,01	3,20	99,92	345	10	158	2	79	78	20	142	105	176	51	163	113	1442
	Brel4 - 460 cm	48,0	0,75	13,43	5,01	0,16	2,75	10,95	1,21	1,83	6,64	0,17	0,72	0,03	8,50	100,14	366	11	97	<1,5	50	45	20	93	169	114	27	89	185	1266
Lois 4	Ap - 20 cm	53,0	0,75	15,76	5,37	0,12	2,46	5,62	1,51	2,17	2,74	0,26	9,84	0,12	0,10	99,82	361	10	118	4	140	52	26	100	123	121	32	90	281	1458
	Brel1 - 90 cm	52,5	0,83	21,05	6,55	0,04	2,41	1,88	1,40	2,31	4,03	0,10	1,81	0,01	5,15	100,08	371	9	113	5	46	44	24	134	85	138	23	97	271	1360
	Brel2 - 140 cm	63,5	0,89	11,70	3,63	0,19	1,92	6,15	1,39	1,67	2,41	0,12	4,38	0,04	2,10	100,08	355	12	114	4	38	33	25	75	131	87	28	63	280	1246
Lois 5	Y - +30 - 0 cm	48,0	0,94	12,38	7,73	0,15	3,73	12,38	1,72	1,36	2,01	0,31	8,19	0,16	0,75	99,81	313	13	182	6	74	50	23	56	276	186	26	101	133	1439
	Ap - 15 cm	48,5	0,89	14,50	7,67	0,17	3,60	9,52	1,46	1,68	2,35	0,40	8,91	0,21	0,10	99,95	394	16	131	<1,5	132	60	24	73	228	197	28	111	161	1552
	BrelCv1 - 120 cm	44,5	0,82	16,00	8,76	0,17	3,32	9,99	1,60	1,72	3,50	0,32	5,96	0,09	3,10	99,85	476	17	130	2	77	72	15	88	194	202	28	133	123	1558
	BrelCv2 - 200 cm	52,0	0,85	18,10	9,08	0,17	3,43	3,16	1,78	2,10	4,20	0,19	1,29	0,07	3,80	100,22	473	17	123	5	77	71	17	104	178	202	28	135	142	1571
Lois 6	Y - +250 - 150 cm	30,0	0,91	6,61	9,93	0,13	4,29	27,08	0,70	0,28	1,95	0,22	17,40	0,18	0,30	99,97	387	15	140	3	108	59	25	75	223	172	28	105	172	1511
	YCv - +150 - 0 cm	39,0	0,89	10,13	10,22	0,17	5,15	18,70	1,52	0,33	2,25	0,27	10,40	0,05	0,55	99,63	329	18	152	11	71	57	28	55	273	202	27	108	144	1475
	Cv1 - 40 cm	30,0	1,36	9,73	8,80	0,16	4,19	25,33	0,78	0,69	2,27	0,18	14,40	0,05	1,80	99,73	211	27	34	<1,5	78	35	5	12	327	224	12	66	37	1067
	Cv2 - 80 cm	38,5	0,88	9,68	12,08	0,19	5,67	16,74	0,78	0,46	2,77	0,15	8,33	0,05	3,40	99,69	197	23	58	<1,5	88	48	7	18	508	260	23	76	77	1381
	Cv3 - 130 cm	56,0	0,84	8,32	5,23	0,10	2,77	12,24	1,81	0,98	1,56	0,21	7,17	0,08	2,77	100,08	152	14	29	<1,5	32	19	8	40	389	173	21	62	62	1000
	Cv4 - 230 cm	53,5	1,41	13,76	8,30	0,11	3,32	11,42	2,27	2,39	0,83	0,40	1,57	0,01	0,60	99,89	181	15	35	<1,5	42	31	10	24	200	203	26	99	72	939
	Cv5 - 400 cm	30,0	0,91	6,61	9,93	0,13	4,29	27,08	0,70	0,28	1,95	0,22	17,40	0,18	0,30	99,97	214	12	54	<1,5	47	45	12	39	267	76	22	48	162	997
	G 6/1 - 330 cm	39,0	0,89	10,13	10,22	0,17	5,15	18,70	1,52	0,33	2,25	0,27	10,40	0,05	0,55	99,63	660	11	98	2	48	38	8	80	526	173	20	58	104	1824

[1] According to Austrian Soil Classification System

[2] LOI = Loss on ignition (1000° C)

Geochemistry

In the doctoral thesis of Hödl (1985), seven samples of 'Rehberg'-amphibolite (loc. typ.) were examined by microanalysis. The contents in the rock sample of Lois 1 are in good accordance with the reported contents of major elements, where the trace elements show some deviations. The higher values of Cr, Cu, Ni and Sr of the Lois 1 samples, however, agree with the contents of the amphibolites from the 'Buschandlwandzug', which are also published as well in the dissertation of Hödl (1985) (Tab. 4). The elevated contents of K, P, and Cu in the uppermost (Ap-)horizon of profile Lois 1 are a consequence of the agricultural use (Tab. 4). The Ca-contents reflect the high amounts of calcite. The results of the geochemical analyses emphasize the missing flows between rock and soil, which may be due to the c alc-sinter layer, as discussed in the Mineralogy section.

Profile Lois 2

Soil physical and chemical parameters

The examination of the chemical parameters of profile Lois 2 showed that the pH-value shows no dynamic behaviour (comparable to profile Lois 1) with values between 7.2 and 7.7 (Tab. 1). The content of organic C is very low, with 0.91 % in the uppermost (Ap-)horizon, which then decreases sharply to 0.22 % in the Brel1-horizon and reaches its minimum of 0.12 % in the lowermost (BrelCv)-horizon. In the Brel2-horizon (170–220 cm), the dithionite-extractable Fe-oxides reach their maximum, but still are in a very low range (Tab. 2). The share of amorphous (active) Fe is small, which is due to a low pedogenetical activity, which is similar to profile Lois 1. The particle size analysis reveals distinct relocation dynamics in the sediments. The gravel content is 25 % in the uppermost horizon (Ap), decreases to 4–11 % in the fossil horizons and increases again in the BrelCv-horizons to 14 and 24 %, respectively. The sand fraction shows a similar distribution pattern. Silt is slightly enriched in the Brel1-horizon with a content of 33 %, whereas it is between 19 and 25 % in the other horizons. The clay fraction shows the strongest dynamical behaviour with clear illuvation features in the lower horizons. In the Ap-horizon the clay content is 20 %, increasing to 43–48 % in the Brel1-, Brel2-, and the upper part of the BrelCv-horizon. In the lower part of the BrelCv-horizon the clay content decreases again to 16 % (Tab. 1). The soil texture of profile Lois 2 is loam in the uppermost horizon Ap, and in the lower horizons loamy clay to clay. Detailed investigations of profile Lois 2 can be taken from Haslinger & Heinrich (2008).

Profile Lois 2 shows no dynamic and active pedogenetical processes. However, the intense clay illuviation in the fossil horizons, particularly the Brel2-horizon, is noticeable.

Mineralogy

The rock sample G2/1 (BrelCv, 280 cm) corresponds to the 'Rehberg'-amphibolite with regard to mineralogy. However, the sample G2/1 sample shows a strong alternate layering, which is in contrast to the amphibolites of Lois 1. The layers which merely contain amphiboles are often very coarse, whereas the layers which contain amphibole, feldspar and clinozoisite are very fine-grained. The sample of G2/2 (BrelCv, 380 cm), is very fine grained and predominated by carbonate in primarily dense layers or as framboidal components. Apart from carbonate, quartz, and feldspar; lithic fragments of amphibolite could be found. From the analysis of the thin section it can be concluded that this sample is a calc-sinter. As discussed in the chapter of Profile Lois 1, this calc-sinter could be a product of decalcification of loess or a weathering product of the marble on the western flank (profiles Lois 5 and 6) of the outcrop, or both. The mineral and lithic fragments of plagioclase and amphibole as well as the alternate layering of carbonate and silicate are a sign that detritus from the weathering of the amphibolite was deposited on top of the calc-sinter in colder periods (winter), subsequently followed by a mobilisation of carbonate-rich fluids from the marble in warmer periods (spring), which has lead to a precipitation of the calc-sinter in the profiles on the northern flank (profiles Lois 1 and 2), and to the intense carbonate illuviation in profiles Lois 1–4 and 7.

The thin section photographs of the rock samples of profile Lois 2 can be taken from Haslinger & Heinrich (2008).

The mineralogical composition of the soil horizons of profile Lois 2 shows a predominance of quartz, calcite and sheet silicates (Tab. 3). The quartz content is relatively stable (22–32 %) down to a depth of 270 cm below surface and decreases strongly in the lower part of the BrelCv-horizon (7 %). Calcite can be found primarily in the uppermost 170 cm and shows a strong decrease below the Brel2-horizon (220 cm) to 6–13 %. The sheet silicate content has an inverse distribution pattern. In the upper part of the profile (down to Brel1) the sheet silicates occur in moderate amounts (up to 21 %), whereas they increase significantly below the Brel2-horizon with contents of up to 56 %.

As in profile Lois 1 it could be observed that the influence of the host rock amphibolite is rather low. The calc-sinter apparently seals the contact between rock and solum. This fact is emphasized by the complete absence of chlorite in the lower horizons of Lois 2. If the weathering of the amphibolite played a role for the pedogenesis of the lowermost horizons, the chlorite content would be significantly higher or at least not lower than in the upper parts of the profile.

The clay mineralogical composition is dominated by smectite and illite. They show the same distribution pattern as in profile Lois 1 – from top to bottom the smectite increases and the illite decreases. Smectite occurs mainly in the classical low-charged form, which is demonstrated by the contraction of the 14 Å-peak to approximately 12 Å upon K-saturation (and not to 10 Å which would be typical for vermiculite). Kaolinite and chlorite occur only in minor amounts; vermiculite is missing almost entirely. The slightly increased content of (detrital) chlorite in the Ap-horizon points to an aeolian nature of the chlorite. Additionally, below the second horizon (Brel1, lower part) mixed-layer clay minerals occur at peaks between 30 and 34 Å, which emphasize the stronger weathering intensity in the fossil horizons. The calcite enrichment in the soil profiles down to the Brel1-horizon (170 cm) is due to the presence of the calc-sinter (rock sample G2/2), which is a product of the weathering of the marble on the western flank or from formerly superimposed carbonate-rich sediments (loess), respectively, as discussed above.

Geochemistry

The geochemical analyses of soil profile Lois 2 show similar contents and lack of soil dynamics, as in profile Lois 1. The influence of the agricultural use is only visible in the elevated Cu-values in the Ap-horizon; the K- and P-contents are not higher, unlike in profile Lois 1 (Tab. 4). The most important difference is the occurrence of the sinter-like rock (G 2/2). However, the Sr-contents in the amphibolite (G 2/1) are exceptionally high. Such high Sr-values are not reported in the doctoral thesis of Hödl (1985). An examination with SEM and microanalysis showed that the Sr does not come from the rock, but from the carbonate crust, which covers the amphibolite. Calcite (and especially its rhombic modification aragonite) is a known trap for Sr, where the Ca is substituted by the Sr.

Profile Lois 3

Soil physical and chemical parameters

As in the other two profiles, the pH-values are relatively constant. However, in the lower part of the B(t)-horizon (from 90 cm) the pH-value increases to over 8 (Tab. 1). The C_{org}-content is only slightly elevated in the uppermost (Ap-) horizon and decreases strongly in the Bh-horizon (0.6 %) and even more in the B(t)- and Brel-horizons (0.1 and 0.3 %). The pedogenic oxides are slightly higher than in the other two profiles, primarily in the fossil horizons (Tab. 2).

From the particle size distribution it can be seen that profile Lois 3 is high in clay content. Due to ploughing, the Ap-horizon shows a homogeneous mixture of sand, silt, and clay, with a gravel content of about 10 %. The lower horizons (Bh to Brel3) have a significantly higher clay content (between 41 and 57 %); the silt contents are between 32 and 39 %. Sand occurs only in minor amounts between 10 and 21 %. A sharp change of texture can be observed in the Brel3-horizon. This is due to the higher sand and gravel content (25 and 24 %) and a lower silt and clay content at 15 and 37 %, respectively. In the lowermost horizon (Brel 4), the texture changes again and the clay content reaches its maximum of 81 % (Tab. 1). The soil texture in the uppermost horizon (Ap) is sandy loam and loamy clay to clay in the lower horizons.

Detailed descriptions of profile Lois 3 can be taken from Haslinger & Heinrich (2008).

Mineralogy

The mineralogical composition of the soil samples in the horizons Ap to Brel3 of profile Lois 3 is dominated by quartz (34–51 %) and sheet silicates (21–50 %) (Tab. 3). In the Brel4-horizon the quartz content decreases sharply to 17 %, whereas the content of sheet silicates shows a sharp increase to 80 %, which is in good agreement with the results of the particle size analysis (clay content 81 %). The proportion of calcite is varying in the profile, with higher contents in the Brel1- and Brel3-horizon (17 and 32 %). The contents of feldspar and hornblende are very low.

The clay mineralogical analyses show a predominance of smectite, illite and kaolinite. Vermiculite and chlorite can only be observed in traces. In comparison to profile Lois 2, the kaolinite content is higher, which can be a result of the longer weathering processes the fossil horizons have undergone or from aeolian processes, where it is a product of the weathering of feldspar from the amphibolite or the granites and gneisses of the Bohemian Massif. However, the longer weathering processes are also evident from the broader illite-peaks (10 Å).

Geochemistry

The distribution patterns of both the major and trace elements of the soil samples of profile Lois 3 are relatively constant over the whole profile and show no dynamical behaviour (Tab. 4). As in the other profiles, the Ap-horizon is enriched in P, S and Cu due to fertilization and phytosanitary measures. The only noticeable enrichment is that of Zr, which reflects the stro nger weathering processes the sediments in this profile have undergone.

Parallels between the profiles Lois 3 and Lois 7 will be discussed in the chapter of the soil micromorphological results of the neighbouring profile Lois 7.

Profile Lois 4

Soil physical and chemical parameters

The particle size distribution of profile Lois 4 shows a relatively homogeneous mixture, similar to profile Lois 3. The horizon Brel1 of Lois 4 corresponds to Brel2 of Lois 3; and Brel2 of Lois 4 corresponds to Brel3 of Lois 3, which is emphasized by the similar grain size distributions in these two profiles. However, the gravel content in the Brel2-horizon is lower than in the Brel3-horizon of Lois 3. The gravel enrichment however seems to be only a local phenomenon (Tab. 1). The soil texture of the Ap-horizon is loam and in the lower parts of the profile loamy clay to clay. The Brel1-horizon shows a strong enrichment in Fe-oxides, resulting in an intense red colouration (Tab. 2).

Mineralogy

Profile Lois 4 is dominated by quartz – especially in the Brel2-horizon – and sheet silicates (Tab. 3). The calcite content is surprisingly low given that the entire Brel2-horizon is covered by secondary carbonates. Apparently, the carbonate illuviation is not sufficient to significantly raise the proportion of calcite. In the Brel1-horizon illuviation of secondary carbonates occurs additionally on the surface of the aggregates and in the vertical and horizontal fissures and cracks. However, there is no significant increase in the calcite content. The quartz content is exceptionally high in the lowermost Brel2-horizon (62 %). Elevated quartz contents could also be observed in the profile Lois 3, whereas in this profile the quartz content does not exceed 51 %. The quartz cannot be a product of the underlying host rock alone, since the amphibolites contain only small amounts of quartz. Therefore, the quartz must also have a different source. Either it was blown in by wind from near loess deposits, or it was flushed in with sandy, Neogene material. In the area around Langenlois, deposits of quartz-rich Upper Miocene ('Pannonium') sediments, gravelly-sandy sediments of the so-called 'Hollabrunn-Mistelbach-Formation', and Middle Miocene ('Badenium') interbedded strata of conglomerate-marl-sand of the so-called 'Hollenburg-Karlstetten-Formation' are known (Roetzel 2002). These three sediment types possibly could have formed the basis of the profiles Lois 3 and 4, particularly in the Brel2-horizon.

Geochemistry
The geochemical analyses reflect the mineralogy of Lois 4. Furthermore, the contents of major and trace elements in the horizons Brel1 and Brel2 are in good accordance with their corresponding horizons in Lois 3 (Brel2 and Brel3) (Tab. 4). As in profile Lois 3, this profile shows no sign of dynamic pedogenesis. Comparable to Lois 3 are the elevated Cu-contents in the Ap-horizon and a Zr-enrichment in the entire profile, which is a sign of intense weathering processes.

Profile Lois 5

Soil physical and chemical parameters
The profile Lois 5 is a disturbed profile with backfill material (horizon designation Y) of 30 cm on top, which is a homogeneous mixture of gravel, sand, silt and clay, as in the Ap-horizon below (Tab. 1). The underlying fossil horizons BrelCv1 and BrelCv2 are mixed with the weathered host rock to a large extent, which leads to gravel contents of 43 and 31 % and sand contents of 30 and 29 %, respectively. The silt contents (12 and 18 %) and clay contents (15 and 24 %) are significantly lower. The soil texture of profile Lois 5 is sandy loam to loam. The pedogenic oxides in the Ap-horizon are lower than in the Ap-horizons of the other profiles, which lead to the conclusion that material from the lower horizons was used for the backfilling (Tab. 2).

Mineralogy
The mineralogical composition of profile Lois 5 is dominated by quartz, calcite and sheet silicates (Tab. 3). Plagioclase and hornblende exist in moderate amounts, and K-feldspar only in low amounts. The comparably high contents of hornblende in the backfill material and in the Ap-horizon cannot be a product of weathering processes, but must be derived from wind-blown detrital material.

The clay mineralogical composition of Lois 5 is different from the other profiles with respect to the very high smectite content. The amphibolite in this profile is more fragmented mechanically than the amphibolites in the other profiles and is therefore more chemically and mineralogically altered. As a consequence, more smectite could form in this profile, wheras in the other profiles, the illite still predominates. The mineralogy of the backfill material is comparable to the mineralogy of the lower horizons. Therefore, it can be concluded, that it is material from local sources. The low amounts of mixed-in construction debris seems to have no effect on the mineralogical and geochemical composition of this profile.

Geochemistry
The distribution of the chemical elements in profile Lois 5 is very stable and shows no dynamics (Tab. 4). Even the backfill material geochemically corresponds to the soil horizons below. Apparently, the backfill material has local sources and was only recently applied, since the Cu-content in the Ap-horizon is still high.

Profile Lois 6

Soil physical and chemical parameters
The profile Lois 6 is a partially disturbed profile with 250 cm backfill material on top (horizons Y and YCv). This material is mixed with the weathered host rock as well as construction debris. Its gravel content is 18 and 26 %; and the sand content is 42 and 38 %, respectively (Tab. 1). Silt exists in proportions of 23 and 27 %, whereas clay occurs only in minor amounts (13 and 14 %). The horizons below show no signs of active pedogenesis and consist nearly entirely of weathered host rock (amphibolite and marble). In the Cv-horizons the particle size distribution was between 25 and 55 % for gravel; 33 and 53 % for sand; and minor amounts for silt (9–19 %) and clay (2–7 %). The soil texture of Lois 6 is sandy loam to loam in the upper part (backfill material), and in the lower (Cv-) parts loamy sand to sand. The chemical parameters are stable throughout the soil profile, however, a significant enrichment of Fe-oxides with contents of 6.10 g/kg could be found in the backfill material and the uppermost horizon below (Cv1, 40 cm), which is about twice as much than in the other horizons (Tab. 2).

Mineralogy
Profile Lois 6 developed on two different host rocks and is therefore mineralogically very different compared to the other five profiles. One host rock is the 'Rehberg'-amphibolite, as in profiles Lois 1 and 2; the other host rock is marble, which occurs as light pink-grey-auburn layers in the amphibolite. These marbles are described in Hödl (1985) as minor constituents in the 'Rehberg-Formation' as well as part of the significant amphibolite-marble-body of the 'Buschandlwandzug'. From this profile, only the marble was sampled (rock sample G 6/1). Apart from limestone as main constituent, diopside, biotite and graphite could be identified as accessories in the thin section. Mineralogically, profile Lois 6 is inhomogeneous, which reflects the two very different host rocks (Tab. 3). The thick backfill material layer is dominated by quartz, followed by plagioclase, sheet silicates and hornblende. In the lower part of the backfill layer, the calcite content increases to 17 %. Starting from horizon Cv1, the calcite predominates. The clay mineralogical composition is completely different to the other profiles. The smectite contents reach extreme values of up to 97 % in the Cv4-horizon. Illite can only be found in the backfill material in minor amount; in the lower horizons it is completely absent. The clay mineralogical composition of the lowermost horizon and the backfill material is very similar. Therefore, it can be concluded that material from the bottom of the vineyard was used for the construction of the neighbouring terrace.

Geochemistry
Geochemically, profile Lois 6 is characterized by the two host rocks amphibolite and marble with high SiO_2- and Ca-values (Tab. 4). Additionally, elevated contents of Sr could be found in the marble sample as well as in the horizons Cv1 to Cv3. The upper layer of the backfill material shows the highest contents of Cu, from which it can be concluded that near-surface material was used for the construction of the backfill layers. A plough layer is missing in profile Lois 6, since the host rock reaches up to the surface of the outcrop. Only the construction of the terrace with the backfill material (250 cm) makes an agricultural usage of this profile possible.

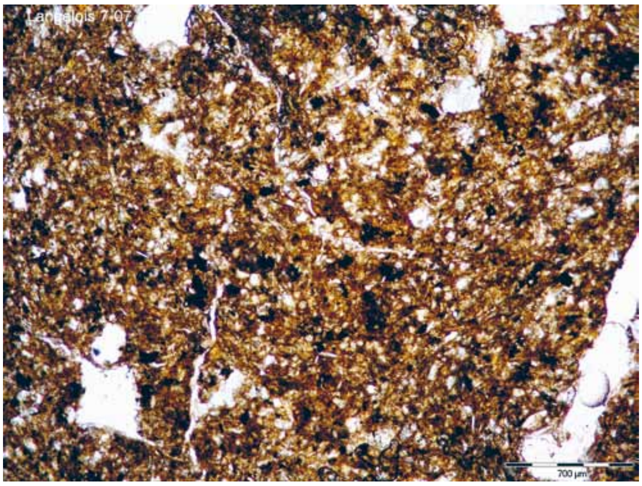
Profile Lois 7

Profile Lois 7 was sampled by Pavel Havlíček, Oldřich Holásek and Michal Vachek. The soil micromorphological descriptions were carried out by Libuše Smolíková according to Kubiena (1956). The horizons of profile Lois 7 continue on the eastern flank in the horizons of profile Lois 3, whereas horizon 'a' of Lois 7 corresponds to horizon 'Ap' in Lois 3; horizon 'b' to horizon 'Bh', horizon 'c' to horizon 'Bt', horizon 'd' to horizon 'Brel1', horizon 'e' to horizon 'Brel2', horizon 'f' to horizon 'Brel3' and horizon 'g' to horizon 'Brel4' (Fig. 3).

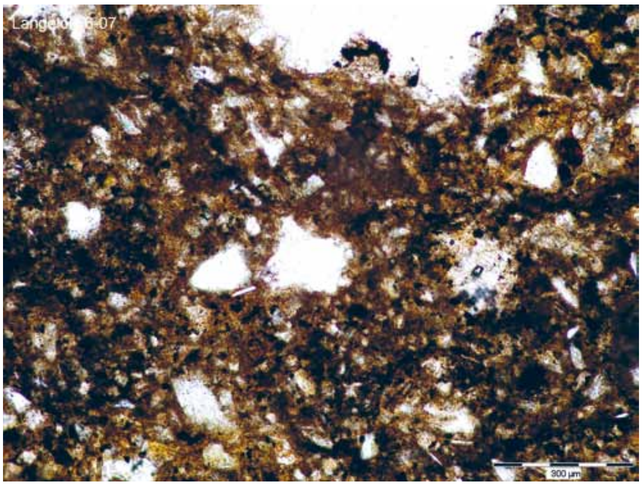
The increased clay content of the Luvisol can be observed in the soil thin sections of the upper two horizons of Lois 7 as well. It leads to the formation of numerous loamy concretions with sharp boundaries as well as an angular blocky structure and abrupt horizon boundaries in the Ap-horizon of Lois 3. Furthermore, stagnic properties could be observed in soil micromorphology which confirms the field observations for the two paleosols Lois 3 and 4. The mineralogical results of the micromorphology correspond very well with the mineralogy of Lois 3 which was measured with XRD. In the horizons 'b' and 'c' (Bh and Bt in Lois 3) garnet and

Fig. 3 a–g: Results of the soil micromorphological analyses of the horizons of profile Lois 7 from the uppermost (a) to the lowermost (g) horizon.

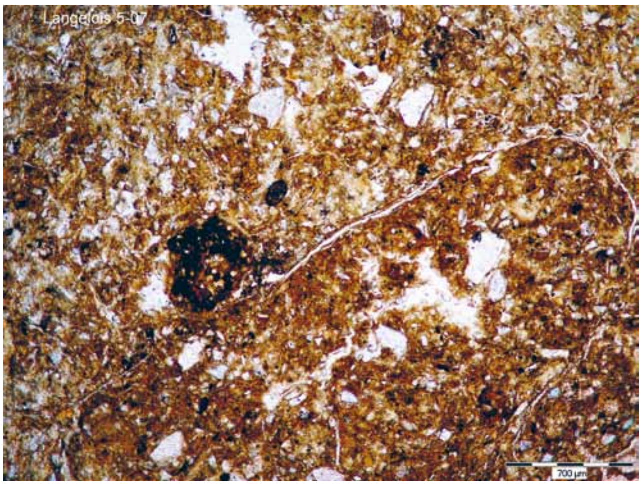
Abb. 3 a–g: Ergebnisse der bodenmikromorphologischen Analyse der Horizonte des Profils Lois 7 vom obersten (a) zum untersten (g) Horizont.



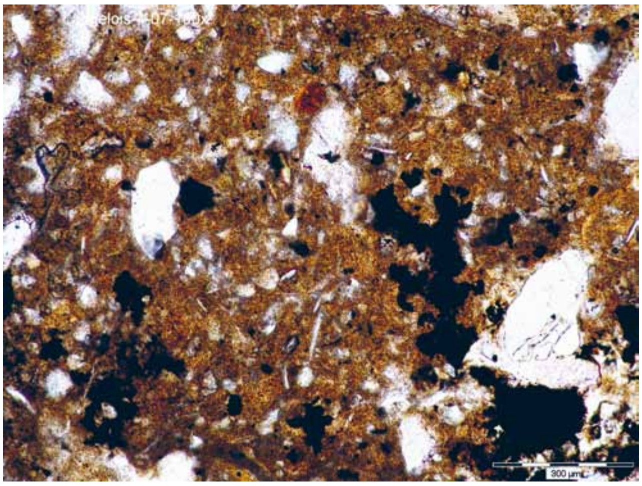
a) *The deep yellowish brown to ochre yellow matrix (dry colour: 2,5 YR 5/6) is peptized. There are many spots, where the brown loam has fluidal structures and is highly birefringent. In the dense matrix only few quartz crystals can be found in the sand fraction. There are extraordinary big brown loam concretions, whereas some of them are broken. Weak stagnic properties in the form of Mn-concretions can be found. The entire matrix is distinctly layered. The horizontal fissures are empty; there are no calcite illuviations. The soil matrix is separated into angular aggregates by these fissures. The brown loam is in parautochthonous position.*



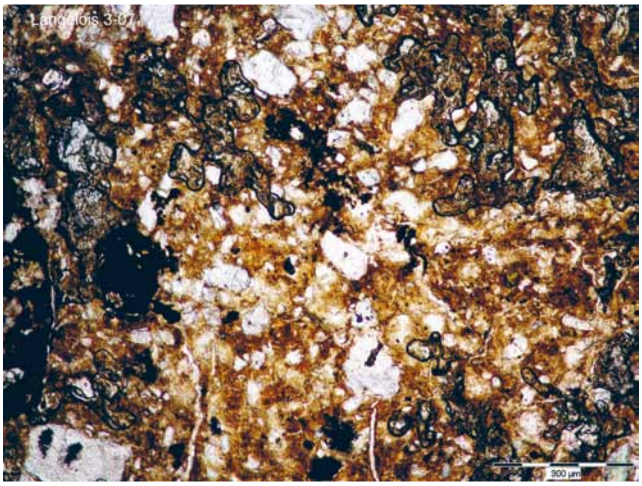
b) *The dark brown, but partially yolk-coloured matrix (dry colour: 5 YR 4/4) matrix consists of brown loam. The matrix is completely peptized, shows typical fluidal structures and a high optical activity. Furthermore, it is separated into distinct polyhedrons. Many cracks and fissures are present, which are broken very smoothly. The soil material is very fine-grained and corresponds to a silt with clayey components. The few sand grains are dominated by quartz, with rare occurrences of garnet, strongly weathered plagioclases and lithic fragments of quartzite. Many concretions of brown loam can be found, which show concentrical development. The pedogenetical signs in this horizon are very weak.*



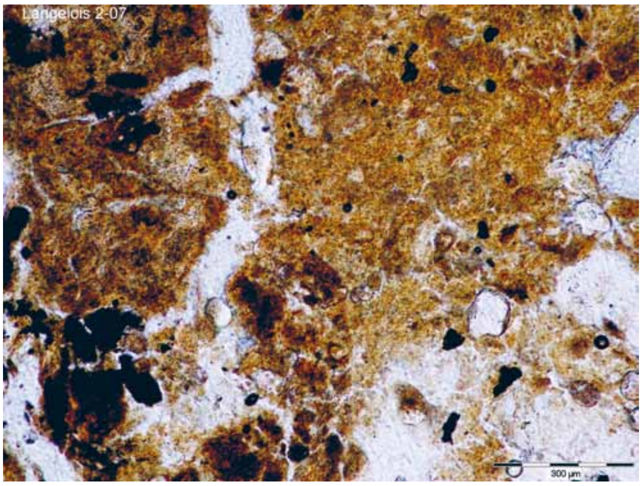
c) *The reddish brown matrix (dry colour: 5 YR 6/4) is peptized with many plasmatic schlieren and fluidal structures. Many large brown loam concretions can be found, whereas Mn-concretions outbalance the Fe-concretions. Some of the concretions have a concentrical structure. The primary components are sandy, their mineralogical composition is diverse: quartz, plagioclase (fresh to weathered), orthoclase, mica, augite, amphibole, olivine, garnet, lithic fragments of quartzite etc. The structure is both primary (dense) and secondary (by pedogenesis) in the form of aggregates. The dense structure shows many cracks and fissures; in the aggregates many fine and medium pores could be found. There are signs of organism activities in the form of spherical aggregates, which have distinct boundaries and which are clearly darker than the surrounding matrix. These aggregates are coprolites of the fossil soil biota. The rare Mn-concretions sometimes have "explosive" boundaries. Few opal phytoliths can be found. The entire matrix is strongly recalcified (amorphous $CaCO_3$-modifications). The material of this horizon is brown loam derived from pedogenesis. After the formation of the brown loam during pedogenesis (climax stadium), this horizon was enriched with allochthonous components and carbonate and developed weak stagnic properties.*



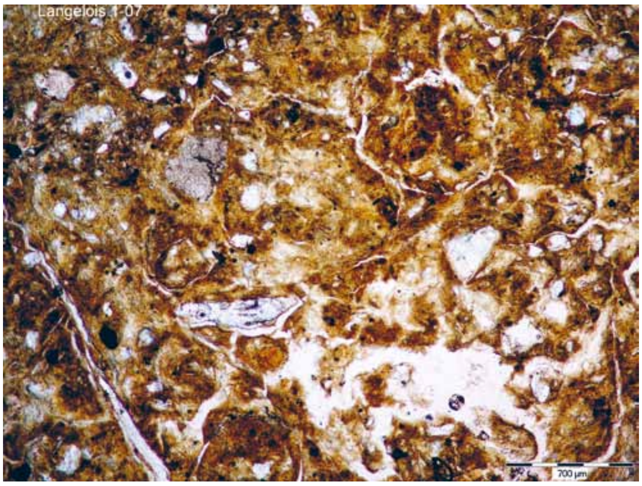
d) *The reddish brown and sometimes red matrix (dry colour: 5 YR 7/6) consists of peptized and sometimes flocculated plasma. However, the colouring of this horizon is not as uniform as in horizon c; additionally, orange and bifrefringent brown loam can be found. This orange loam seams the boundaries of the segregates and granules of the matrix as well as some pores. The structure of the horizon is very dense; most of the voids are cracks and fissures. The primary minerals are granulometrically larger than the minerals in horizon c. The sand fraction is dominated by quartz. Weak stagnis properties with abundant Mn-concretions can be found. Intense carbonate illuviations (amorphous* $CaCO_3$*-modifications) are present in the entire matrix, but also in the form of seams in the pores of the aggregates. This horizon is regarded as red loam, which is strongly polygenetic.*



e) *This horizon shows irregular colouring from brownish red to reddish brown (dry colour: 5 YR 6/8). It consists of peptized and to a minor extent flocculated plasma. Both aggregate and granular structure can be found. Therefore, two different void structures are present. The sediment is silty, whereas sandy crystals of quartz, sometimes garnet, augite and fresh plagioclase occur. In this horizon, neither brown loam concretions nor carbonate illuviations can be observed. This horizon is red loam, which was enriched with allochthonous components at a later stage. This horizon corresponds to the Pedocomplex X (Günz/Mindel, Cromer) or older.*



f) *The brown and primarily flocculated matrix (dry colour: 10 YR 7/4) is concentrated in granules. Furthermore, the matrix contains orange and peptized material as well as loess. Some of these components are seamed with orange brown loam, which is a sign of lessivation. Mn-seams are often developed on the outer boundaries of the orange seams.. The matrix is very dense and shows no typical structure. The substrate is poorly sorted and corresponds to a silt, whereas quartz crystals predominate. This mixed matrix, abundant brown loam concretions as well as Mn-concretions with "explosive" boundaries can be found. This horizon contains intense carbonate illuviations in the wide voids. The Mn-seams contain one generation of large calcite rhombohedrons, which fill all the remaining voids. Furthermore, abundant carbonate-"nests" can be found. In places, small, red coprogeneous elements of recent acarides (Acari) can be observed. The brown loam is friable, sandy and highly polygenetic. The deposition of the sediments was followed by a new sedimentation cycle of loess and lessivation. Weak stagnic properties and abundant carbonate illuvations can be found. Such extraordinarily complex polygenetical soils have only been reported from the Pedocomplex X (Günz/Mindel, Cromer) or older up to now.*



g) *The reddish brown matrix (dry colour: 7,5 YR 5/8) is peptized. The brown loam shows high optical activity and shows fluidal structures. The structure is segregated; the matrix is primarily separated in (sub)angular polyhedrons. Only in places, granules from the lower parts of the profile are incorporated. The primary components are silty and only rarely show larger particle sizes. Quartz is the only autochthonous mineral; sometimes, allochthonous plagioclase and biotite occur. Cracks and fissures are the only voids present; some of them have a horizontal orientation. Abundant brown loam concretions and rare Mn-concretions can be found, whereas the Mn-concretions are often broken. Weak and irregular recalcification features (amorphous* $CaCO_3$*-modifications) can be observed. This horizon is a red loam. Theses soils developed in Central Europe at the border of the Lower to Middle Pleistocene for the last time. In the Cromer-Interglacial (Günz/Mindel, Pedocomplex X), formerly called "red soils", such as Terra Rossa or Ferreto, developed.*

olivine could be identified in the soil thin section. The predominance of quartz in the entire profile and the occurrence of calcite in the form of calcite illuviation are in accordance with the results of Lois 3. In addition to the results of Lois 3, the results of the soil micromorphology showed that calcite does not only occur in the aggregates, but also as cutans in the pores (see Fig. 3, d). The colour descriptions in the soil thin sections of Lois 7 confirm the results of Lois 3 with respect to the increasing reddening from the upper to the lower part of the profile. However, the colour in the soil thin sections was described with a more yellowish hue than in the field analysis of the soil colour.

The red loams in the paleosols allow for an approximate age classification of these soils, since red loams were formed for the last time at the border between Lower and Middle Pleistocene. The investigations furthermore showed that the red loam horizons are strongly polygenetic, which emphasizes their classification into Pedocomplex X, Cromer Interglacial.

4 Summary and discussion

NW of Langenlois (Lower Austria) in an outcrop of loess-paleosol-sequences developed on ‚Rehberg'-amphibolite, six soil profiles (Lois 1 to 6) were investigated and sampled. Two soil profiles (Lois 1 and 2) developed on the 'Rehberg'-amphibolite; two on the amphibolites-marble-body of the 'Buschandlwandzug' (Lois 5 and 6); and two soil profiles are sequences of polycyclic paleosols with several fossil horizons without visible host rock (Lois 3 and 4). Profile Lois 7 was sampled separately and described thoroughly with regard to soil micromorphology. Parallels between Lois 7 and the other soil profiles, particularly with the neighbouring Lois 3, were observed.

The mineralogical composition of the profiles Lois 1 and 2, which developed on amphibolite, is dominated by quartz, calcite, hornblende and sheet silicates; the clay mineralogical composition by smectite and illite with minor amounts of chlorite and kaolinite. The two paleosols Lois 3 and 4 consist nearly entirely of quartz and sheet silicates. The dominance of sheet silicates results in extremely high clay contents in these two profiles. Calcite could only be found in minor amounts in Lois 3 and 4. Together with the high contents of kaolinite in the clay fraction, this emphasizes the long and intense weathering processes these sediments have undergone. The profiles 1–4 and 7 show decalcification in the upper parts of the profiles and illuviation of secondary carbonate in the lower parts. The carbonates precipitate mainly on the edges of the aggregates as well as within the aggregates (Lois 3, 4, and 7) or cover whole horizons and the host rock (Lois 1 and 2) with a thick, purely white crust. The profiles Lois 5 and 6 are characterized by the two very different host rocks amphibolite and marble; subsequently, the mineralogy of these two profiles is dominated by quartz, plagioclase, calcite, and sheet silicates. The clay fractions in both profiles contain partially extreme amounts of smectite (up to 97 %); illite occurs in minor amounts. The high smectite contents cannot be a product of amphibolite weathering alone, since the amphibolite is rather fresh. It is likely that the smectite is derived from pre-weathered material, e.g. Middle Pleistocene ('Badenium') sediments.

Noteworthy in the profiles 1–4 and 7 is the intense illuviation of secondary carbonate. The calcite covers the solum as well as the host rock amphibolite as a thick, purely white crust. The calcite crust is only present at the surface of the amphibolites and easy to remove by hand. In the profiles Lois 3, 4 and 7 the secondary carbonates can be found on the surface of the aggregates as well as in the pores of the aggregates. Such high amounts of carbonate cannot be a product of recent pedogenetical processes. Apparently, the carbonate was infiltrated from carbonate-rich sediments (loess) formerly on top of the profile which are now eroded. Furthermore, a calc-sinter layer was found in profile Lois 2. This calc-sinter could be derived from the marble layers which can be found on the western flank of the outcrop (Lois 5 and 6). The outcrop slightly declines from the western towards the northern and eastern flank. It is possible that calcite-rich solution mobilised during the weathering of the marble ran off laterally and precipitated in the profiles on the northern (Lois 1, 2 and 7) and eastern (Lois 3 and 4) flank. However, it is more likely that both processes – decalcification of formerly superimposed loess and precipitation from calcite-rich weathering solutions from marble – led to the intense calcite illuviation. The calc-sinter layer apparently seals the material flows between rock and solum. This hypothesis is supported by the results from the geochemical analyses.

The geochemical analyses showed that the amphibolites are enriched in Ba, Cr, Cu, Ni and Sr, which corresponds very well with the reported values of the 'Rehberg'-amphibolite (loc. typ.) (Hödl 1985). However, as discussed above, the amphibolites have only limited influence on the soil parameters, mineralogy and geochemistry within profiles Lois 1 and 2. The geochemical distributions in profiles Lois 3 and 4 are very stable. All four soil profiles from Lois 1 to Lois 4 show similar geochemical compositions. Elevated Zr-contents could be found in the two paleosol profiles Lois 3 and 4 which is characteristic for intensively weathered sediments.

The soil profiles Lois 5 and 6 are also geochemically stable and influenced by the host rocks amphibolite and marble. The rocks of Lois 1, 2, 5, and 6 are only slightly weathered; therefore, there was no enrichment of chemical elements in the soil profiles. All soil profiles have elevated contents of Cu in the plough layer (Ap), which is due to phytosanitary measures in viniculture.

The soil profiles in the 'Red Outcrop' of Langenlois are relatively static profiles without significant recent pedogenetical processes. The agricultural use of the soils with accompanying tillage stimulates the pedogenesis to a small degree by mixing and aerating the upper soil layers which favours mainly lessivation, the only pedogenetical process active at present. In the paleosols, older signs of lessivation could be observed in the form of clay cutans on the edges of the aggregates and, additionally, weak stagnic properties. The profiles with no visible host rock (Lois 3, 4 and 7) are sequences of polycyclic sedimentation and subsequently several generations of fossil horizons. According to the soil micromorphological analyses, the soils of the 'Red Outcrop' can be classified into the Lower to Middle Pleistocene.

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