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

Quaternary Sediments at the Southeastern Margin of the Bohemian Massif in the Borderland of Austria and the Czech Republic (Lower Austria – South Moravia)

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7 Text-Figures, 1 Table

Österreichische Karte 1:50.000
Blatt 8 Geras
Blatt 9 Retz
Blatt 22 Hollabrunn
Blatt 23 Hadres

Quaternary sediments
Micromorphology
Paleogeography
South Moravia
Lower Austria
Stratigraphy
Weinviertel
Fossil soils

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Quartäre Sedimente am Südostrand der Böhmischen Masse im Grenzgebiet von Österreich und der Tschechischen Republik (Niederösterreich – Südmähren)

Zusammenfassung

Am Südostrand der Böhmischen Masse wurden im Grenzgebiet von Österreich und der Tschechischen Republik in Niederösterreich und Südmähren quartäre Sedimente untersucht. Neben der geologischen Detailkartierung der quartären Schichtfolgen erfolgte die mikromorphologische Untersuchung der in den Löss-Komplexen eingeschalteten fossilen Böden. Damit konnten die Paläoböden in diesem Raum typologisch bewertet und stratigraphisch eingestuft werden.

Die meisten Löss-Komplexe mit ihren fossilen Böden blieben im Bereich des Kartenblattes Hadres im Pulkautal und südlich von Hollabrunn und auf tschechischem Gebiet auf dem Kartenblatt Retz vor allem im Nationalpark Podyjí entlang des Thayatales erhalten.

Die untersuchten Aufschlüsse beinhalten Paläoböden der Bodenkomplexe PK II bis PK X aus dem gesamten Pleistozän. Neben unterpleistozänen Böden des Ferreto-Typs, die sich auf sandigen Kiesen der Hollabrunn-Mistelbach-Formation bildeten, kommen hier vor allem Böden des Ober- und Mittelpleistozäns im Löss vor. Letztere können den Bodenkomplexen PK II und PK III bzw. PK IV bis VI zugeordnet werden. Die ältesten Böden der Bodenkomplexe PK VII und PK X, die sich zuletzt im Cromer-Interglazial (Mittel/Unterpleistozän) bildeten, wurden in Österreich nördlich des Pulkautales und bei Lukov in Tschechien gefunden. Die meisten Böden befinden sich in autochthoner Position, ein geringerer Teil auch in parautochthoner Lage. In manchen Bereichen wurden jedoch nur Bodensedimente gefunden.

Abstract

Quaternary sediments were studied in the Austrian-Czech borderland at the southeastern margin of the Bohemian Massif in Lower Austria and South Moravia. Besides detailed geological mapping of the Quaternary strata intercalated fossil soils in loess complexes were studied by means of soil micromorphology, leading to a typological evaluation and stratigraphical integration of the paleosoils in this area.

Most of the loess complexes with fossil soils were preserved on sheet Hadres in the valley of the river Pulkau and south of Hollabrunn and in the Czech territory of sheet Retz along the Dyje valley, mainly in the National Park Podyjí.

The investigated outcrops show paleosoils from the whole Pleistocene from soil-complexes PK II to PK X. Beside Lower Pleistocene soils of ferreto type on sandy gravel of the Hollabrunn-Mistelbach Formation, especially Upper and Middle Pleistocene soils occur here, mainly on loess. The latter soils are determined to the soil-complexes PK II and PK III, resp. PK IV to VI. North of the river Pulkau and in the Czech Republic near Lukov the oldest soils of PK VII and PK X could be verified, which were formed for the last time in the Cromer Interglacial (Middle/Lower Pleistocene).

Most soils were preserved in autochthonous position, a smaller part also in para-autochthonous position. In some places only soil sediments were found.

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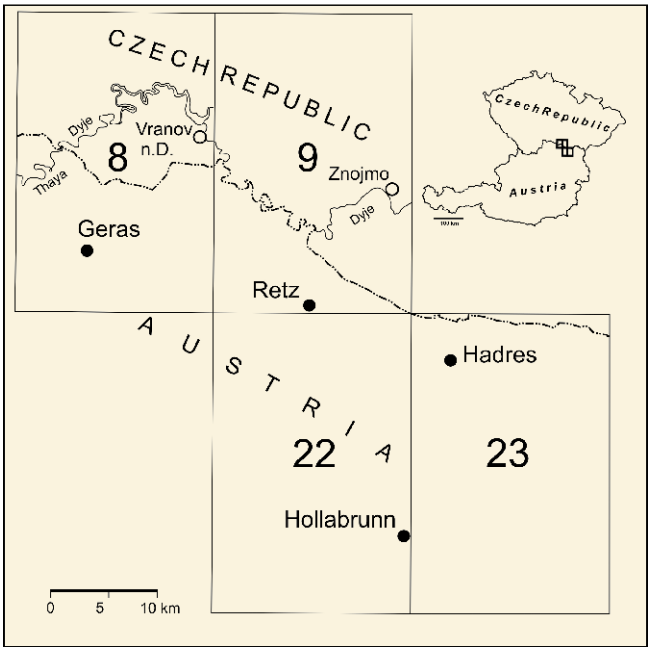
Introduction

In the past in Austria only little attention was paid to Quaternary sediments at the southeastern margin of the Bohemian Massif in the vicinity to the Czech Republic because in this area the occurrence of fossil soils is not as rich as in other regions, like Krems, Horn, and Hollabrunn. This lack in Quaternary research changed radically since 1982, when the Geological Survey of Austria started mapping and geological investigations in this area with significant cooperation of geologists from the Czech Geological Survey (Text-Fig. 1) (P. Batík †, I. Cicha, P. Čtyroký †, J. Čtyroká, T. Hájek, P. Havlíček, O. Holásek, O. Krejčí, Z. Novák, P. Pálenský, J. Rudolský †, M. Růžička, Z. Stráník, L. Švábenická, M. Vůjta). The results were published in numerous mapping reports and other publications (Batík et al., 1993, 1994; Cicha & Rudolský, 1996, 1997, 1998, 2000a, b; Čtyroká & Čtyroký, 1991; Čtyroká et al., 2002; Čtyroký, 1995, 1996, 1997, 1998; Havlíček, 1995, 1996, 1997, 1998, 2000a, b, 2002, 2003; Holásek, 1996, 1997, 1998, 2000a, b; Novák, 1997, 2000a, b; Novák & Stráník, 1998; Pálenský, 1996, 1997, 1998; Roetzel, 1983, 1988, 1989, 1990, 1991, 1992, 1993, 2003a, 2007; Stráník, 1996, 1997, 2000), as well as in the geological map sheets 8 Geras, 9 Retz, 22 Hollabrunn, 23 Hadres, and in the map of the National Park Thayatal-Podyjí (Roetzel et al., 1998, 1999, 2001, 2004, 2007; cf. Batík, 1992; Čtyroký, 1983, 1987) and their explanatory notes (Roetzel et al., 2005, 2008, 2009).

Additionally to the mapping on the scale of 1:10.000 P. Havlíček and O. Holásek carried out detailed documentation and sampling of exceptional Quaternary geological profiles. L. Smolíková dealt with micromorphological research of fossil soils and J. Kovanda did malacofauna analysis (cf. Havlíček et al., 1998a, b, 2003, 2006; Smolíková, 1994, 1998a, b).

During the Pleistocene the formation of sediments on the southeastern margin of the Bohemian Massif was very complex. In the region of Geras – Vranov nad Dyjí – Retz – Znojmo – Hadres and southwest to southeast of Hollabrunn partly thick loess complexes with fossil soils and their derivates correspond to repeatedly recurring erosion and accumulation phases with alternating periods of sedimentation and stagnancy of erosion. At the end of the Pliocene and at the beginning of the Pleistocene the Bohemian Massif was uplifted and the foreland of the Alps declined. River courses at the border of the Bohemian Massif were cutting deeply into the Miocene sediments and crystalline rocks. In the foredeep along the Dyje (Thaya) and Pulkau rivers fluvial terraces support a slower deepening originating in different accumulation levels (Roetzel et al., 2005, 2009). In the Quaternary rocks weathering, denudation and redeposition was strong, which particularly was the determining factor in the creation of deluvial, deluvial-aeolian and deluvial-fluvial sediments.

The aim of the presented work is predominantly the typological evaluation and stratigraphical integration of fossil soils found during the geological mapping on sheets 8 Geras, 9 Retz and 23 Hadres by means of soil micromorphology. The paleopedological research was primarily aimed at the Pleistocene soils developed in loess complexes, to a lesser degree also at the terrace gravel.



Text-Fig. 1.
General map of the investigated area.

Geological Setting

On the southeastern margin of the Bohemian Massif Quaternary sediments with loess and partly intercalated paleosoils are widespread. They can be found in the vicinity of Lančov, Vratěnín, Mašovice, Weitersfeld, east of Retz, north and south of Hadres, south and east of Hollabrunn, and in the vicinity of Herzogbirbaum. Numerous fossil soils of different age within loess accumulations are of great stratigraphical and palaeogeographical importance.

Erosion relicts of fluvial Pleistocene sediments are not so common but still of considerable importance. These relicts of terraces can be mainly found in valleys of bigger watercourses, e.g. the rivers Pulkau, Dyje (Thaya), and Göllersbach. On sheet Hadres the fluvial gravel predominantly occurs on the gentle northern and northwestern slopes below an elongated range of hills formed by sands and gravel of the Upper Miocene Hollabrunn-Mistelbach Formation. The Pleistocene gravel mainly was reworked from these older Neogene sediments. Their relicts are lying in different levels most frequently extended in the flow directions of the rivers Pulkau and Göllersbach. They were formed during the deepening of the drainage area in the Pleistocene. In the investigated area the occurrences of Pleistocene fluvial sediments are divided into four stratigraphic levels from the Lower to Upper Pleistocene according to different altitudes (Roetzel et al., 2009).

Other Quaternary sediments like deluvial, deluvial-aeolian and deluvial-fluvial sediments are of lesser extent and of lesser importance.

In most parts of the Alpine-Carpathian Foredeep in the investigated area the Quaternary sediments cover Neogene (Miocene) deposits whereas in the Bohemian Massif mainly crystalline rocks form the pre-Quaternary basement. However, in the northwestern crystalline region in shallow basins also marine to brackish sediments are the bases for Quaternary deposits (cf. Roetzel et al., 2005, 2008, 2009).

In the Lower Miocene (Upper Eggenburgian – Ottnangian) mainly nearshore sediments of the Retz Formation occur. These fine to coarse sands with intercalations of fossil-rich calcareous sandstones are overlain by fine-grained, clayey basin sediments of the Zellerndorf Formation. Towards the south and southwest in the Pulkau area the Retz Formation passes into calcareous sandstones of the Zogelsdorf Formation.

In the West, in isolated basins on the elevated plain of the Bohemian Massif, brackish-marine, very fine grained, carbonate-free and smectitic clays of the Weitersfeld Formation represent the equivalent to the marine sediments of the Ottnangian Zellerndorf Formation (ROETZEL et al., 2005, 2008).

Still further to the West, in the area of Langau, but also northward around Niederfladnitz and Znojmo, shallow marine to brackish sandy to gravely, kaolin-rich silts and clays of the Langau Formation were deposited in shallow, isolated depressions and flooded valleys. North of Langau and around Šafov and Nový Petřín the sediments show the influence of fresh water, where in the Ottnangian brown coal was formed in an estuary with half-bogs and swamps. These coal bearing sediments are overlain by shallow marine, micaceous fine sands and silts of the Riegersburg Formation, which mark the highstand of the sealevel in the Ottnangian (ROETZEL et al., 2005, 2008).

In the area of Niederfladnitz, Weitersfeld and Theras poorly sorted, reddish brown to yellowish brown, silty-sandy quartz-gravel of the Theras Formation overlie the older, marine sediments above an erosional contact plane. These sediments may indicate the retreat of the sea in the Upper Ottnangian but since no fossils have been found in these coarse sediments so far, their age cannot be determined for certain (ROETZEL et al., 2005, 2008).

During the Karpatian and Early Badenian shallow seas covered the edge of the Bohemian Massif and even temporarily intruded far inland towards the west.

Deposits of the Laa Formation (Karpatian) constitute mostly carbonaceous clays, silts and micaceous fine sands, often alternating with quartz-rich sandy gravel. In the foredeep they are widespread north and south of the Pulkau valley between Watzelsdorf and Laa an der Thaya and continue towards the north far into the Czech Republic (ROETZEL, 2003b; ROETZEL et al., 2009).

Overlying the Laa Formation, sediments of the Grund Formation (Lower Badenian) similarly consist of carbonaceous silts and clays with mica-rich intercalations of fossil-bearing fine- and medium-grained sands (ĆORIĆ et al., 2004). The sediments mainly can be found northwest to northeast of Hollabrunn but they also crop out northeast of Retz between Unterretzbach and Chvalovice. West of Mailberg in the Grund Formation intercalations of biogenic red algae limestones of the Mailberg Formation occur (cf. MANDIC, 2004; ROETZEL et al., 2009).

Early Sarmatian sediments from a short-lived transgression of the sea into an incised valley can be found in the surroundings of Hollabrunn along the Göllersbach valley. These deposits of the Ziersdorf Formation are mainly fine sands, silts and clays with coarse grained intercalations of sands and gravel (MANDIC et al., 2008; ROETZEL et al., 2009).

After the final retreat of the sea from the foredeep a river system was established in the Upper Miocene, draining the foredeep towards the east (NEHYBA & ROETZEL, 2004). This Paleo-Danube accumulated in the Pannonian gravel and sands of the Hollabrunn-Mistelbach Formation, which today can be found in an elongated range of hills between Krems, Hohenwarth, Ziersdorf, Hollabrunn, and Mistelbach.

The crystalline basement on the sheets Geras and Retz is formed by numerous metamorphic and plutonic rocks which belong to the Moravian tectonic unit and the westerly Moldanubian unit. These rocks are opened in a unique cross section in the deeply incised valley of the river Dyje (Thaya) in the National Park Thayatal-Podyjí (ROETZEL et al., 2005).

The lowest structural unit within the Moravian unit west of the Waitzendorf fault is the plutonic complex of the Thaya Batholith. Above these cadomic granitoids metamorphic sediments of the Therasburg Group and the overlying Pernegg Group are following. In the Czech Republic these two units are described as the lower and upper parts of the Lukov Group. In the central part of the Moravian unit, the "Weitersfelder Stängelgneis", which is granitic gneiss associated with metamorphosed sediments, lies between the Therasburg and the Pernegg Groups, resp. within the Lukov Group. Both groups mainly contain micaschists and paragneisses, but the Pernegg Group differs from the lower Therasburg Group by a general lack of quartzite and the abundant occurrence of marble and calc-silicate-gneiss. The structurally highest unit above the Pernegg Group is the Bittesch unit with the Bittesch gneiss as the most typical rock type. The lower part of the Bittesch unit contains layers of calc-silicate-gneiss, marble, but also micaschists, aplites and pegmatites.

Further to the west the Moldanubian Drosendorf unit (equivalent to the Vranov Group of the Moravian unit in the Czech Republic) mainly comprises biotite-paragneiss closely associated with biotite-muscovite-schist. Quartzite, graphitic quartzite, amphibolite, marble, calc-silicate-gneiss as well as graphitic schist and graphitic gneiss exist as intercalations. The Moldanubian Gföhl unit (equivalent to the Šafov Group of the Moravian unit in the Czech Republic) overlies the Drosendorf unit and consists mostly of rather uniform biotite-muscovite-schist and fine-grained biotite- or biotite-muscovite paragneiss. These include thin intercalations of graphitic quartzite, ultramafic rocks and marble.

Development of Quaternary Sediments

During the Pliocene, about 5–2.5 million years ago, the course of the river Danube changed southwards to the area of the current stream, probably triggered by tectonically induced river capturing. Due to the associated large-scale erosion at that time, only a small amount of sediments was preserved from this period.

The main development of today's morphology of the territory took place in the Pliocene, however, considerable changes occurred in the Pleistocene (roughly 2.5 million to 11.700 years ago), when colder and warmer climatic periods oscillated inducing periods of sedimentation and erosion. Gradual incision of water courses into Neogene sediments and crystalline basement rocks resulted in a

deepening of the river Dyje (Thaya) in the National Park Thayatal-Podyjí by more than 120–135 m. Along the river Dyje gravelly relicts were preserved in different levels illustrating the gradual deepening of the water course. Today the oldest sandy gravel can be found approximately 110–135 m above the present fluvial plane of the Dyje-river. They probably are remains of a Pliocene river course, which passed through at this level in the initial phase of the river incision. As a consequence of alternating erosion and accumulation phases during the Pleistocene in the Dyje valley levels with fluvial gravel were formed, now preserved in 75–90 m (Lower Pleistocene), 12–50 m (Middle Pleistocene), and 1–5 m (Upper Pleistocene) above today's river. In tributaries like in the Fugnitz valley similar accumulations originated, which probably are also of Upper Pleistocene age, showing a base level of 8–10 m. In the east during the Pleistocene a gradual redeposition of sandy gravel of the Hollabrunn-Mistelbach Formation took place. Their relicts occur today in different levels at the northwestern rim of this formation, north- and westward towards the valleys of the Pulkau and Göllersbach. They irregularly cover gentle slopes, mostly following directions of local brooks and to a limited extent forming local terraces. They were preserved in 25–50 m (Lower Pleistocene), 5–25 m (Middle Pleistocene) and 1–5 m (Upper Pleistocene) above today's watercourses.

Loess originated both on the plateau in the vicinity of the river Dyje and in valleys of watercourses (Dyje, Pulkau, etc.). Predominantly on eastern and southeastern gentle slopes drifts created and loess was preserved to a lesser extent as banks or flat covers. The sources of material for loess development were Neogene sediments and deposits transported by meltwaters on flat territories. As a consequence of increased precipitation mainly in higher positions a secondary decalcification took place and thus loess-loam originated. In the warmer and more humid interglacial and interstadial periods of the Pleistocene, soils were formed in periods of stagnancy of sedimentation, again interrupted by a new deposition of younger loess. The micromorphological investigation of fossil soils proved the development of soils in the studied area during the whole Pleistocene (soil complexes PK II – PK X).

On the foot of slopes and in shallow depressions and hollows deluvial-aeolian deposits locally originated as a consequence of loess repeatedly being blown onto slopes, where deluvial sediments were formed. Silts and clays which are shifted by solifluction and gravitational movement irregularly interchange with aeolian silt to silty-sandy intercalations.

In the Pleistocene at the beginning of warmer periods the creation of deluvial sediments started as well. Most frequently their development carried on after melting of the surface of permafrost beds, when sediments and weathering products were oversaturated by water and flowed down the slopes. The lithological composition depends on the character of weathering, residues of sediments and crystalline rocks in the nearby vicinity and basement.

At the beginning of the Holocene (about 11.700 years ago) considerable climate warming and humidification took place. In that time nearly in all valleys, erosion furrows and hollows enormous quantities of fluvial and deluvial-fluvial deposits developed. The lithology of fluvial sediments depends on the geological composition and the character of weathering of rocks in the whole catchment area. Therefore accumulations in floodplains are relatively variable in lithology. Deluvial-fluvial sediments fill up bottoms of occasionally flown-through shallow depressions, broader gorges and hollows. Water courses of tributaries either are continuously connected or form visible outwash cones. Their lithological composition too is closely linked to the character of weathered rocks and sediments in the nearby vicinity.

Distribution of Aeolian Sediments and Fossil Soils

Just as in South Moravia loess also was deposited in vast and very massive blankets along the southeastern margin of the Bohemian Massif in Lower Austria. Their sedimentation, interrupted by periodic hiatuses, took place on leeward sides of slopes during the whole Pleistocene. Thus massive loess series with complicated structure and polygenetic, mostly interglacial soils arose.

On the geological maps on scale 1 : 50.000 (ROETZEL et al., 1998, 1999, 2001, 2004, 2007) it clearly can be seen how their extent and thickness is changing in dependence of altitude, basement geology and morphology. The morphology of the southeastern margin of the Bohemian Massif in the surroundings between Geras and Retz is very rugged. In this territory between the villages Dallein, Fronsburg, Merkersdorf and Niederfladnitz the distribution of loess and loess-loam is limited to the lower lying areas between 520–400 m above sea level, mostly at the southeast to eastward slopes. Due to this very pronounced morphology occurrences of aeolian sediments are very frequent but discontinued here. Their thickness mostly ranges up to 4 m, around Zissersdorf maximally up to 7 m. Loess covers not only gentle eastern to southeastern slopes, but in some places also flat areas. They frequently are connected to deluvial sediments, additionally containing weathered rock debris. In the vicinity of outcrops of weathered crystalline rocks it is difficult to distinguish weathered residua from deluvial-aeolian or deluvial sediments (cf. ROETZEL et al., 2008).

On sheet Retz the Quaternary sediments continue on the Czech side, forming extensive loess covers with fossil soils northwest of Znojmo and also around this town (Znojmo-Dřevařské závody, Sedlešovice, etc.). Southeast of the crystalline escarpments of the Waitzendorf fault and the Diendorf fault on the sheets Retz and Hollabrunn distribution and thickness of Quaternary sediments is increasing strongly. On mildly sloping or flat territories in substantially lower altitude, loess forms extensive complexes of strata above the Neogene sediments up to 10–17 m thick (cf. ROETZEL et al., 1998; HAVLÍČEK et al., 1998b).

In the western part of sheet Hadres extensive loess blankets rapidly fade away towards the east and occur less in disjointed areas. In the northeastern part of this territory loess is even missing. The biggest loess blankets in the area of sheet Hadres form drifts and banks south of the Hollabrunn-Mistelbach Formation, mostly in the territory between Großstelzendorf – Bergau – Porrau and Großmugl – Herzogbirbaum – Nursch. In smaller areas loess is situated in the vicinity of Weyerburg and Enzersdorf im Thale. In the northwestern part of this territory aeolian sediments

are preserved, for example, in the vicinity of Wullersdorf and Immendorf. North of Großkadolz they merge into relatively massive drifts of deluvial-aeolian sediments. The thickness of loess ranges mostly up to 4 m; in some places between Großstelzendorf and Obergrub up to 8 m. In Göllersdorf (brickyard Wienerberger) loess and deluvial-aeolian sediments, 6 to 8 m thick, are exposed (cf. ROETZEL et al., 2007, 2009). Loess, about 20 m thick, was quite sporadically found south of the hunting lodge Gflez northwest of Bergau (cf. ROETZEL et al., 2007, 2009).

The stratigraphically most important loess series from the Lower to Middle Pleistocene with the best developed interglacial fossil soils were predominantly preserved along the Pulkau valley, as proved in the vicinity of Alberndorf, Untermarkersdorf, Hadres, Großkadolz, and Mailberg. South of the rim of the Hollabrunn-Mistelbach Formation fossil soils mainly were discovered in the vicinity of Großstelzendorf, to a lesser extent also around Bergau and Porrau (cf. ROETZEL et al., 2007, 2009).

Text-Fig. 2.
Track-cut in the NP Podyjí between Podmolí and Lukov. Rotlehm (soil-complex PK X; Middle / Lower Pleistocene) developed on weathered mica schist.
Photo: O. Holásek & P. Havlíček.

Description of Fossil Soils

In the Austrian part of sheet Hadres fossil soils mostly can be found northwest and northeast of Hadres, around Alberndorf and Seefeld, northwest of Mailberg, and in the southwestern part of the territory near Großstelzendorf, Obergrub and Porrau. In the Czech Republic important outcrops with fossil soils are concentrated in the area of the National Park Podyjí.

In a track-cut between Podmolí and Lukov a typical reddish rotlehm is developed on weathered Proterozoic mica schist of the Lukov Group. This is one of the oldest paleosoils in this area, which might have formed at the latest in the Cromer Interglacial (Middle/Lower Pleistocene) (HAVLÍČEK & SMOLÍKOVÁ, 2003a) (Text-Fig. 2).

In the Austrian part the oldest fossil soils are brown earthificated braunlehms and braunlehm-like pseudogley, rotlehm and rubefied braunlehms of the soil-complex PK VII and PK X, which occur northwest of Großkadolz and north-northwest of Hadres (Text-Fig. 3) (HAVLÍČEK et al., 1998a; SMOLÍKOVÁ, 1998a). Fossil soils of soil-complex PK VII or maybe an older one also occur close to the chapel in Porrau and near the Hubertuskapelle north of Obergrub.

Text-Fig. 3.
Outcrop in a vineyard NNW of Hadres with soil-complex PK X; Middle/Lower Pleistocene. Spade for scale.
Photo: O. Holásek & P. Havlíček.

On the northern edge of the National Park Podyjí east of Mašovice loess with five fossil soils concentrated into three soil-complexes from the Middle Pleistocene were exposed in excavations of Neolithic trenches. The basal soil corresponds to a braunlehm (minimum soil-complex PK VII). A spotted fossil soil in its overburden belongs to soil-complex PK VII or PK VI–V (?) and an overlying chernozem resembles some of the Holstein Interglacial soils (PK VI-V). At last a pair of youngest luvizems belongs to soil-complex PK IV (HAVLÍČEK & SMOLÍKOVÁ, 2003b) (Text-Fig. 4).

In the Trausnitz valley between Konice and Popice (HAVLÍČEK & SMOLÍKOVÁ, 2002), close to the confluence to the river Dyje, a loess drift with two fossil soils of braunlehm-type (minimum soil-complex PK VII) is exposed on the eastern slope (Text-Fig. 5).

In the brickyard Wienerberger in Göllersdorf at the bottom a brown earthificated luvizem (soil-complex PK VI) is preserved in the profile. After a long hiatus it is overburden by a PK II chernozem.

Text-Fig. 4.
Outcrop in the NP Podyjí east of Mašovice. Three soil-complexes with five fossil soils (PK IV–VII) in loess, exposed in an excavated Neolithic trench. Hammer in centre of photo for scale.
Photo: O. Holásek & P. Havlíček.

Text-Fig. 5.
Outcrop in the Trausnitz valley in the NP Podyjí. Two fossil soils of braunlehm-type (minimum soil-complex PK VII) in loess.
Photo: Th. Hofmann.

Text-Fig. 6.
Outcrop in the vineyards SSW of Alberndorf in the Pulkau valley. A soil of soil-complex PK VI above Miocene sediments. Spade for scale.
Photo: O. Holásek & P. Havlíček.

Text-Fig. 7.
Outcrop in the western cellar lane in Mailberg with two fossil soils (PK II and III) in loess.
Photo: O. Holásek & P. Havlíček.

Further, two fossil soils of PK V and one of soil-complex PK VI (Holstein) – a braunlehm-like parabraunerde – are preserved south and north of Alberndorf (Text-Fig. 6) (Havlíček et al., 1998a).

In the National Park Podyjí Cílek et al. (1996) described a group of strata of deluvial sediments and loess with two fossil soils (soil-complex PK II or PK IV) 10 m above the alluvial plain of the river Dyje. In Vranov nad Dyjí near the pseudocarst cave "Ledové slůje", the same authors recorded 2.2 m thick loess and loam with a soil horizon of Bt1 parabraunerde. Finally on the southeastern slope of Gališ in the cut of a path a B horizon with a substantial carbonate horizon transmitted by solifluction can be seen which, most probably, is an interglacial soil.

In Vranov nad Dyjí close to a petrol station a series of deluvial and aeolian sediments with a fossil soil was exposed in the overburden of a fluvial terrace 15–20 m above the river. It is the Bt horizon of a luvizem (probably soil-complex PK III, the last interglacial). A similar interglacial fossil soil of soil-complex PK III, including two interstadial chernozems of Upper Pleistocene age is developed in the loess profile below the dam in Vranov nad Dyjí (Havlíček & Smolíková, 2003a; Roetzel et al., 2005, 2008).

Brown basal soils (parabraunerde) of soil-complex PK III – Stillfried A were found west and northwest of Mailberg, near Porrau and Großstelzendorf. Chernozems were preserved in places in their overburden in parautochthonous position (Text-Fig. 7) (Havlíček et al., 1998a).

Northwest of Alberndorf two chernozems (PK II – Stillfried A) rest in superposition above PK III.

Conclusions

In the studied territory the occurrence of fossil soils is not as rich as in the Danube region. However, systematic geological mapping led to the discovery of numerous localities with paleosoils from the whole Pleistocene (soil-complexes PK II – PK X).

Besides Lower Pleistocene soils of the ferreto type on sandy gravel of the Hollabrunn-Mistelbach Formation, especially Middle and Upper Pleistocene soils occur here (cf. Tab. 1). A lower rate of polygenesis in the soils in most cases signifies younger age. Intensity and a number of individual polygenetic processes quite depend on the course of Pleistocene climatic, sedimentary and pedogenetic cycles.

Most of the Middle to Upper Pleistocene loess complexes with fossil soils were preserved on sheet Hadres in the valley of the river Pulkau and south of Hollabrunn and in the Czech territory of sheet Retz along the Dyje valley, mainly in the National Park Podyjí. In these regions not only fossil soils from soil-complexes PK II and PK III, but also PK IV–VI occur. North of the river Pulkau and in the Czech Republic near Lukov the oldest soils of PK VII and PK X could be verified, which were formed for the last time in the Cromer Interglacial.

Most soils were preserved in autochthonous position, some also in parautochthonous position. In some places only soil sediments were found.

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Stratigraphy	PK	Fossil soils	Localities
Upper Pleistocene	II	chernozem (perhaps degradated)	Vranov n. D., Alberndorf, Großstelzendorf, Porrau,
	II/III	illimerized soil (parabraunerde - Stillfried A)	Vranov n.D., Mailberg
Middle Pleistocene	IV	luvizem	Mašovice, NP Podyjí
	V	chernozem, braunlehm-like parabraunerde	Mašovice, Alberndorf
	VI	braunlehm-like parabraunerde, spotted	Alberndorf, Göllersdorf, Mašovice
		fossil soil, brown earthificated luvizem	
	VII	braunlehm	Großkadolz, Hadres, Mašovice,Trausnitz valley, Porrau,Obergrub
Lower Pleistocene	X	rubefied braunlehm, brown earthificated braunlehm, braunlehm-like pseudogley (ev.also PK VII?), rotlehm	Großkadolz, Hadres
		rubefied ferreto	Podmolí-Lukov
			Znojmo, Sedlešovice

Table 1:
Scheme of development and classification in soil complexes (PK) of the studied fossil soils.

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