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"EXCURSION GUIDE FOR THE LOESS REGION OF THE EASTERN WEINVIERTEL, STILLFRIED (AUSTRIA)"

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1 INTRODUCTION

1.1 General remarks

Continental Quaternary sedimentary archives comprise valuable information on palaeoclimate and palaeoecology, which are correlative with marine isotopic curves and ice core data. Beside palaeoclimatic data, terrestrial sequences are probably the most important archives able to record palaeo-topography and Quaternary landscape evolution, data which is otherwise not easily extracted from geological record. Palaeo-landscapes, in turn, may serve as reference surfaces for reconstructing, dating and quantifying tectonic processes during the last glacial-interglacial cycles. Loess/palaeosols sequences record complex inter-relationships, and represent an inter-active zone of exchange between topography, parent rock, the geo-ecosystem, and the atmosphere. They represent the former palaeo-land surfaces and allow reconstructions on the base of pedostratigraphy and dating methods. Furthermore, loess/palaeosol sequences can be used to reconstruct different patterns and changes of palaeoclimate, respectively palaeoenvironments, and to recognise geomorphological processes during past glacial/interglacial cycles.
During glacial periods, loess had been accumulated and partly redeposited in periglacial areas. Warmer and more stable interstadial and interglacial phases are recorded by different types of palaeosols.

In general, Austrian loess was mainly investigated by FINK (1954, 1956, 1979), who developed the stratigraphical framework with focus on the loess regions of Lower Austria. KOHL (2000) and WEINBERGER (1955) investigated Quaternary deposits of Upper Austria. More recent works were done by TERHORST et al., (2002), TERHORST (2007) and SCHOLGER et al., (2008) in Upper Austria. The studies consider loess/palaeosol sequences in the N Alpine foreland of Upper Austria.
For the study area of Lower Austria, there are only a few works since FINK (1956). We present one of the key sites of the classical stratigraphy in Upper Austria, with focus on the section of Stillfried A (Eemian - Lower Pleniglacial) and Stillfried B (Upper Middle Pleniglacial - onset of the Upper Pleniglacial).

1.2 General setting of the study area

The area of Stillfried belongs to the Panonnian climate, which is characterised by precipitation rates of about 400-500 mm/a. In comparison to other regions in Austria the precipitation rate is very low.
The average annual temperature is about 10°C. In summer, arid conditions are possible for longer periods (cp. HARLFINGER & KNEES, 1999, HARLFINGER, 2002). The tables (Tab. 1, Tab. 2) show data of Hohenau (25 km N of Stillfried) and give an impression of the annual course. The main wind direction in this area is north-west most of the year, but especially in winter the wind direction often changes to south or south-west (Fig. 1).

Table 1: Temperature - Climate data of Hohenau (Lower Austria) 1971-2000 (www.zamg.ac.at), t [°C]...daily mean of temperature, mtmax [°C]...mean of all daily maxima, mtmin [°C]...mean of all daily minima, tmax [°C]...absolute maximum, tmin [°C]...absolute minimum.

	t	mtmax	mtmin	tmax	Tmin
Jan	-1.4	2.2	-4.5	18.3	-29.3
Feb	0.2	4.8	-3.3	18.1	-24.0
Mar	4.6	10.2	0.4	24.6	-16.3
Apr	9.2	15.4	3.7	27.9	-6.1
May	14.3	20.7	8.0	29.8	-3.2
Jun	17.3	23.5	11.0	35.6	-0.8
Jul	19.3	26.0	12.6	37.0	4.2
Aug	19.0	25.9	12.8	36.9	1.3
Sep	14.4	21.0	9.3	32.7	-1.4
Oct	9.0	14.9	4.8	27.7	-8.9
Nov	3.6	7.5	0.6	20.6	-17.3
Dec	0.3	3.4	-2.4	15.1	-23.5
Year	9.2	14.6	4.4	37.0	-29.3

Table 2: Precipitation - Climate data of Hohenau (Lower Austria) 1971-2000 (www.zamg.ac.at), rsum [l/m²]...sum of precipitation (monthly mean), rmax [l/m²]...highest amount of precipitation within 24 hours, n1 [day] number of days with precipitation ≥ 1 mm, n10 [day] number of days with precipitation ≥ 10 mm.

	rsum	rmax	n1	n10
Jan	27.4	20	6.5	0.3
Feb	25.4	21	6.1	0.5
Mar	27.8	22	6.3	0.4
Apr	37.7	25	6.9	0.9
May	53.2	44	8.2	1.7
Jun	61.8	51	8.7	1.9
Jul	63.7	64	8.6	1.8
Aug	46.4	39	7.0	1.3
Sep	47.0	48	7.1	1.3
Oct	30.4	21	5.5	0.8
Nov	42.8	35	8.1	1.1
Dec	34.2	22	7.8	0.6
Year	497.8	64	86.8	12.6

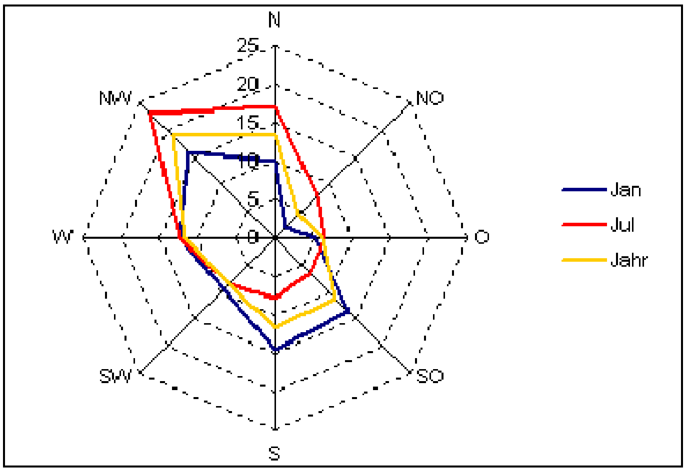

Figure 1: Wind direction (direction and percentage) - Climate data of Hohenau (Lower Austria) 1971-2000 (www.zamg.ac.at).

Figure 2: Map of Austria and the position of Stillfried.

The study area is situated at the fringe of the E "Weinviertel" (Fig. 2), which belongs to the Austrian dry loess zone according to FINK (1956). The "Weinviertel" is a hilly region with characteristic dry valleys of the loess zones. It is part of the intraalpine Vienna Basin, which consists of Tertiary sediments with a thickness of several thousand meters.
The region around the Vienna Basin belongs to the junction of "stable" Europe (the Bohemian Massif), the Alpine-Carpathian thrust wedge and the Pannonian Basin system.
Continuous surface uplift of some 450 m since the Miocene, consequent fluvial incision of the Danube and its tributaries, protracted strike-slip and extensional deformation at the Alpine-Carpathian-Pannonian junction, and sediment accumulation in Quaternary basins subsiding along major fault systems in spite of the general surface uplift, are present.

The geological underground of the study area is mainly constituted by marine sediments and belongs to the last marine transgression of the region. Pannonian sediments reach a thickness of up to 1500m and consist of sands, clays and marls, interrupted by gravel series and lignite. The Upper Pannonium sediments were formed by limnic-fluviatil processes (see Fig. 3 and Fig. 4).

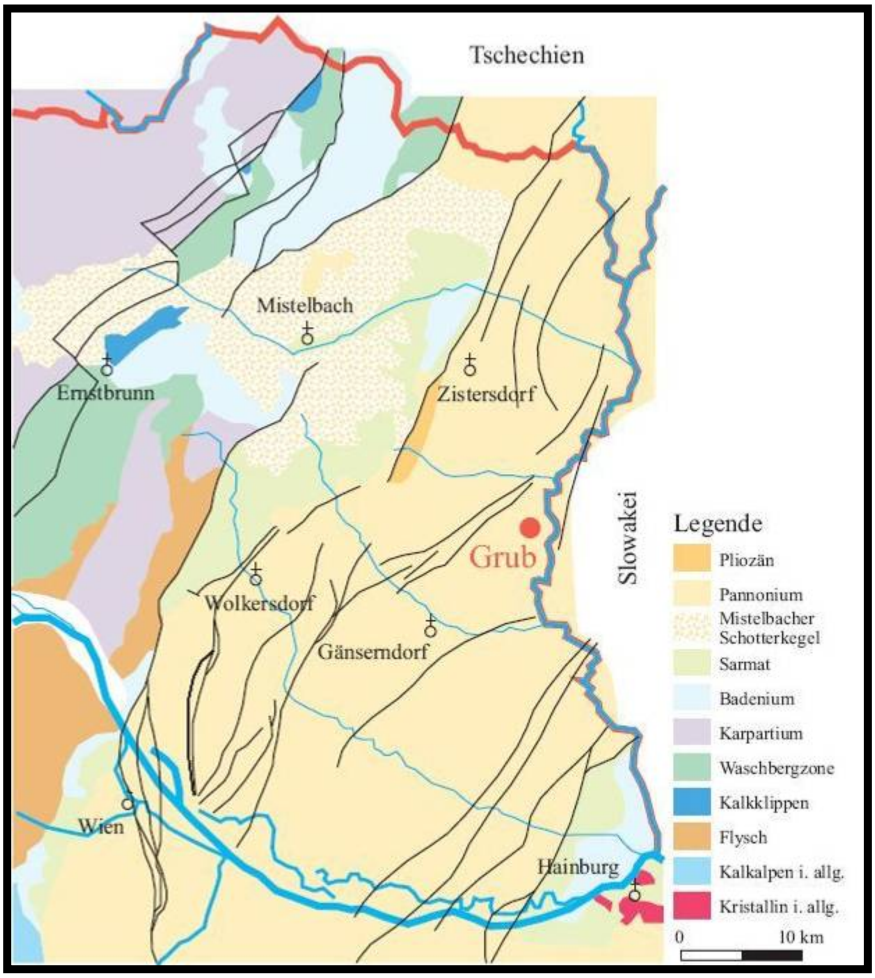

Figure 3: Geological map without consideration of Quaternary sediments (RIEGLER, 2007, on the base of Thenius (1974) and the Geological map of Lower Austria (1:200 000).

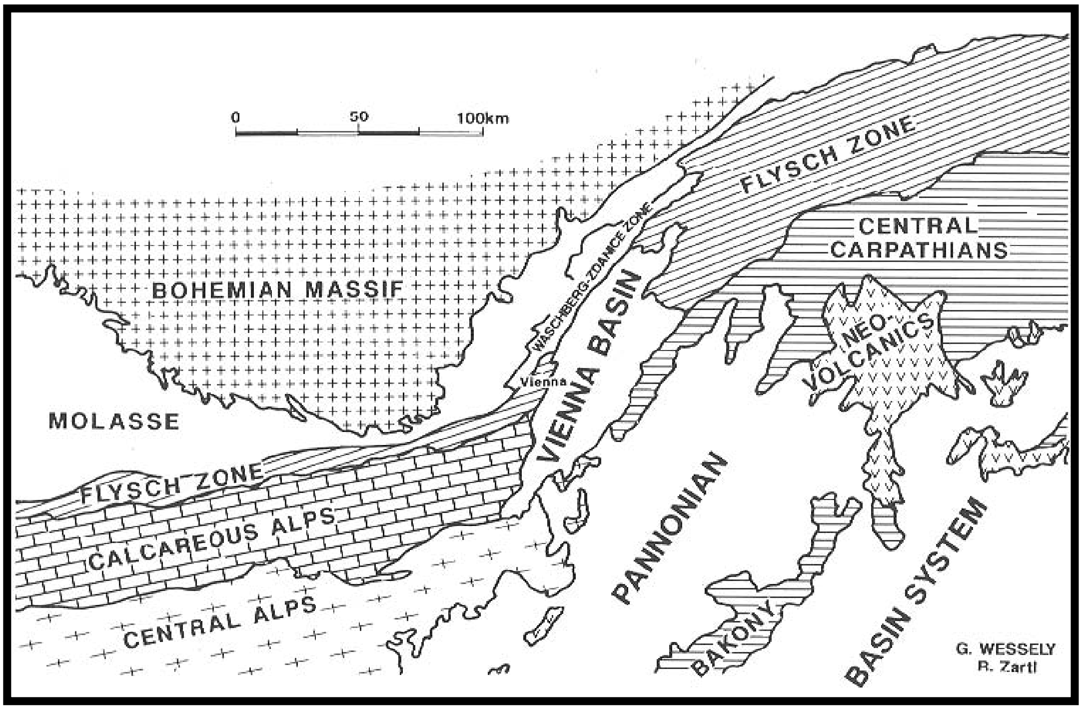

Figure 4: Geological overview of Austria (eastern Parts) and the Vienna Basin (acc. to SAUER ET AL., 1992).

1.2.1 The distribution of loess in Lower Austria

In Lower Austria wide areas are nearly completely covered with loess (Fig. 5). Therefore loess is the most significant landforming factor in this region. Aeolian sediments have been preferentially deposited on E and N facing slopes, however, W facing slopes are covered by loess as well. It is supposed that the aeolian transport is not exclusively due to W winds (SCHLEGEL, 1961), FINK (1979) and SMALLEY & LEACH (1978) state that the provenience was the area of the river March and its eastern tributaries. The loess is thinning out in western direction.

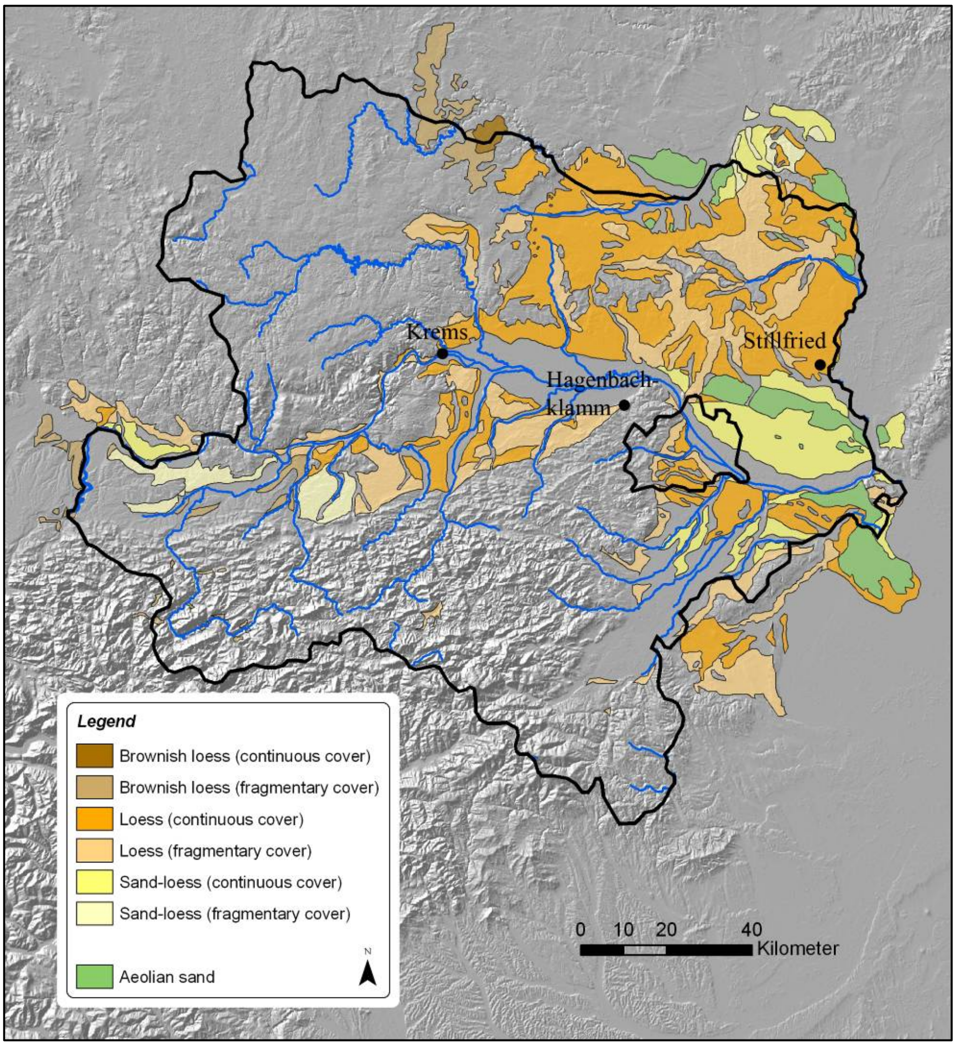

Figure 5: Map of the loess distribution in Lower Austria according to LOISHANDL-WEISZ & PETICZKA (2005).

Although the genesis of this sediment is nearly the same at all locations, we have to differ between the E and W regions due to the climatic conditions in this region, with annual precipitation decreasing from W to E. Moreover, the chemistry of the insufflations areas also changes and therefore we have to distinguish between the subunits shown in Figure 5.

The modern soils situated round the location of "Stillfried" and "Grub an der March" are very homogenous. The most significant and widely spread soil is of the type is a Chernozem. Its typical profile is determined by a depth of 60-120 cm with a thick A horizon, followed by the parent material in form of loess or tertiary sands. Characteristic catenas are presented during the excursion.

1.3 State-of-the-art

On the base of the research done by Julius Fink (FINK, 1954, 1956, 1979) the palaeosols of Stillfried reached a position of international standard in the field of quaternary research. This situation applies especially for the key section of Stillfried B. Today the profile of Stillfried is a synonym for a pedogenesis in the timescale of the Upper Pleistocene, corresponding to a middle Plemiglacial interstadial (c.f. FLADERER, 2001, WALLNER et al., 1990). Furthermore, the palaeosols of Stillfried A are present in form of an exemplary profile. Generally speaking, the stratigraphy of Stillfried A is believed to be of Eemian to Lower Pleniglacial age. International publications (e.g. OCHES & MCCOY, 1995, FRECHEN et al., 2003) investigated the famous position, however, many studies are still using the results of FINK (1956).The more recent studies show single dating results between 87±4.8 ka BP and 79±4.8 ka BP

The problem concerning former studies of Stillfried is on the one hand that they have provided many insights using new techniques and methods (WALLNER et al., 1990), but were always focussed on one detail. A complete new interpretation of the whole section of Stillfried B is not existing. On the other hand a lot of correlations were established relating to Stillfried B as standard profile (WEISSMÜLLER, 1997, ZÖLLER et al., 1994), but still using the old data by Julius Fink. For a critical stratigraphic discussion see PETICZKA & RIEGLER (2006), DÖPPES & RABEDER (1997).

In the framework of a research project funded by the "Wiener Hochschuljubiläumsfond" the profile of Stillfried B was studied by a set of modern methods.

Another emphasis of the project mentioned above is the comparison of different analytical methods for the measurement of the same parameters either in the field or in the laboratory. This could help in future to find significant conclusions by measuring just a few parameters.

2 RESULTS

2.1 Stillfried B

The profile was interpreted by using the Austrian Soil Classification (Österreichische Bodensystematik, NESTROY et al., 2000) including the parameters carbonate concentration, soil colour according to MUNSELL.

For the first sampling procedure undisturbed samples at intervals of 10 cm were taken. Each sample had approx. 300 grams. This should allow to get an overview of the sedimentary situation. In the following statements we refer to that mentioned sampling method.

Furthermore, a block of loess (monolith) with a height of 220 cm including the palaeosols of Stillfried B has been taken. By transporting this monolith into the laboratory the advantages of an in situ sampling can be combined with better analysis conditions in laboratories. Hereby it is possible to use a sample interval of only 1 cm.

The loess/palaeosol sequence of Stillfried belongs to the Upper Pleistocene. The so called "Stillfrieder Komplex" (= Stillfried A) was first mentioned by BOEHMKER (1917) and it shows an interglacial soil corresponding to a Bt Horizon, which is overlain by three humic horizons.

In former studies Stillfried B is corresponding to the Denekamp-Interstadial (FINK, 1979) and furthermore to the palaeosols of Dolní Věstonice (B3) and the Lohner Boden (Lohne soil, (acc. to SEMMEL, 1968) and to the palaeosol MF1 in Central Hungary (PECSI & RICHTER, 1996).
The palaeosols of Stillfried B were found in several sites in the municipality of Stillfried in the course of geological mapping (RÖGL & SUMMESBERGER, 1978). Stillfried B is located in he western part of the abandoned brickyard of Stillfried. The exact position due to a surveying by tachymetry of the reference point (RP) is at 787.766,60 / 363.520,06 m (BMN), the height is 173 m above sea level.
The complete palaeosol is striking from ESE to WNW within an angle of dip of 10° to NNE.
In general, the results of the field research are very similar to those of FINK (1954). The pale browning of the horizon of Stillfried B is decalcified and lies above the calcareous subsoil.
There is a significant trend indicating three palaeosols shown in the curves (Fig. 6). We can recognise two clearly separated horizons. In the area of -60 cm There is a lower concentration of carbonates as well as a change in colour to red (Fig. 7). The second part down to -150 cm corresponds to a soil horizon as well. Again there is a lower concentration of carbonates accompanied by a change of colour to red.
The palaeosols can be traced by all analyses like CEC, AS and TOC (Fig. 8).

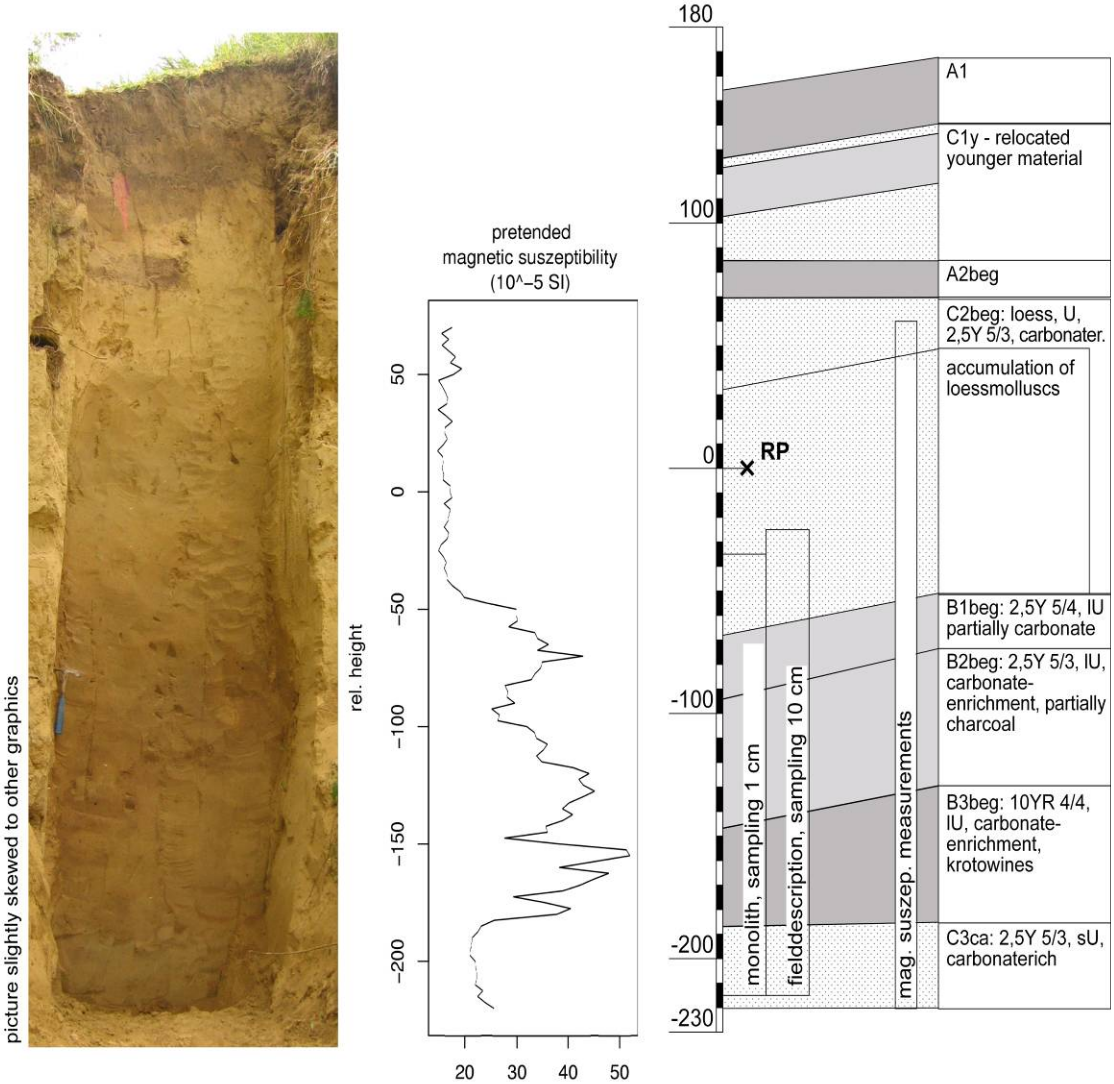

Figure 6: Stillfried B: Photo, magnetic susceptibility, soil description, according to PETICZKA et al., 2007).

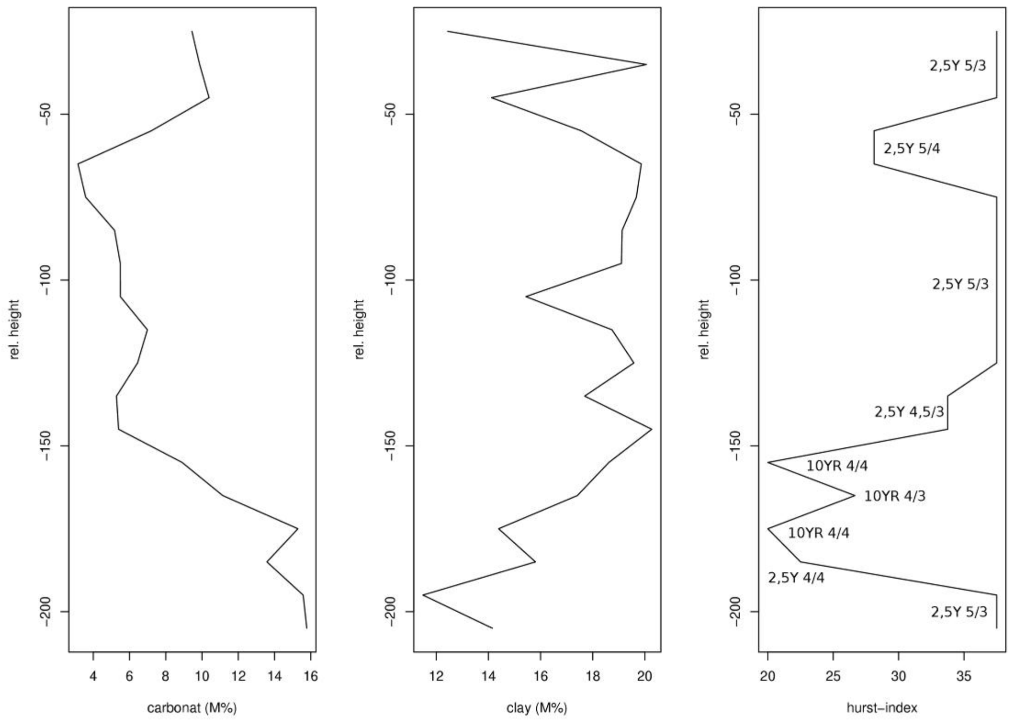

Figure 7: Curves of carbonate, clay content and colour index.

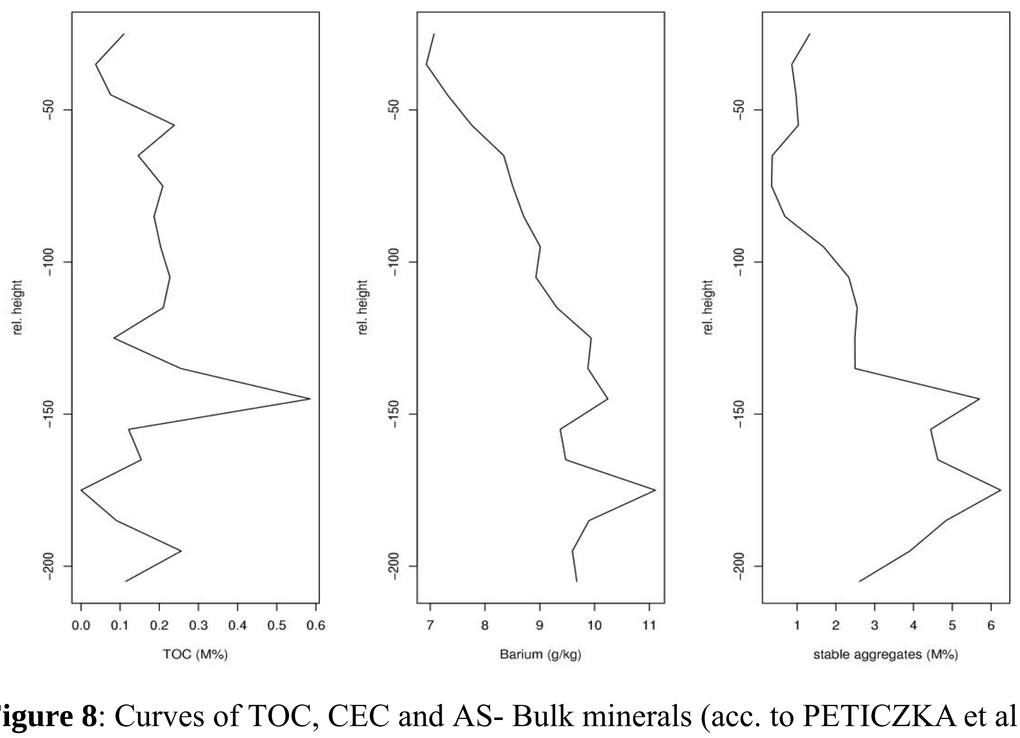

Figure 8: Curves of TOC, CEC and AS- Bulk minerals (acc. to PETICZKA et al., 2007).

The bulk mineralogical assemblage is dominated by medium to high amounts of quartz, and also medium to high amounts of feldspars. Feldspar as well as K-feldspar and plagioclase are present. The plagioclase is a Na rich albite and is more abundant than K-feldspar. A significant trend of enrichment in distinct parts of the profile can not be seen. The sum of layer silicates represents the clay minerals including micas and chlorites. The amount is generally small except in the part between 60 and 100 cm. The peaks of mica and also chlorite are very sharp and therefore indications for a weak weathering intensity. Remarkable is the relatively high amount of chlorite in the whole profile. Both carbonate minerals calcite and dolomite are present in all samples of the profile. A clear trend can be seen: whereas calcite is present in small amounts in the profile, the part between 60 and 100 cm shows a significant decrease. Only traces (1 to 2 %) can be found. Dolomite shows the same trend as calcite, although it is generally less present in the profile. Remarkable is the occurrence of amphibole minerals (in traces) in all samples.

The bulk mineralogical assemblage represents the parent material of the geological provenience of the loess. Quartz and feldspars originate from the granites and gneisses of the Central Alps and the Bohemian Massive, whereas the carbonate minerals come from the Calcareous Alps. The weathering intensity is generally low, because the carbonate minerals are not totally dissolved and chlorite is present in the whole profile.

In spite of this, some significant signals of pedogenesis can be found between 60 - 100 cm, particularly underlined by the enrichment of clay minerals (from small to medium amounts of layer silicates) and the significant decrease of carbonate minerals calcite and dolomite (Tab. 3).

Table 3: Bulk minerals (PETICZKA et al., 2007).
***......................high amounts * small amounts
**........................medium amounts . traces

Depth [cm]	Chlorite	Mica	Amphib.	Σ Layer silicates	Quartz	K-Feldsp	Plagiocl	Calcite	Dolomite
20-30	*	*	.	*	**	*	***	.	*
30-40	*	*	.	*	**	*	**	*	*
40-50	*	*	.	*	**	*	**	*	*
50-60	*	*	.	*	**	*	**	*	*
60-70	*	*	.	**	**	*	**	.	.
70-80	*	*	.	**	**	*	**	.	.
80-90	*	*	.	**	**	*	**	.	.
90/100	*	*	.	**	***	*	**	.	.
100-110	*	*	.	*	**	*	**	*	*
110-120	*	*	.	*	***	*	**	*	.
120-130	*	*	.	*	**	*	**	*	.
130-140	*	*	.	*	**	*	**	*	.
140-150	*	*	.	*	**	*	**	*	.
150-160	*	*	.	*	**	*	**	*	*
160-170	*	*	.	*	***	**	**	*	*
170-180	*	*	.	*	**	*	**	*	*
180-190	*	*	.	*	**	*	**	*	*
190-200	*	*	*	*	**	**	***	*	*
200-210	*	*	.	*	**	*	**	*	*

Clay minerals (acc. to PETICZKA et al., 2007):

Two types of clay minerals are dominant in the clay fraction of the analysed profile. Smectite can be found in amounts of 35 to 40 % and illite with amounts between 30 and 35 %. Chlorite is present in all samples and shows values up to 25 %. Kaolinite could be found with amounts of 5 to 10 %, mostly as poorly crystallized type. Vermiculite is present in some samples but generally in very small amounts. Both types 14 Å - and the 18 Å-vermiculite were proved. Moreover, two types of mixed layer minerals occur in most samples (Tab. 4).
The distribution of the mentioned clay minerals is regularly and homogenous in all samples. No trend is visible.
The relatively low weathering intensity is reflected in the clay mineral assemblage.

The mentioned changes in the bulk mineral assemblage caused by week pedogenesis are not reflected in the qualitative and quantitative clay mineral distribution. The existence of carbonate minerals in the whole profile did not decrease the pH value below 7. The pH value is one of the most sensitive parameters for hydrolysis. The analysed clay minerals are inherited from the parent material, neoformation could not be detected. Unclear is the status of the small amounts of mixed layer minerals in the profile.

Table 4: Clay minerals in the clay fraction (<2µm) (PETICZKA et al., 2007).
***......................high amounts   *   small amounts
**........................medium amounts   .   traces

Depth [cm]	Smectite	Vermic. 18	Vermic. 14	Illite	Kaolinite		Chlorite	Mixed Layer
					well cryst.	poorly cr.		
20-30	**			**		*	**	*
30-40	**	*		**		*	**	
40-50	**			**		*	**	.
50-60	**			**		*	**	.
60-70	*	*		**	.	*	**	.′
70-80	**			**	.	*	**	.
80-90	**			**		*	**	.
90-100	**			**		*	**	*
100-110	**			**		*	**	
110-120	**			**		*	**	.
120-130	**			**		*	**	
130-140	**		.	**		*	**	
140-150	*	*	.	**	*	*	**	
150-160	**			**	*	*	**	.′
160-170	**			**	*	*	**	*′
170-180	**			**	*	*	**	*′
180-190	*	*		**	.	*	**	*′
190-200	**		*	**	*	*	**	.′
200-210	**			**	.	*	**	**′

3 SUMMARY

All in all, we observe a negative correlation of carbonate concentration and clay on the one hand and an increase for the parameters CEC, AS and magnetic susceptibility indicating pedogenetic processes on the other hand. The reason for the second peak in the susceptibility record requires further investigation, because of the abundance of charcoal in this horizon.
On the base of further analyses it was possible to determine a new palaeosol in the depth of -60 to -100 cm. In particular the bulk mineralogy is significant for pedogenetic processes in the studied profile.
Furthermore, there is a slight increase of the carbonate content and a difference in colour.
Regarding the results of the field and laboratory analyses as well as the results achieved by FINK (1956, 1979), we can establish a new picture of the situation at the location of Stillfried B. Stillfried B is now considered as a pedocomplex, consisting of three separated palaeosol horizons. This fact explains unconformities in age determination and divergent pedostratigraphical results of former studies (c.f. discussion in ZÖLLER et al., 1994).

Acknowledgements
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