Uniqueness of limestone soil-forming substrate in the forest ecosystem classification

P. Šamonil

Department of Forest Ecology, Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Brno, Czech Republic

ABSTRACT: The uniqueness of limestone soil-forming substrate was assessed with respect to the classification of forest ecosystems. 50 soil profiles from the Bohemian Karst were studied and the results were confronted with previously published works from other karst areas. The evaluation of soil profiles was based on a macroscopic description, on the results of chemical and physicochemical analyses, and on a micromorphological study. The carbonate bedrock was a cause of specific genesis of soils in these sites – both recent and relict ones (terrae calcis). However, it does not always condition the unique characteristics of these sites whose differentiation would call for an *a priori* special edaphic category. Unique geochemical characteristics of the substrate are modified on the gradient of advanced pedogenesis (Holocene up to mid-Pleistocene soils were assessed) by a very intensive soil-forming process connected with the impact of allochthonous, mostly aeolian material. Two possible approaches were designed for the classification of these sites: (*i*) wider conception – distinction of the basic edaphic category with small limitations for the quality of soil-forming substrate, (*ii*) narrower conception – limestone edaphic category with a number of limitations to distinguish this edaphic category.

Keywords: limestone; pedology; micromorphology; Rendzic Leptosol; terra fusca; ecosystem classification; Bohemian Karst

Species composition and physiognomy of plant communities closely correlate with site edaphic characteristics. At a local and regional level, ecotope pedological and geomorphologic characteristics can be considered a primary factor of differentiation – hence classification of natural ecosystems. The ecotope characteristics are used mainly in mapping at a scale ≤ 1:25,000 and with the basic segment size of up to ca 1.5 ha (Haase 1989; Klijn, Udo de Haes 1994). On a broad supraregional scale and with a coarse "grain" of classification the natural ecosystems are differentiated especially with respect to the development of (macro-)climate. On this scale, the considerably variable edaphic conditions rather recede into the background (Bohn et al. 2000; Davis, Holmgren 2001).

As the Central European landscape has been under a considerable anthropogenic impact for a long time, the phenomenon must be taken into account also in the classification of natural ecosystems. The human impact may be taken into consideration in full – with the classification focused on the actual situation, or the situation may be modelled or even reconstructed at a limited or even zero human impact – with the classification of potential or reconstructed situation (Tüxen 1956; Mikyška et al. 1968; Chytrý 1998; Neuhäuslová et al. 1998; Bohn et al. 2000; Viewegh et al. 2003, and others). In the latter case, slightly altered edaphic site parameters are preferred as classification criteria, on the basis of which the localities considerably disturbed by humans are assessed (mapped) vicariously – by analogy. Classification systems constructed in this way often classify carbonate bedrocks (consisting mainly of calcite or dolomite – Hejtman 1981) as a unique geological basement for the development of specific natural

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ecosystems (Paal 1997; Zelenková 2000; Viewegh et al. 2003, and others).

If the species composition of phytocoenoses is a primary classification criterion (e.g. Jurkevič et al. 1971; Hančinský 1977; Schwarz 2005), and particularly if it is the actual situation that is to be characterized – mapped (Chytrý et al. 2001), the mentioned separation of the carbonate basement is not usually so pronounced – the classification of soil and geological conditions is made vicariously. The edaphic characteristics are taken into account intuitively (cf. Neuhäuslová et al. 1998; Moravec et al. 1995, 2000) although the criteria are sometimes concealed (Hédl 2005). On the other hand, they are sometimes used quite openly and may be important criteria of classification (cf. Chytrý 2000; Chytrý et al. 2007). It is to say that using the criteria of plant community links to site characteristics the primarily fully floristico-sociological classifications (e.g. Braun-Blanquet 1921) become the classifications of whole ecosystems to some extent (Hédl 2005). In these taxonomies separate units are differentiated with a considerable affinity to the carbonate bedrock (Jermakov 1987; Neuhäuslová et al. 1998; Moravec et al. 2000; Chytrý, Tichý 2003, and others). They are usually delimitated by the occurrence of diagnostic calciphilous plant taxa [*Sesleria caerulea* (L.) Ard., *Cephalanthera damasonium* (Mill.) Druce, *C. rubra* (L.) L. C. Richard, *Cystopteris fragilis* (L.) Bernh., etc.], according to which they are often given names (e.g. the association *Cephalanthero-Fagetum* Oberdorfer 1957).

Thus a general view is accepted that the carbonate bedrock shows some specific features in terms of both soil development and development of respective phytocoenoses (Šamonil 2005a; Šamonil, Viewegh 2005). So far unresolved questions remain the measure of this uniqueness:

What are the characteristics in which the soil-forming substrate (not only the parent rock) on the carbonate bedrock differs from the substrate on other bedrocks?

How does the course of pedogenesis on the carbonate bedrock differ from that of pedogenesis on other bedrock types?

At what stage of soil development are the parent rock specific features still preserved?

Different approaches to this problem are obvious from the analysis of systems classifying the natural ecosystems in the Czech Republic (CR). The geobiocoenological system (Zlatník 1956; Buček, Lacina 2002) rather diverts from the unique position of limestone in the course of time. On the contrary, in the substitute ÚHÚL (Institute of Forest Management) Typological System (Anonymous 1971/1976; Plíva 1984, 1991; Viewegh et al. 2003) the limestone sites are gradually gaining independence (cf. Schwarz 2005; Jermakov 1987; Paal 1997; Helmer et al. 2002).

Objectives: (*i*) to assess the uniqueness of soils on limestone with respect to the differentiation and classification of forest ecosystems, (*ii*) to propose new classification criteria and approaches.

MATERIAL AND METHODS

Data sampling

First of all, the study is based on data from the Bohemian Karst (Fig. 1). Together with the Moravian

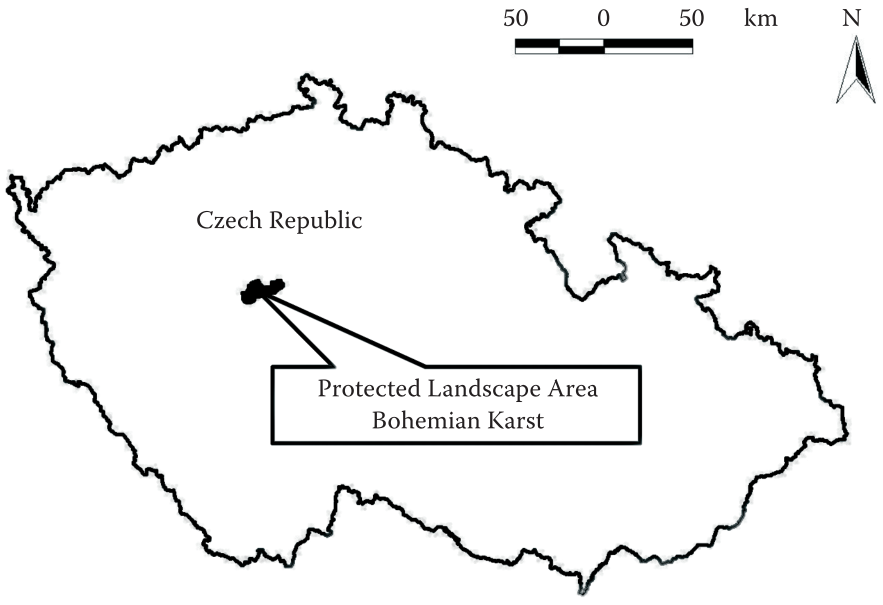

Fig. 1. Location of the area under study

Karst the two karstic areas in the Czech Republic are the largest territories modelled by limestones. Zelenková (2000) distinguishes individual limestone sites in the forest ecosystems of Bohemian Karst on more than 3,500 ha.

A total of 50 soil profiles were studied in the Bohemian Karst in near-natural forest ecosystems (Vrška, Hort 2003) with the developed crown canopy, which occurred on carbonate (39), carbonate-silicate (5) and purely silicate (6) subsoils. The geological basement was formed of the particularly diverse limestone facies of Silurian and Devonian age (from ludlow to zlichov), marl slates, altered basalts (diabase), tuffaceous limestones, siltstones and gravel sands (namely fluvial terraces of Miocene age).

Data analysis

The soil environment was assessed by a macroscopic description of soil profiles, on the basis of results from the chemical and physicochemical analyses of soil samples (Anonymous 2003a; Zbíral 2002, 2003), and on the basis of a micromorphological study of soil sections (e.g. Kubiëna 1970; Smolíková 1982; Dalvigne 1998; Gregorová et al. 2002). Some soils on the gradients of pedogenesis and soil solum thickness were surveyed micromorphologically. Hydropedological soil characteristics and soil environment links to the species composition and physiognomy of phytocoenoses were not evaluated.

Statistical data of soil profile characteristics were processed by software (ter Braak, Šmilauer 2002; Lepš, Šmilauer 2003; Anonymous 2003b). The statistical significance of variables was assessed by the Monte Carlo test with 4,999 permutations. The critical level of significance was selected as $P = 0.05$.

Pedogenesis and soil characteristics representing the "carbonate (limestone) sites" (specification see below) were confronted with other site types. Different soil types on the "limestone sites" were also compared. Data from a pedological survey in the Bohemian Karst were compared with the data from other regions published previously.

The important classification criterions are such soil properties that the other ecosystem components (primarily the species composition of phytocoenoses) directly affect.

RESULTS AND DISCUSSION

Specification of limestone sites

The first condition in comparing limestone sites with other site types is the *participation of carbonate rock in soil genesis*. In all soils on the limestone of the Bohemian Karst limestone was a soil-forming substrate at the same time. The only exceptions were profiles in Tertiary (Miocene) fluvial terraces where limestone was only a D-horizon, i.e. an underlying rock (Němeček et al. 2001). The cases were declined already at the beginning as the representatives of limestone sites.

In addition to limestone, a part of the soil profiles exhibited an admixture of the skeleton of carbonate-silicate or silicate rocks, often of allochthonous origin – slope transport. These soils were withdrawn from the "limestone sites" as well. *The nature of solid rock is a necessary primary criterion making these sites eligible for the purposes of further analyses* (Zelenková 2000; Viewegh et al. 2003).

At the first stage of this work, limestone sites were considered to be only the sites with soil profiles exhibiting the (macro-)skeleton of carbonate rock.

Specific features of soil-forming substrate on limestone sites

Development of weathering products and soils on limestone is usually seen in its continual dissolution and in the related surface accumulation of soil consisting of partly transformed clay non-carbonate residues (Schaffer et al. 1962; Šály 1978). This indicates that – due to this conception – the soil cannot develop on absolutely pure limestones and in the absence of material *ex situ*. However, in the presence of vegetation, the biosphere activity with the processes of organic matter accumulation and conversion would be sufficient for the development of initial soils (according to Lavkulich 1969; Martini, Chesworth 1992; Němeček et al. 2001). Werner (1958) and Smolíková (1982) arrived at a conclusion that in climatic conditions similar to those prevailing today in Central Europe, a 1 cm thick weathering product of terra fusca soil type (see below) developed over a thousand years and even longer on the parent rocks with ± 7% of insoluble residue. Rohdenburg and Meyer (1963) and Němeček et al. (1990) informed that a limestone layer of 0.2–0.4 m dissolved in the Holocene era, from which a layer of soils could have been developed at a maximum thickness of 10 cm. The recent soils *in situ* of the described genesis are therefore very shallow, which corresponds also with the surveys made in the Bohemian Karst. These soils can usually be classified as Rendzic Leptosols (Anonymous 1998a; Driessen et al. 2001). It follows that the proportions of $CaCO_3$ and non-carbonate accessories in limestone determine the rate of pedogenesis to a considerable extent as well as the chemical and physicochemical composition of developing soils. The amount of accessories is very variable, and may differ even by tens of per cent within a single limestone facies (Svoboda et al. 1957; Kužvart et al. 1992). *Limestone is in general undoubtedly a specific, although considerably variable soil-forming substrate* (Šamonil 2005a).

The assessment of soil-forming substrate on limestone sites is nevertheless far from being confined to the study of the characteristics of limestone and geological basement. In spite of the fact that the sites were above delimitated by the occurrence of carbonate rock in the subsoil, the rule does not exclude a possibility of the allochthonous origin of a part of the soil-forming substrate.

It is exactly the amount and the *nature of material ex situ* that appear to be conclusive in the assessment of the "uniqueness" of soils on solid carbonate rock with the *presence of aeolian material* being of key importance. Chronic impact or occasional occurrence of "dust events" are reported from most regions of the world: Slovakia – Western Carpathians (Šály 1974; Šály, Mihálik 1970), the Netherlands (Arens 1996), Switzerland (Sticher et al. 1975), U.S.A. (Harland et al. 2002), Nepal (Guggenberger et al. 1998), Asia – Gobi (Wake et al. 1994; Husar et al. 2001; Jaffe et al. 2003), Japan (Ono et al. 1998), New Zealand (Stewart et al. 1984). The territory of the Czech Republic is no exception (Hibsch 1930; Kukal 1978; Šály 1986). Although the long-distance transport of aeolian material in Central Europe was documented (Šály 1974), today's opinion speaks of relatively short transport distances – most frequently tens (max. hundreds) of kilometres, with the predominance of W and NW winds (Ambrož 1947; Růžičková 2001, etc.). Consequently, the nature of the depo-

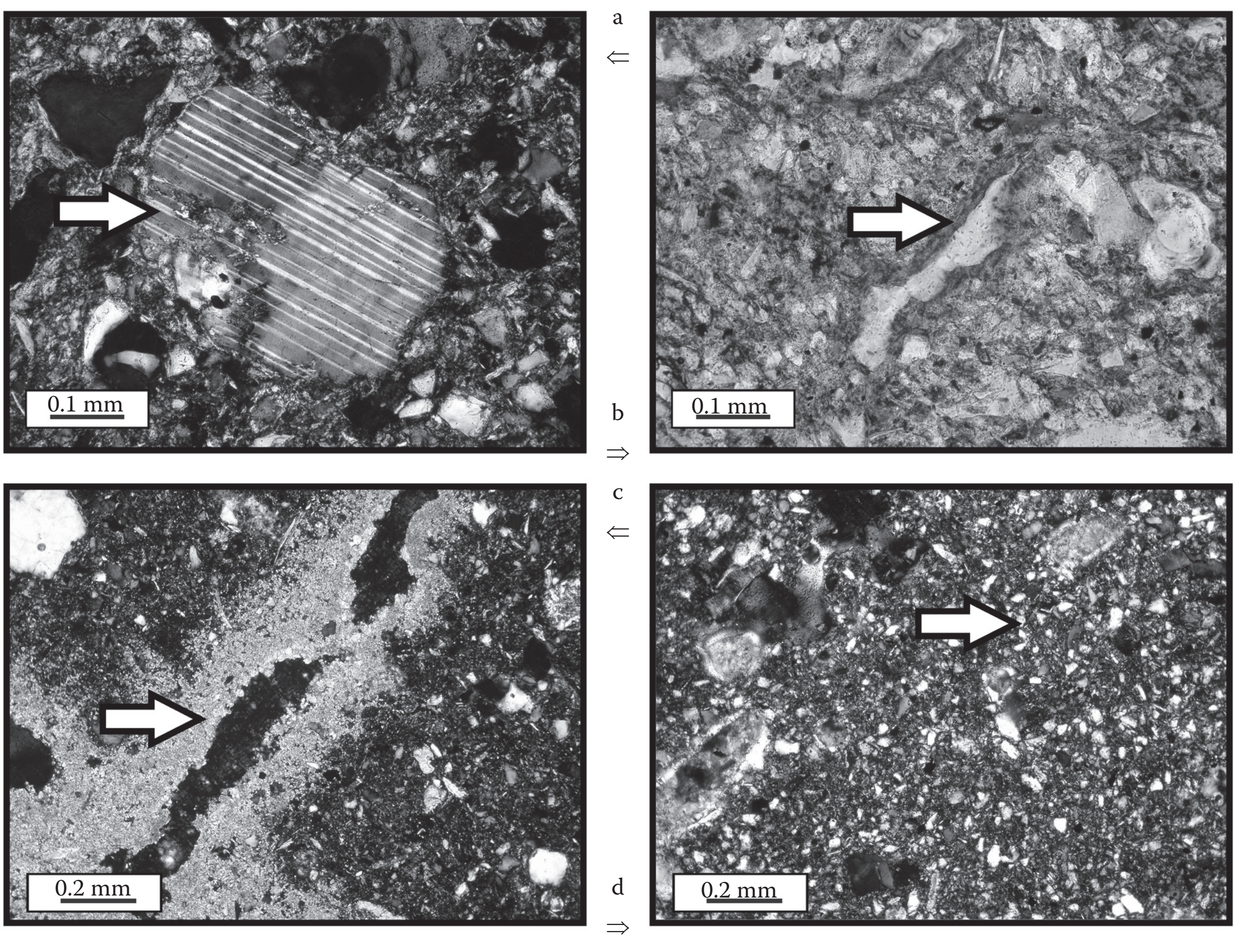

Fig. 2. Micromorphological features of soil profiles on the limestones of the Bohemian Karst.
a – Fragment of plagioclase in the substrate (C) horizon of Luvic Cambisol with typical parallel lamellas. The presence of plagioclase demonstrates the aeolian origin of the part of the soil-forming material; (X-nicol); b – Clay argillans on the walls of segregates demonstrate an illimerization process; argic horizon of Luvisol with polyhedrical soil structure; (II-nicol); c – Carbonates of secondary origin (decalcification of the upper part of soil) occur on the walls of intake channels; substrate (C) horizon of Luvic Cambisol; (X-nicol); d – Size sort out fragments of quartz demonstrate the aeolian origin of the major part of albic (E) horizon in Luvic Cambisol; (X-nicol)

sited material partly depends on the local geological and geomorphologic situation.

It is hard to imagine that soils on the limestones of Bohemian Karst were developing without the presence of aeolian material; it had to be so if we take into account the time horizon of the development of these soils (see below). The assessment of allochthonous material must be made by means of a micromorphological survey.

Micromorphological survey

The study of soil sections was used for the following purposes:

(*i*) exact documentation of the nature of soil-forming substrate

(*ii*) assessment of soil age

(*iii*) exact documentation of the course of pedogenesis

(*i*) All soils of the Bohemian Karst subjected to the micromorphological survey showed the occurrence of the aeolian component (Fig. 2). A number of minerals were discovered that were either extraneous to the carbonate rock or that had weathered from the middle part of the profile (see below) long ago if taking into consideration the detected age of soils. The allochthonous component in the soils on the limestone of Bohemian Karst is represented mainly by plagioclase, amphibole, muscovite, biotite and quartz (Šamonil 2005b). Particularly with the A-E-B-C stratigraphy of soils the upper organomineral (A) and albic (E) horizons contain high to dominant proportions of the clearly assorted microskeleton of aeolian origin. A lithological barrier is developed between the albic (E) and metamorphic (B) horizon, which often closely relates also to the different age of the material in the two horizons (Šály 1982; Sokolov et al. 1983; Šamonil 2005a). Their entirely different chemical and physicochemical characteristics (and sometimes also a different mineralogical composition of the clay fraction – cf. Šály, Mihálik 1970) intensify the process of illimerization (see below). Consequently, the *stratigraphy/stratification of soils is a result of the combination of geologico-geomorphological and pedogenetic processes.*

The presence of aeolian material in the soils of the Bohemian Karst fully corresponds with the results of Šály (1982), who did not find any profiles formed only of the insoluble residue of carbonates even in young A-C soils but described at least a 10% admixture of extraneous (aeolian) material, mainly quartz. The proportion of the aeolian component and its pedogenetic importance has however been secondary in these soils of the Bohemian Karst at all times. Their organomineral (A) horizon is constituted mostly by the amorphous, transformed humus substance, limestone skeleton and its residues. At greater depths the horizon passes into limestone disintegration or directly into the compact bedrock.

In relict soils (e.g. Ruhe 1975) the occurrence of material *ex situ* can be expected and the material can be considered a necessary part of pedogenesis (Bronger, Sedov 2002). Šály (1982) did not even admit the autochthonous (*s.s.*) development of these soils while establishing the soils as exclusively allochthonous or parautochthonous (cf. Smolíková 1982 – she also admitted the automorphous character of these soils within certain limits). The studied relict soils of the Bohemian Karst were classified as autochthonous or parautochthonous and contained a substantial proportion of material *ex situ* in all cases, which blends in the B horizon with the residues of limestone and which has already yielded to weathering to a considerable extent.

(*ii*) Soils on the limestone of Bohemian Karst are of very diverse age (Šamonil 2005a). The assessed A-C soils of the Bohemian Karst were very young, undoubtedly of the Holocene age. In the initial form they could have developed already in 10^2 years (Targulian, Krasilnikov 2004). However, on the specific terrain forms these soils may also be considered as a culmination stage of pedogenesis.

On the other hand, the micromorphological study of soils with fully developed B horizon often corroborated a considerably advanced stage of development. Relict soils have been preserved on the limestones of the Bohemian Karst (Homola 1950; Smolíková 1960, 1963a; Smolíková, Ložek 1962; Šamonil 2005a,b), especially on undulating peak plateaus referred to as a plane karst (Cílek 2002). The development of these soils occurred already in the warm periods of Pleistocene – Eemian, Holstein interglacial. Some of them exhibit signs of even older climatic extremes of the first order (Šamonil 2005a).

Soils of similar characteristics are reported also from other karst areas of the Czech Republic (Smolíková 1973; Pelíšek 1984) and other countries (Smolíková 1958, 1963b; Bronger, Smolíková 1981; Bronger et al. 1984; Šály 1995; Bronger, Bruhn-Lobin 1997; Yaalon 1997; Durn et al. 1999; Zagórski 2003).

(*iii*) The intensive and long-lasting pedogenesis of relict soils on the limestones of the Bohemian Karst – including also the process of rubefication in exceptional cases (according to Kubiëna 1956a) – reached the complete decalcification of soils and destruction of all readily weathering minerals. In fully developed soils carbonates occurred only in the substrate horizons where they were of both primary and secondary origin – in the form of calcite rhombohedrons or needles on the walls of intake channels. The segregate, polyhedric, dense soil structure of (palaeo)metamorphic (B) horizon – often also with signs of the process of illimerization (paleargic horizon according to Němeček et al. 1990) – was formed of the peptized soil mass and minerals resistant to weathering (quartz, muscovite). The clay fraction of soils under study showed a dominant representation of kaolinite and quartz; the substantial presence of goethite can also be considered an evidence to the relict development of soils in the Bohemian Karst (Šamonil 2005b).

Soil-forming processes documented micromorphologically on the limestones of the Bohemian Karst are as follows (Fig. 2): organic matter accumulation and conversion, decalcification, calcification, illimerization, br(a)unification, rubefication, gleyzation (Šamonil 2005a).

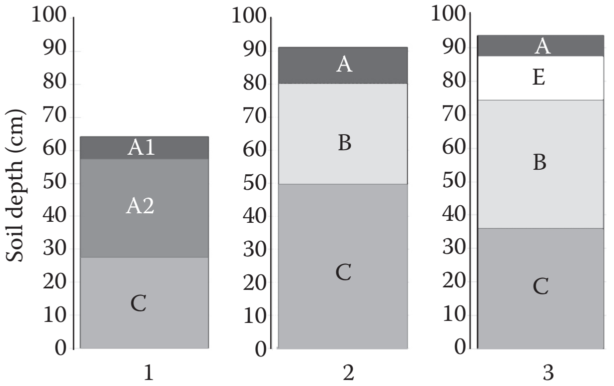

Fig. 3. Mean thickness of soil horizons and entire soil profiles on the Bohemian Karst limestones of main soil units (from 30 soil profiles). Soil horizons: A – organomineral surface horizon, E – albic (eluvial) horizon, B – subsurface metamorphic horizon (sometimes with the features of illimerization or rubefication = cambic, paleargic, metamorphic horizon), C – substrate horizon

The soils on limestones represent a long gradient of chemical properties of soils on various parent materials (Šály 1986; Batjes 1995) close but no sharply separate segment.

Soil chemistry

The "gulf" between the A-C soils and soils with the A-E-B-C stratigraphy (Fig. 3, Table 1) was clearly demonstrated to exist also in chemical properties. The two cases represent opposite poles in the soil range of limestone sites in the Bohemian Karst. Although the two groups of soils have the identical basement, they differ in age, in the proportion of the aeolian component, and often significantly in the climate at the time of their development – contrasting in the course of pedogenesis. The values of soil reaction and $CaCO_3$ content presented in Fig. 4 closely correlate with other soil characteristics (Šamonil 2005a) – sorption complex saturation, supply of available nutrients, etc. (Fig. 5, Table 1). Between these two extreme aspects there were soils with the B horizon at a varied stage of development, missing the albic horizon at all times (Table 1, Fig. 5). In addition, the classified soil units significantly differed also in their chemical and physicochemical characteristics ($P < 0.05$). The best separated among the three wide soil units (Fig. 5) was a group with the A-E-B-C profile stratigraphy – Luvic Cambisols and Luvisols ($P < 0.0001$, $F = 5.46$).

The greatest differences between the studied soils were at a depth of about 15 cm. The soils of A-E-B-C stratigraphy contain the eluvial – albic – horizon at this depth whose chemical properties sharply contrast with the thick and fully saturated (often 99%) A horizon of the A-C soils.

Classification of soils

According to the international classification (Anonymous 1998a; Driessen et al. 2001) the soils can be classified into the following several groups on the basis of their stratigraphy and mode (cf. Kubiëna 1956b; Smolíková 1982):

– *Soils with the A-C stratigraphy* can be classified as Rendzic Leptosols (Humic and Eutric), Lithic Leptosols (Rendzic and Eutric) or Hyperskeletic Leptosols (Rendzic, Calcaric and Eutric).
– *Recent soils with the A-B-C stratigraphy* can be classified as Eutric Cambisol (Chromic) or Calcaric Cambisol (Eutric).
– *Recent soils with the A-E-B-C stratigraphy* can be classified as Vertic Luvisols (Calcaric, Albic and Cutanic) or Luvic Cambisols (not distinguished in the system of Driessen et al. 2001, cf. Němeček et al. 2001 – "kambizem luvická").
– *In the case of the relict development, soils with the A-B-C and A-E-B-C stratigraphies* can be best designated as (Norm-)Terra fusca, Braunerde-Terra fusca up to Kalkterra fusca (Anonymous 1998b; see also Šály 1962, 1986; Kubiëna 1970; Houba 1970). According to Nettleton et al. (2000), the soils in question are Paleoinceptisols or Paleoeldisols. Contemporary soil classification systems in the Czech Republic (Hraško et al. 1991/1993; Vokoun 2000; Němeček et al. 2001) do not distin-

Table 1. Laboratory analysis of three typical soil profiles on the limestones of the Bohemian Karst

Soil		Rendzic Leptosol		Calcaric Cambisol			Luvic Cambisol				
		A	C	A	B	C	A	E	B	B/C	C
Horizon		organo-mineral	substrate	organo-mineral	Cambic	substrate	organo-mineral	Albic	Argic	Argic/substrate	substrate
Depth of horizon (cm)		0–50	50–80	0–9	9–52	52–108	0–6	6–16	16–38	38–62	62–108
Dry matter 105°C (%)		95.23	97.20	96.22	96.34	97.90	96.45	96.90	94.78	95.65	97.90
Ignition loss 550°C (%)		15.87	5.94	11.10	5.43	5.94	10.03	5.10	6.54	6.15	4.73
pH $_{H_2O}$ (/)		7.32	8.03	6.46	7.48	7.74	6.24	4.70	5.74	7.91	7.80
pH $_{CaCl_2}$ (/)		6.86	7.56	6.15	6.81	7.36	5.83	3.66	4.37	7.16	7.24
Oxidizable carbon C_{ox} (%)		4.59	0.89	3.49	1.12	1.15	2.94	1.39	0.93	0.83	0.41
Total nitrogen N_{Kjel} (%)		0.504	0.090	0.321	0.110	0.120	0.223	0.070	0.084	0.091	0.080
Carbonate (%)		7.00	49.60	0.10	0.20	43.20	0.10	0.00	0.30	24.40	43.20
Leach by 0.1 mol/l $BaCl_2$	Ca (mg/kg)	9,372	4,960	6,175	4,913	4,450	2,764	442	4,236	6,029	3,600
	K (mg/kg)	235.70	62.70	93.10	64.20	42.30	152.20	60.50	130.80	122.50	95.50
	Mg (mg/kg)	227.50	45.00	245.40	151.60	39.00	137.00	28.00	127.60	83.80	38.00
	Na (mg/kg)	19.90	6.20	17.30	22.30	7.40	16.40	7.00	16.20	20.50	6.50
	Al + H (mval/kg)	< 0.60	1.00	1.00	1.30	1.30	19.40	94.50	9.00	< 1.00	< 1.00
Cation exchange capacity (CEC) (mval/kg)		493	254	332	262	228	173	121	235	312	186
Base saturation (%)		100.00	99.60	99.80	99.30	99.40	88.90	21.70	96.10	99.90	99.50

guish these soils, classifying the relict soils improperly by the features of recent soils. According to the international classification scheme (Anonymous 1998a; Driessen et al. 2001) the soils in question are still Chromic Cambisols or Chromic Luvisols (see also Vrbek 2006). Unlike the Czech taxonomy (Němeček et al. 2001), the international taxonomy of soils becomingly includes also the criterion of the content of carbonates in the soil-forming substrate in the range of cases.

CONCLUSIONS

Carbonate rock is a specific soil-forming substrate that conditions the development of unique soils. In the case of recent soils it essentially affects their properties. The role of carbonate basement is of singular character also in the development of the relict soils of terra fusca and terra rossa types. Nevertheless, the exceptional geochemical properties of the substrate are modified in them by a long-term and very intensive soil-forming process connected among other things with the impact of allochthonous, mainly aeolian material and decalcification of the soils. In spite of the apparently existing specific features that can be revealed in the pedogenesis of these soils, the basic physicochemical and chemical characteristics of the soils need not deviate from the general framework of soils on eutrophic (ultrabasic, silicate-carbonate, carbonate) bedrocks. Consequently, the soils do not always create unique ecological characteristics of the site, for which the sites should be *a priori* separated at the level of a special edaphic category.

Results of chemical and micromorphological analyses of soils on the carbonate bedrock suggest two possible approaches to the classification of these sites (respective ecosystems):

– *Wider approach – Distinction of the basic edaphic category.* This category contains soils developing on solid carbonate rocks, silicate-carbonate rocks and ultrabasic rocks (tuffaceous limestones, marl slates, basalt, diabase, etc.). It includes the soils of all above

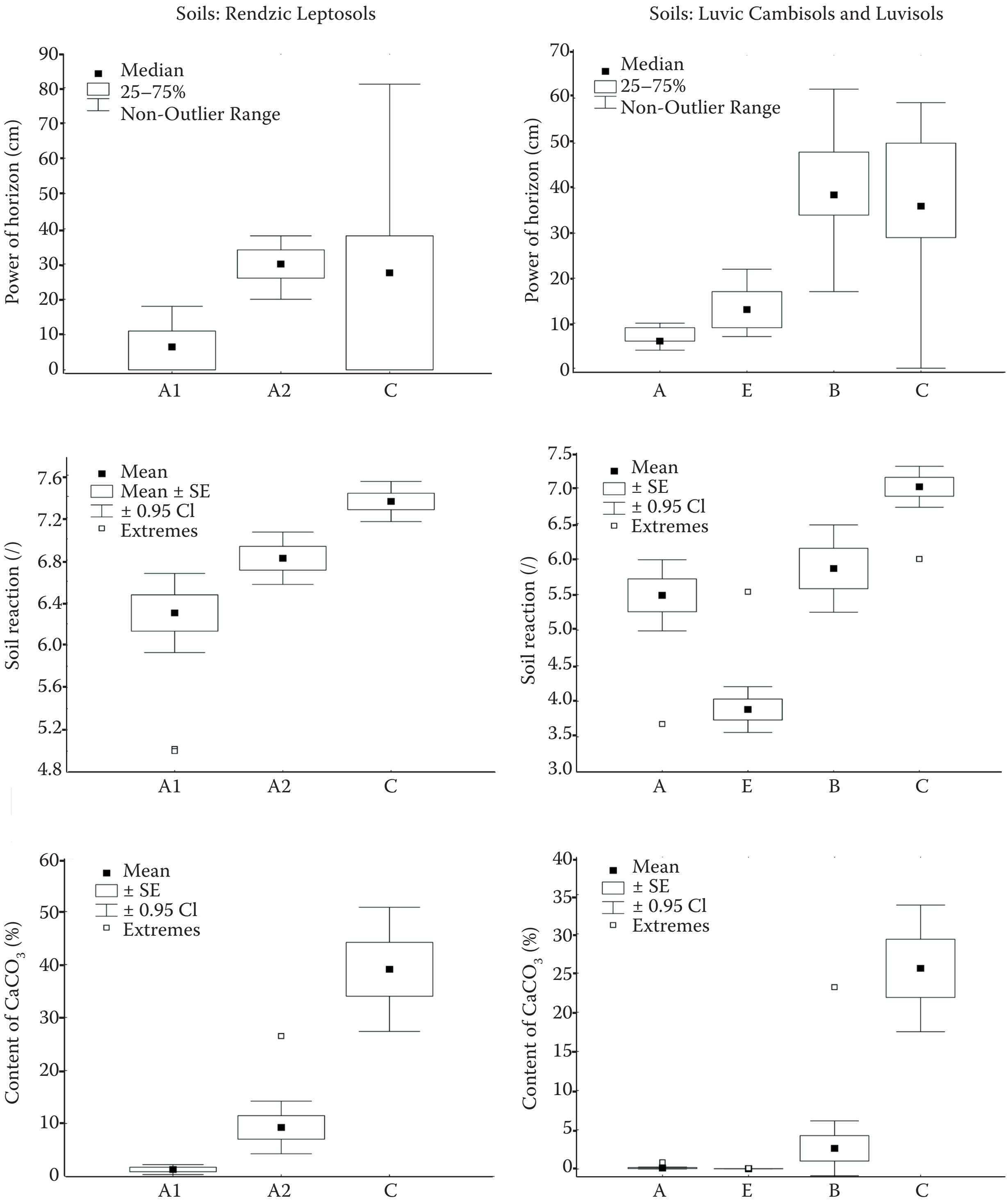

Fig. 4. Characteristics of two opposite soil units on the Bohemian Karst limestones – horizon thickness, soil reaction (KCl) and $CaCO_3$ content (from 26 soil profiles)

classified units. The only condition required for the classification of a site in this category is a significant presence of the geological basement in pedogenesis.

– *Narrower approach – Distinction of the limestone edaphic category*. This category contains only sites on the solid carbonate rock (limestone, dolomite), which are further delimitated by the following conditions:

– carbonate bedrock is the only source of (macro-) skeleton in the soil,

– carbonate bedrock is a dominant soil-forming substrate (not exceptional),

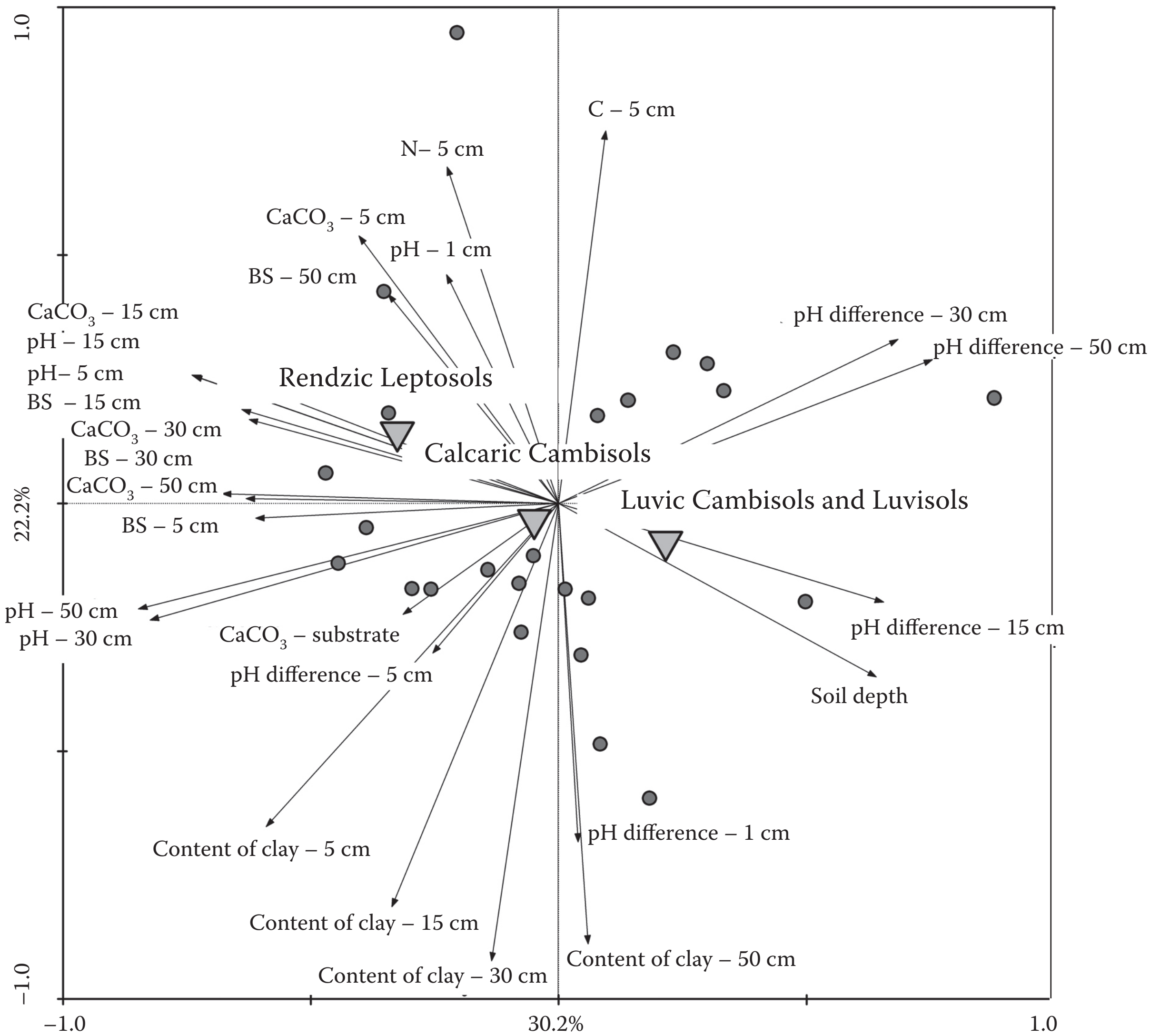

Fig. 5. Variability of soils on the carbonate sites of the Bohemian Karst; Principal Component Analysis (PCA), physical and chemical properties of soil profiles and soil depth are environmental variables (ter Braak, Šmilauer 2002); soil classification units are supplementary variables

– allochthonous material deposited by wind (also by slope displacement to a smaller extent) may be present but it does not form continuous layers and its impact on the soil chemistry and pedogenesis is considerably limited,
– the soil does not have the eluvial horizon developed,
– provided that the metamorphic B horizon is present, the skeleton contains carbonate rocks.

The above classification applies to all A-C soils and some soils with the A-B-C stratigraphy including relict soils.

The described characteristics may be further complemented by the soil profile thickness limit or by the carbonate content limit (Driessen et al. 2001). Another classification criterion may be the soil development mode in combination with exactly detected micromorphological features (e.g. mass nature). Nevertheless, these criteria would apparently be beyond possibilities of field survey.

At the same time, the results suggest that in some cases the gradient of a selected soil characteristic (which is the carrier of an important part of the forest systems variability in the given segment of the ecological network) may be a more favourable forest typology classification criterion rather than the specification of typological units rigorously according to soil taxonomy units. These criteria need be sought at a simultaneous verification of soil environment relation to the species composition and physiognomy of phytocoenoses.

It is suggested that the existing criteria for the classification of forest systems (Plíva 1984, 1991; Viewegh et al. 2003) will be modified as mentioned above since the distinction of edaphic category merely on the basis of the geological basement character is not acceptable.

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Jedinečnost půdotvorného substrátu vápence v klasifikaci lesních ekosystémů

ABSTRAKT: Hodnotila se výjimečnost vápencového podloží – půdotvorného substrátu – vzhledem ke klasifikaci lesních ekosystémů. Problematika byla šetřena studiem 50 půdních profilů z Českého krasu a konfrontací dosažených výsledků s dříve publikovanými pracemi z krasových oblastí České republiky i z dalších států. Půdní profily byly hodnoceny na základě makroskopického popisu, výsledků chemických a fyzikálně-chemických rozborů a mikromorfologickým studiem půdních výbrusů. Karbonátová hornina byla příčinou specifické geneze půd na těchto stanovištích – recentních i reliktních (terrae calcis). Nepodmiňuje ovšem vždy unikátní ekologické vlastnosti těchto stanovišť, pro které by bylo třeba *a priori* rozlišovat zvláštní edafickou kategorii. Výjimečné geochemické vlastnosti substrátu jsou na gradientu pedogeneze (hodnotily se holocenní až středně pleistocenní půdy) v pokročilém stadiu modifikovány velmi intenzivním půdotvorným procesem, spojeným s impaktem alochtonního, převážně eolického materiálu. Byly navrženy dva možné přístupy ke klasifikaci stanovišť na pevné karbonátové hornině: (*i*) širší pojetí – rozlišení edafické kategorie bazické, s drobnými omezeními stran povahy půdotvorného substrátu, a (*ii*) užší pojetí – rozlišení edafické kategorie vápencové s řadou omezení, která vymezují tuto edafickou kategorii od kategorie bohaté.

Klíčová slova: vápenec; pedologie; mikromorfologie; rendzina; terra fusca; klasifikace ekosystémů; Český kras

Corresponding author:

Ing. Pavel Šamonil, Ph.D., Výzkumný ústav Silva Taroucy pro krajinu a okrasné zahradnictví, v. v. i.,
Oddělení ekologie lesa, Lidická 25/27, 657 20 Brno, Česká republika
tel.: + 420 541 126 260, fax: + 420 541 246 001, e-mail: pavel.samonil@vukoz.cz