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Fifty Years of Geological Cooperation between Austria, the Czech Republic and the Slovak Republic

Stratigraphy of Quaternary Fossil Soils along Highway A5 between Wolkersdorf and Schrick (Vienna Basin, Lower Austria)

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Österreichische Karte 1:50.000
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Micromorphology
Palaeopedology
Pleistocene
Quaternary
Fossil soil
Loess

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Stratigraphie quartärer Böden an der A5 Nordautobahn zwischen Wolkersdorf und Schrick (Wiener Becken, Niederösterreich)

Zusammenfassung

Beim Bau der A5 Nordautobahn im nordöstlichen Niederösterreich zwischen Wolkersdorf und Schrick konnten komplex aufgebaute pleistozäne Schichtfolgen dokumentiert werden. Die dort häufig in den Lössen eingeschalteten fossilen Böden wurden durch mikromorphologische Untersuchungen den Bodenkomplexen PK II bis VI aus dem Ober- bis Mittelpleistozän zugeordnet.

Die vollständigste Löss-Abfolge war über miozänen Silten und Tonen (Sarmatium–Pannonium) nordwestlich von Gaweinstal entwickelt. Dort konnten in einer Senke mit bis zu 7 m quartärem Löss sechs mittel- und oberpleistozäne Bodenhorizonte bzw. Bodensedimente der Bodenkomplexe PK V–VI, PK III, PK II–III und PK II nachgewiesen werden.

Abstract

Short time exposures during the construction of highway A5 in northeastern Lower Austria between Wolkersdorf and Schrick were used for documentation of complex Pleistocene loess sections. Abundant intercalated fossil soils were assigned by micromorphological investigations to the soil complexes PK II to VI (Upper to Middle Pleistocene).

The most complete loess section was developed northwest of Gaweinstal above Miocene silts and clays (Sarmatian and Pannonian), where a depression was filled with at least 7 m Quaternary loess interrupted by six Middle and Upper Pleistocene soil horizons and soil sediments of soil complexes PK V–VI, PK III, PK II–III, and PK II.

Introduction

In cooperation with the Geological Survey of Austria, the University of Vienna and the Czech Geological Survey Prague important loess profiles, exposed during the construction of highway A5 north of Vienna, were studied. In 2007 and 2008 Pavel Havlíček investigated nine sections in the surroundings of Schrick, Gaweinstal and Wolkersdorf (Text-Fig. 1, Tab. 1). In these outcrops the exposed loess profiles with many soil complexes were documented in detail and sampled for 22 micromorphological analyses (Tab. 2). Afterwards a detailed palaeopedological elaboration of all sections and micromorphological investigation was done by Libuše Smolíková (cf. Smolíková, 2009).

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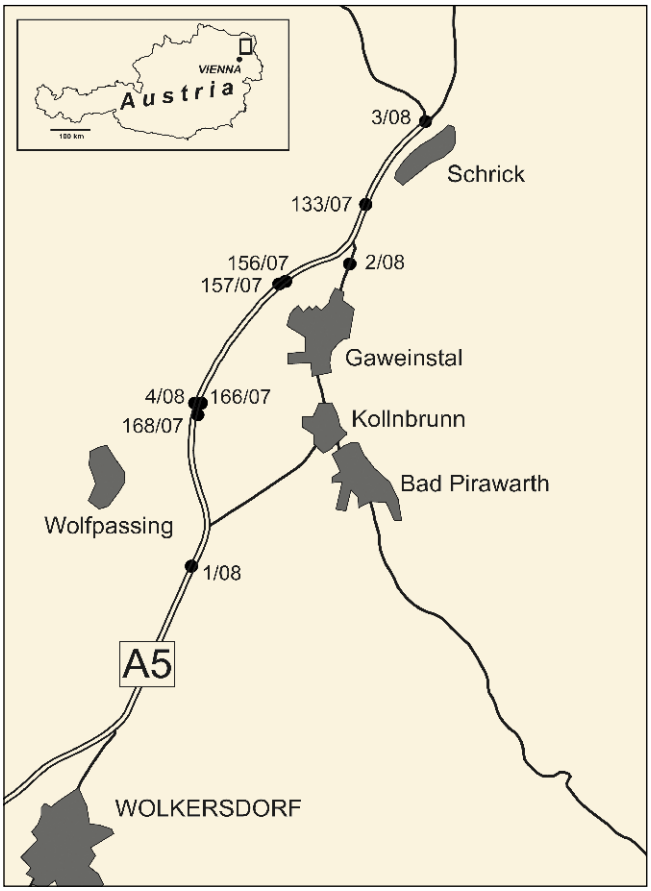
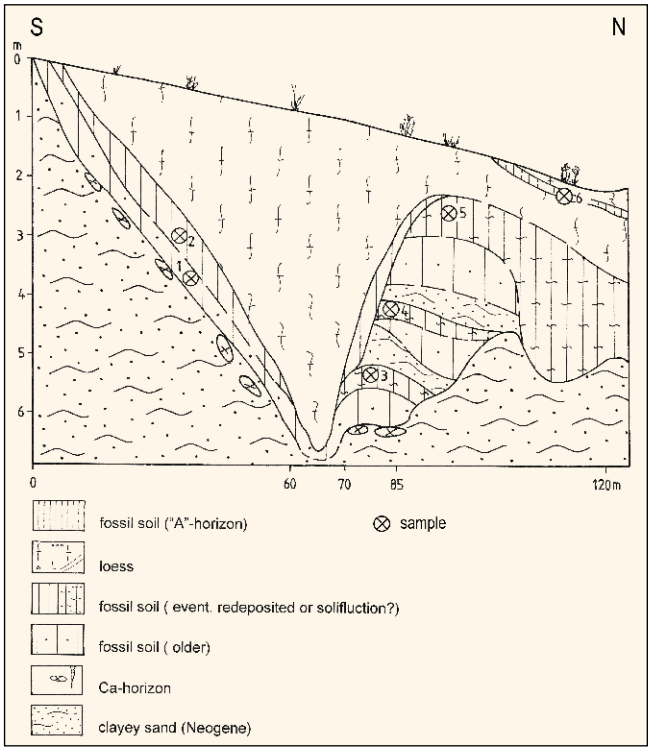


Text-Fig. 1.
General map with the studied sections on highway A5 between Wolkersdorf and Schrick (cf. Tab. 1).



Text-Fig. 2.
Sketch of section 157/07 northwest of Gaweinstal.
157/6/07: youngest Pleistocene chernozem, PK II; 157/2/07: chernozem of Stillfried A, PK II–III; 157/5/07: original basal soil of Stillfried A, PK III; 157/4/07: soil sediments; 157/3/07: mixed soil sediments; 157/1/07: braunlehm-luvizem, corresponding to one of the interglacial intervals of Holstein, PK V–VI.

Geological Setting

The investigated section of highway A5 between Schrick and Wolkersdorf is located in the Vienna Basin. In some parts sediments of the Miocene basement are exposed below the Quaternary cover. Between Wolkersdorf and Gaweinstal mainly sediments of the Sarmatian are cropping out, whereas in the north, southwest of Schrick, the Pannonian deposits prevail (GRILL et al., 1954, 1961; SCHNABEL et al., 2002). The marine Sarmatian sediments mainly consist of sands, sandstones and silty clays, which are in some areas very fossiliferous. In the fluvial to lacustrine Pannonian deposits silts and clays with intercalations of sands and gravel dominate (GRILL, 1968; HARZHAUSER et al., 2004). However, most of the investigated area is covered by loess, where in many locations fossil soils are intercalated (cf. GRILL, 1968).

Lithology of Quaternary Sediments

The loess series exposed by the huge excavations during the construction of highway A5 cover a pre-Quaternary morphology with an erosion surface on the Neogene sediments. They show, in some areas, a thickness up to more

Sample	Locality	Latidude	Longitude
133/07	N Gaweinstal	N 48° 30´ 06.1´´	E 016° 36´ 05.3´´
156/07	NW Gaweinstal	N 48° 29´ 14.3´´	E 016° 34´ 44.5´´
157/07	NW Gaweinstal	N 48° 29´ 12.8´´	E 016° 34´ 38.1´´
166/07	W Kollnbrunn	N 48° 27´ 51.4´´	E 016° 33´ 18.1´´
168/07	W Kollnbrunn	N 48° 27´ 44.6´´	E 016° 33´ 14.3´´
1/08	NE Wolkersdorf	N 48° 26´ 02.03´´	E 016° 33´ 09.1´´
2/08	N Gaweinstal	N 48° 29´ 26.2´´	E 016° 35´ 48.9´´
3/08	N Schrick	N 48° 31´ 05.5´´	E 016° 37´ 05.8´´
4/08	W Kollnbrunn	N 48° 27´ 51.4´´	E 016° 33´ 15.1´´

Table 1.
List of investigated outcrops with WGS84 coordinates.

than 10 m. Beside the typical loess also sandy intercalations occur, showing the character of wind-blown sands in the aeolian series. However, soliflucted sediments occur here as well. The numerous fossil soils frequently grouped into soil-complexes (PK) illustrate hiatuses of varying duration in the loess deposition during the periods of sedimentation stagnancy.

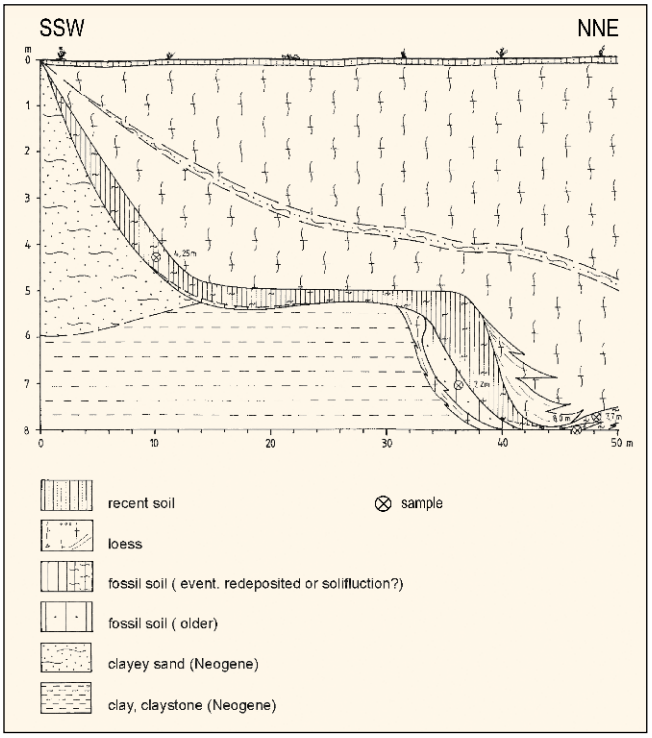
In the sections 4/08 west of Kollnbrunn and 2/08 north of Gaweinstal (cf. Text-Figs. 1, 7) the fossil soils are penetrated by desiccation cracks, filled by younger loess; the surface of the soils is affected by Upper Pleistocene solifluction (palsen, frost turbulences). Within the loess formation up to three soil horizons are intercalated, corresponding to PK II–III. Also krotovinas in the upper chernozem in section 166/07 (cf. Text-Fig. 6), filled by loess are remarkable, exemplifying the soil-life of this soil. In this loess exposure, more than 13 metres thick, three soil horizons are developed, of which the lower two are affected by solifluction.

Section 157/07 northwest of Gaweinstal (Text-Figs. 2, 3) opened a complex loess profile filling up a valley in east-west direction with at least 7 m of Quaternary sediments. Here above Miocene silts and clays three Middle Pleistocene soil horizons could be found. The youngest Upper Pleistocene chernozem horizon of soil complex PK II and PK II–III (Stillfried A, sample 157/2/07 and 157/6/07) is developed within the loess, and above an older fossil soil (157/1/07).

Text-Fig. 3.
Section 157/07 northwest of Gaweinstal.
Northern part of the section with mixed soil sediments (157/3/07) at the base followed by soil sediment (157/4/07) and basal soil of Stillfried A (PK III, 157/5/07) above. The depression on the left is partly filled with young loess.
Photo P. Havlíček.

Stratigraphy	PK	Fossil soils	Localities
Upper Pleistocene	II	carbonate chernozem - the youngest humus soil of Stillfried A	133/3/07 (N Gaweinstal)
		chernozem	157/6/07 (NW Gaweinstal)
		carbonate chernozem; upper soil PK II	166/3/07 (W Kollnbrunn)
		chernozem - lower soil PK II	166/2/07 (W Kollnbrunn)
	II-III	chernozem Stillfried A	2/08 (5.6 m; N Gaweinstal) 157/2/07 (NW Gaweinstal)
		chernozems	4/08 (3.1 m, 4.0 m, 4.7 m, W Kollnbrunn)
	III	A - chernozem horizon - the oldest humus soil of Stillfried A	133/2/07 (N Gaweinstal)
	III	B-horizon of weakly earthificated luvizems; the oldest soil of Stillfried A	133/1/07 (N Gaweinstal)
		luvizem (parabraunerde - illimerized soil); basal interglacial soil (R/W)	166/1/07 (W Kollnbrunn)
		B-horizon of luvizem; basal soil of Stillfried A	168/07 (W Kollnbrunn)
		B-horizon of luvizem; soil is typical for the last Interglacial	1/08 (4.25 m; NE Wolkersdorf)
	III	XXX	
		fossil soil sediment after redeposition of humus horizon; this position probably corresponds to the original basal soil of Stillfried A	157/5/07 (NW Gaweinstal)
Middle Pleistocene	IV	B-horizon of luvizem, upper soil PK IV	1/08 (7.2 m; NE Wolkersdorf)
		A-horizon of luvizem, lower soil PK IV	1/08 (7.7 m; NE Wolkersdorf)
	V-VI	braunlehm-luvizem; this soil corresponds to one of the interglacial intervals (M/R, Holstein)	157/1/07 (NW Gaweinstal) 1/08 (8.0 m; NE Wolkersdorf)
	V-VI	XXX	
		soil sediment from chernozem	156/07 (NW Gaweinstal)
		mixed soil sediment	157/3/07 (NW Gaweinstal)
		soil sediment	157/4/07 (NW Gaweinstal)

Table 2.
Scheme of development and classification in soil complexes (PK) of the studied fossil soils along highway A5 between Wolkersdorf and Schrick.



Text-Fig. 4.
Sketch of section 1/08 northeast of Wolkersdorf.
At the base of the depression a relic of a braunlehm-luvizem PK V or PK VI (8.0 m). Above (7.7 m) a fragment of an A-horizon of a weakly developed luvizem (lower soil of PK IV). At 7.2 m a B-horizon of a weakly developed luvizem (upper soil of PK IV) affected by solifluction. On Neogene sediments at 4.25 m a B-horizon of a finely brown earthificated luvizem (PK III, interglacial climate optimum).

Similarly section 1/08 northeast of Wolkersdorf has a complex structure (Text-Fig. 4, 5). In a huge depression on greenish-grey Miocene clays with abundant calcareous concretions and sands Middle Pleistocene fossil soils of soil complex PK IV–VI (samples 7.2 m, 7.7 m, and 8.0 m) are developed. In the SSW part of the profile relicts of soil complex PK III (sample 4.25 m) were determined in their overburden, which originated after a longer hiatus. After another hiatus of sedimentation and soil creation this depression was filled up with Upper Pleistocene loess with distinguishable deposition of deluvial sands and silts in the centre and wind-borne deposits removed by solifluction, showing the complex development with a number of interruptions in sedimentation even in this youngest loess.

Text-Fig. 5.
Detail of section 1/08 northeast of Wolkersdorf.
At 7.7 m of the section an A-horizon of a weakly developed luvizem affected by solifluction, corresponding to the lower soil of PK IV.
Photo P. Havlíček

In section 133/07 north of Gaweinstal three soil horizons of soil-complex PK II–III were developed in Upper Pleistocene loess, more than 10 m thick. Between the middle and upper soil, loess is removed by solifluction, probably proving a hiatus in sedimentation.

Erosive surfaces of fossil soils in places or possibly lacking soil complexes in superposition as well as occurrence of solifluction and interchanging of loess with mixed deluvial-aeolian and soil sediments from chernozem demonstrate the complex palaeogeographical development of Pleistocene sediments in this part of the Vienna Basin (cf. sections 156/07, 157/07 northwest of Gaweinstal).

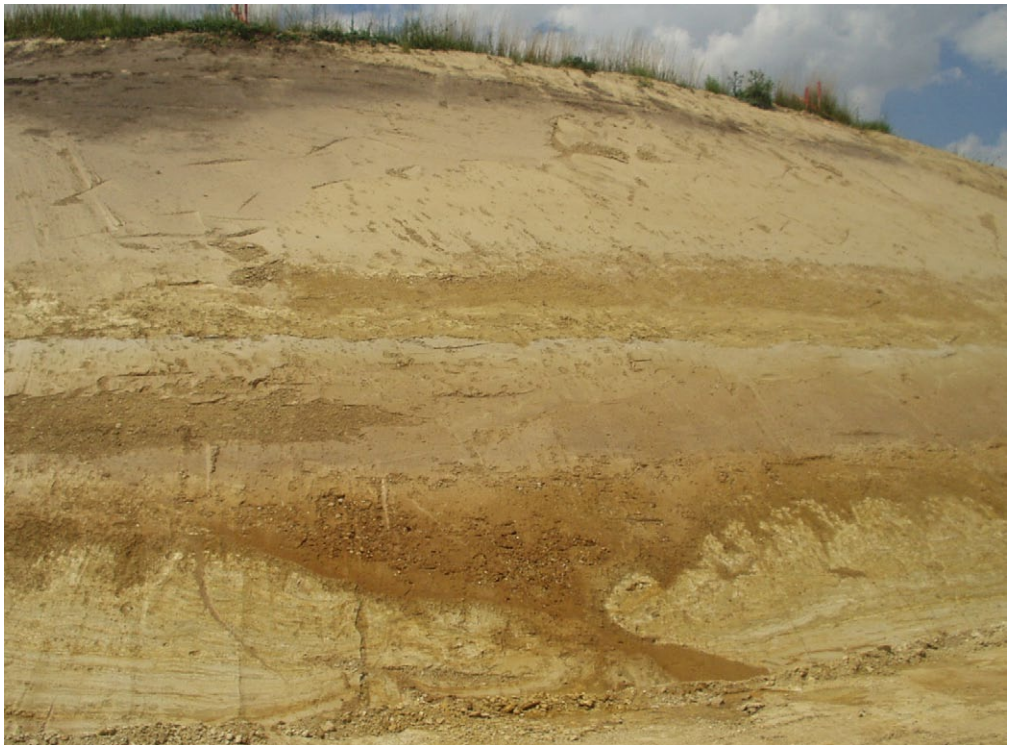
No fossil soil was observed in section 3/08 north of Schrick near the crossing of highway A5 with the Schrick – Mistelbach road. There, an erosional depression in Miocene claystones and silts is filled with loess and sands, 7 m thick.

Micromorphology of Fossil Soils

All principal data on Quaternary geology and soil micromorphology of the investigated sections including the stratigraphical classification are summed up in Table 2. The micromorphological determination of fossil soils is one of the most important methods of research of loess formations. It considerably helps solving stratigraphical and palaeogeographical problems. The studied sections of highway A5 between Wolkersdorf and Schrick provided significant contributions to the explanation of the landscape evolution during the Pleistocene in this part of the Vienna Basin. The sections opened fossil soils and soil sediments of the Upper and Middle Pleistocene, assigned to the soil complexes PK II to VI.

The highway cuttings west of Kollnbrunn (Text-Fig. 6) altogether showed three fossil soils, where the youngest is a typical carbonate chernozem (166/3/07 – upper soil of PK II), whereas the middle soil (166/2/07) corresponds to a mildly para-autochthonous chernozem (lower soil of PK II). The lower soil (166/1/07), partly displaced by solifluction, is an intensively brown earthificated luvizem (para-

Text-Fig. 6.
Section 166/07 west of Kollnbrunn.
Loess formation with three fossil soils. The youngest soil (166/3/07; below the compressor) is a typical carbonate chernozem (upper soil of PK II). In the lower part of the section a mildly para-autochthonous chernozem (166/2/07; lower soil of PK II). At the base an intensive brown earthificated luvizem (parabraunerde – illimerized soil; 166/1/07), displaced by solifluction, which is a basal interglacial soil of R/W (Eem; PK III).
Photo P. Havlíček.



Text-Fig. 7.
Detail of section 2/08 north of Gaweinstal.
Typical chernozem penetrated by frost wedges (depth 5.6 m). This chernozem belongs to one of three humus horizons of Stillfried A (PK II–III).
Photo P. Havlíček.

braunerde – illimerized soil). It is a basal interglacial soil of R/W – Eem (PK III).

In another outcrop west of Kollnbrunn (168/07) a brown soil horizon is developed. It is a B-horizon of granulated to weakly earthificated luvizem (basal soil of Stillfried A).

The micromorphological research at section 4/08 west of Kollnbrunn close to a highway bridge proved that even all three soils at depths of 3.1 m, 4.0 m, and 4.7 m correspond to chernozems of PK II–III, where the best developed soil was the middle one at a depth of 4.0 m. A similar chernozem was developed in an outcrop at an underpass approx. 480 m south of section 4/08 (Peticzka et al., 2009, p. 53ff., cf. Text-Fig. 8).

In section 2/08 north of Gaweinstal (Text-Fig. 7) a typical chernozem was developed originating from a thin loess cover, which means, that gravels at its basement do not correspond to its C-horizon, but to the D-horizon. This chernozem belongs to one of three humus horizons of Stillfried A (PK II–III; sample 5.6 m).

Text-Fig. 8.
Outcrop west of Kollnbrunn at an underpass, approx. 480 m south of section 4/08. Strongly developed chernozem of PK II–III above Neogene sands and silts.
Photo R. Roetzel.

In the same period the loess strata north of Gaweinstal (133/07) with three fossil soils originated. The youngest soil is a deep black humus A-horizon of typical carbonate chernozem; probably it is the youngest humus soil of Stillfried A (PK II, 133/3/07). The middle fossil soil is an A-chernozem horizon with a relatively higher portion of humus soils with braunlehm concretions. Bioturbation came from the genetically underlying but separated B-horizon. It is likely that this partially polygenetic soil corresponds to the oldest humus soil of Stillfried A. The A-horizon of a fossil chernozem is the oldest humus soil of Stillfried A (PK III, 133/2/07). The oldest soil horizon is polygenetic and formed when the relief of partial braunlehm-like plasma (luvizem under forest) arose. In the warm and humid climate the granulation to brown earthification of partial braunlehm-like plasma (drying and partial temperature lowering) occurred. It was followed by a mild pseudogleying (declining interglacial period) and enrichment with carbonates as a consequence of new loess creation (very cold climate). The oldest soil of Stillfried A is a B-horizon with granulated to weakly earthificated luvizems (PK III, 133/1/07).

One of the most important sections is the highway cutting northwest of Gaweinstal (157/07) (Text-Fig. 2, 3). In the upper part probably the youngest Pleistocene chernozem PK II (157/6/07) is preserved within the loess, which eventually is younger than a soil in the southern part of the section (157/2/07) pointing to PK II–III (Stillfried A). Below, on the base of the loess filling in a noticeable depression a complex formation of fossil soils and soil sediments is developed. On the top fossil soil sediments are developed on relocated silts after redeposition of the humus horizon; strong, intensive illimerization and earthification took place and pseudogleying and re-calcification followed. The last Pleistocene illimerization took place in the last interglacial R/W, so that this position probably corresponds to the original basal soil of Stillfried A (PK III, 157/5/07). In the soil horizon below (157/4/07) the soil sediments or sands, in which removed and weakly humus remains of soil prevail, are exemplified. In the horizon 157/3/07 mixed soil sediments, which consist of redeposited soils with a small portion of peptisated plasma and flocculated and weakly humus soil, are preserved. Both described soils are developed on overblown silts. The oldest fossil soil in this profile (157/1/07) is a brown soil horizon. This parautochthonous soil corresponds to a brown soil (braunlehm-luvizem). The development of this soil was affected by extensive disquiet braunlehm-like, slightly brown earthificated parabraunerde? (granulated luvizem), which are typically developed in PK V–VI, where it recurs four times. This soil corresponds to one of the interglacial intervals (Holstein; PK V–VI).

In the section 156/07 northwest of Gaweinstal a soil horizon affected by solifluction is developed on Neogene sands. It is the soil sediment from a chernozem, which consequently underwent pseudogleying and was slightly recalcificated.

The last important section northeast of Wolkersdorf (1/08) is a loess formation with fossil soils filling a depression (Text-Fig. 4, 5). In a depth of 4.25 m a B-horizon of a finely brown earthificated luvizem is developed on Neogene sands and calcareous clays. This soil is typical for the last Interglacial (PK III), where it represents the (interglacial) climate optimum. In the NNE part of the section in a depth of 7.2 m a B-horizon of a weakly developed luvizem affected by solifluction is developed (upper soil of PK IV). In a depth of 7.7 m a fragment of an A-horizon of a weakly developed luvizem corresponding to the lower soil of PK IV was discovered. It is rather more intensively developed than the upper soil, which for that matter is valid for all soil complexes. The oldest remain of a fossil soil is a small relict in 8.0 m, which is a B-horizon of a braunlehm-luvizem (= braunlehm-like parabraunerde) of soil complex PK V or PK VI.

Conclusions

By the investigation of the Pleistocene sections new insights into the formation of loess with fossil soils and soil sediments could be gained in this part of the Vienna Basin. Sections from the Upper and Middle Pleistocene with fossil soils classified into the soil complexes PK II to PK VI were found. They demonstrate the complex development of sediments and fossil soils in the Pleistocene, when periods of sedimentation, erosion and solifluction periodically alternated with calm development of fossil soils (hiatuses).

In the most important section 157/07 northwest of Gaweinstal (Text-Fig. 2, 3) during the development extraordinary intensive dynamics appeared. This outcrop demonstrates how in the course of one certain interval of a Pleistocene climatic cycle on the habitat not only various soil types, but also their occurrence (modes) alternate in the sense of KUBIËNA (1956). It involves a diverse variability of both (soil types and modes – i.e. a form of occurrence; cf. KUBIËNA, 1956). In that section three different soil types occur: braunlehm-like luvizem, typical to weakly developed luvizem and various humus soils, including the chernozems overlying the primary loess. Here a series of various soils and their transition forms occur from the oldest autochthonous fossil soils up to fossil soil sediments, corresponding to modes 6, 9, 12 (e.g. fossil luvizem of mixed soil sediments; sample 157/5/07, modus 9).

By micromorphological analyses of soil sediments it may be possible to determine original autochthonous soil types and to use them for palaeoclimatic and palaeogeographic reconstruction, not only for this habitat but also for the surrounding territory.

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References

GRILL, R. (Ed.), BRAUMÜLLER, E., FRIEDL, K., GÖTZINGER, G., JANOSCHEK, R. & KÜPPER, H. (1954): Geologische Spezialkarte der Republik Österreich 1:75.000 – Gänserndorf mit dem österreichischen Anteil des Blattes Marchegg. – Geol. B.-A., Wien.

GRILL, R. (Ed.), BACHMAYER, F., FRIEDL, K., JANOSCHEK, R. & KAPOUNEK, J. (1961): Geologische Karte des nordöstlichen Weinviertels 1:75.000. – Geol. B.-A., Wien.

GRILL, R. (1968): Erläuterungen zur Geologischen Karte des nordöstlichen Weinviertels und zu Blatt Gänserndorf. – 155 S., Geol. B.-A., Wien.

HARZHAUSER, M., DAXNER-HÖCK, G. & PILLER, W.E. (2004): An integrated stratigraphy of the Pannonian (Late Miocene) in the Vienna Basin. – Austrian Journ. Earth Sciences, **95/96**, 6–19, Wien.

KUBIËNA, W.L. (1956): Zur Methodik der Paläopedologie. – Actes du VI Congrès International du Quaternaire (Rom – Pisa), 296–395, Rom.

PETICZKA, R., RIEGLER, D., HOLAWE, F. (Eds.), JABUROVA, I., NEUGEBAUER-MARESCH, CH., OTTNER, F., TERHORST, B. & SCHLAIPFER, M. (2009): 28. Jahrestagung des Arbeitskreises Paläopedologie der Deutschen Bodenkundlichen Gesellschaft 21. bis 23. Mai 2009 in Wien: Exkursionsführer. – 68 p., Wien.

SCHNABEL, W. (Ed.), KRENMAYER, H.G., MANDL, G.W., NOWOTNY, A., ROETZEL, R. & SCHARBERT, S. (2002): Geologische Karte von Niederösterreich 1:200.000 mit Kurzerläuterung. – Geol. B.-A., Wien.

SMOLÍKOVÁ, L. (2009): Bericht 2008 über paläopedologische Aufnahmen im Quartär auf den Blättern 21 Horn und 39 Tulln und von Aufschlüssen der Nordautobahn A 5 auf den Blättern 25 Poysdorf und 41 Deutsch-Wagram. – Manuscript library: Geol. B.-A. / Wiss. Archiv ALK 039, 025, 041 SMO/08, 2 S., Praha.

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