An Analysis of the Rendzina Issue in the Valid Czech Soil Classification System

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Abstract: The article deals with the soil classification system valid in the Czech Republic. Using the soil type Rendzina from the former genetic-agronomic soil classification as an example, it analyses and revises the class definitions (soil types and subtypes), particularly their clarity, solidity, and mutual exclusivity based on the real state of diagnostic characteristics. The article advocates that the valid national soil classification system should be adequately detailed to satisfy practical needs and to preserve its convertibility into the international classification WRB system. At the same time, it should not be inconsistent with the methodology of the international project SOTER.

Keywords: soil classification; genetic-agronomic classification; TKSP CR; soil conversions; Rendzina

The classification is a prerequisite, a principal means of communication in all sciences and, with increasing knowledge, it needs to be revised regularly (Ahrens *et al.* 2003; Bouma 2003; Buol 2003).

Taxonomic systems have been developed specifically for the communication between scientists. Pragmatic, special-purpose systems developed for the technical communication often have a low efficiency and with further development tend to become quickly outdated (Kellog 1974; Blum & Laker 2003).

The Taxonomic Soil Classification System of the Czech Republic (TKSP CR), dealt with mainly by Němeček and Kozák (2001), Němeček *et al.* (2001), Vokoun *et al.* (2003), allows a unified classification of agricultural and forest soils. It is a hierarchical system which, in keeping with the world development, distinguishes the parent materials, diagnostic horizons, and soil properties. A significant advantage is its comparability with the World Reference Base (WRB), an international reference system whose the latest version comes from 2006 (see IUSS Working Group WRB 2006). Regardless of the number of attributes used, WRB enables us to create a strictly hierarchical structure which is in accord with the requirements of the digital transfer of information (Deckers *et al.* 2003). It does not mean a change in or replacement of national classification systems; it is an instrument for their better correlation (ISSS-ISRIC-FAO 1998). At lower levels of generalisation, it depicts geographically conditioned differences (Dudal 2003).

Blum and Laker (2003) have introduced the following three criteria of a well-designed soil classification system (at national level):

It must be complex – able to accommodate all the soils found in the given country. The class definitions have to be clear, solid, and mutually exclusive and based on the real state of the soil characteristics.

Only such soil properties should be used as criteria for higher levels of classification, which can be easily measured and understood.

The classification systems have to be well structured for the similarities and differences between soils to be clear and comprehensible.

Analysing the pilot area of Litoměřice district and Rendzina soil type, the present article examines whether the TKSP CR system meets these criteria.

MATERIAL AND METHODS

In the period of the General survey of agricultural soils (hereafter KPZP) in the 1960s, when the genetic-agronomic soil classification (hereafter GAK KPZP) was carried out, Rendzina soil type (RA) was the second most widespread soil type (after Chernozems) in the district of Litoměřice and was found on 22.63% of the district agricultural land (Němeček *et al.* 1965) (Figure 1). In the TKSP CR (the latest classification system), Rendzina is partially included in its most similar soil type, the newly established Pararendzina (PR) (highlighted in Figure 2), occurring on about 12% of the district agricultural land, partially in e.g. Regozem soil type, too.

In the genetic-agronomic classification of the General survey of agricultural soils (see Němeček *et al.* 1967), the soil type Rendzina covers the following main diagnostic horizons and features: light-coloured humus horizon, sorptive saturated to humus containing carbonates (h, hca, Orh, Orhca); sometimes dark humus horizon, sorptive saturated to containing carbonates (H, Hca, OrH, OrHca); under humus horizon carbonate substrate (Pca) or first horizon of weathering (V) with the thickness of up to 0.5 m, with fragments of carbonate rock; deeper carbonate rock (M) is always found. In the order of soils, Rendzinas are placed after brown and initial soils. The system distinguishes a group of subtypes of mountain locations and a group of subtypes of lower locations: the mountain subtypes are characterised by a more noticeable accumulation of humus and its deeper penetration in the profile. The genetic-agronomic classification distinguishes the following subtypes of Rendzinas:

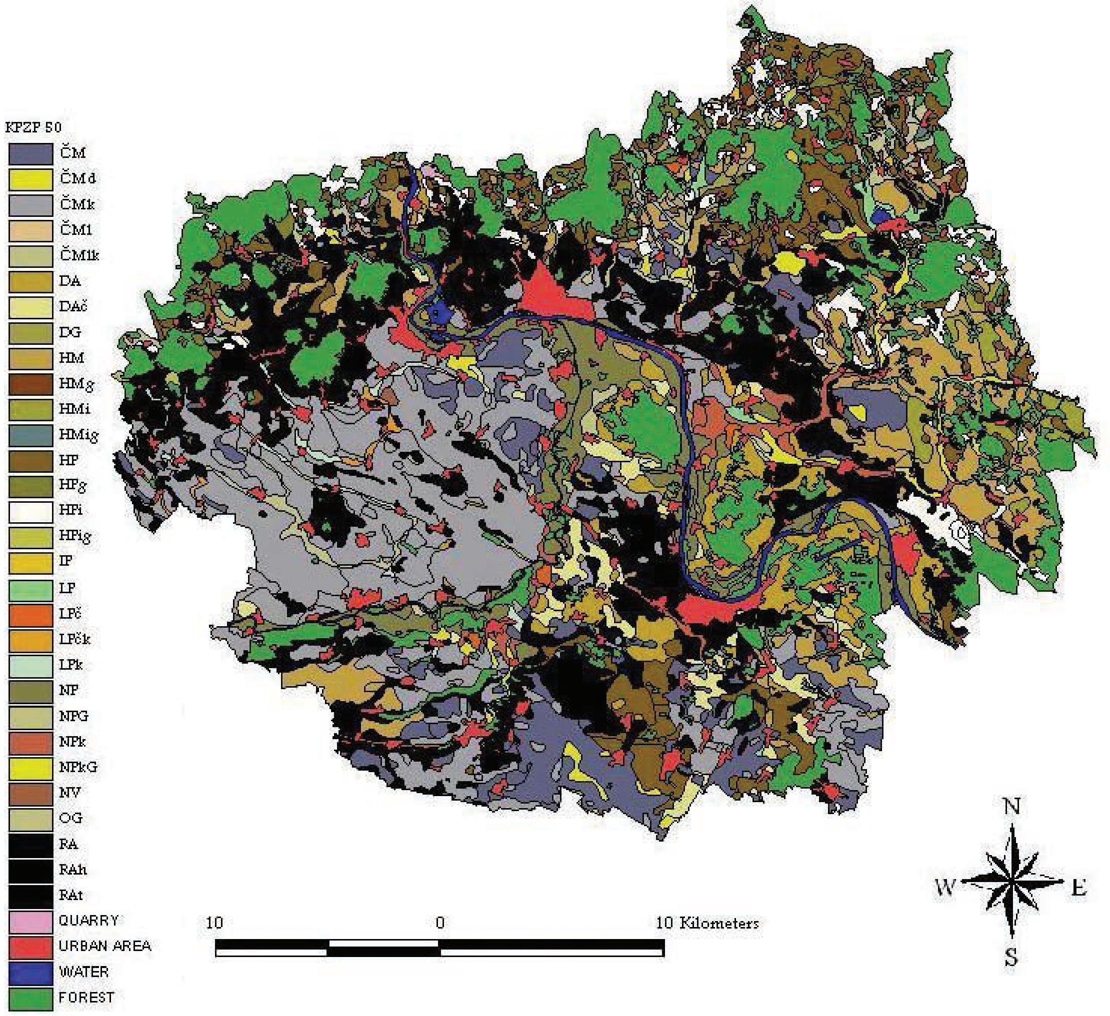

Figure 1. Digitised soil map at the scale 1:50 000 of Litoměřice district from KPZP with marked Rendzinas

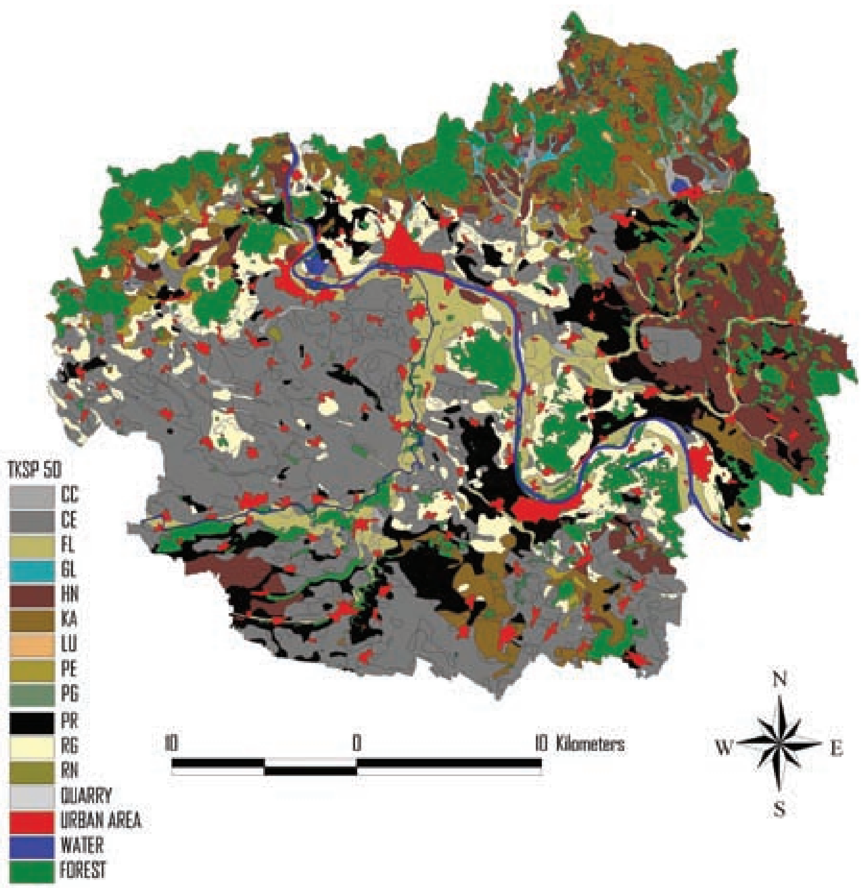

Figure 2. Soil map at the scale 1:50 000 of Litoměřice district with marked Pararendzinas

(typic): found on a variety of substrates. It covers shallow gravelly soils, desiccative, with one-sided chemism (limestone, dolomites), as well as deeper profiles with a more balanced chemism on slightly consolidated silicate horizons with the admixture of carbonates and on marls; brown – h: found on marls, arenaceous marls, shallow to medium-deep residual products of limestone leaching and up to the depth of maximum 0.5 m decalcified carbonate substrates with a higher level of sorptive saturation; anthropogenic – an: created by draining or terracing of vineyards. The profile of the former is significantly modified by mechanical interventions and is enriched with organic substances (up to the depth of 0.4–0.5 m); the terrace in the latter is often a place of mineral and organic materials accumulation. Autohydromorphic subtypes and development stages are created in the conditions of local waterlogging, especially on heavier substrates, in RA units; flood-plain – l: increased moisture is accompanied by the accumulation of dark humus substances in a more powerful humus horizon; stagnic – g: gleying at decreased permeability of the profile above 1 m; gleyic – G: the influence of ground water or decreased permeability below 1 m. The varieties of Rendzina are: dark – t: formed under locally favourable conditions for a more significant accumulation of humus – on limestone, marls, sometimes on other substrates; slightly stagnic – (g): slight gleying at decreased permeability of the profile above 1 m; slightly gleyic – (G): only local influence of ground water or decreased permeability below 1 m. The subtypes, varieties, and the forms of erosion are listed in Table 4, in the Results and Discussion section.

Rendzinas are classified as soils developing on limestones and dolomites, carbonate weathering ultra-basic rocks, consolidated sedimentary rocks with the admixture of carbonates (sandstones, shales), slightly consolidated sedimentary rocks, carbonate slope deposits, slightly consolidated carbonate clayey shales and neogenic sediments and on marls.

In the Taxonomic Soil Classification System of the Czech Republic (Němeček *et al.* 2001), Rendzinas are listed under the referential class Leptosols. These soils are formed from the disintegrated solid or semi-solid rocks or their basal formation. They are characterised by a high content of skeleton starting in the upper 0.5 m to shallowness of the profile (solid rock is found in the depth of up to 0.3 m). It allows only several types of horizons of organic matter accumulation in a limited proportion of fine earth – melanic horizon (Am), umbric horizon (Au), common is a sequence of litter (O) and humic forest horizon (Ah) and traces of cambic horizon (Bv) or micropodzolization.

The soil type Rendzina (RZ) forms from skeletal disintegrated carbonate rocks and is characterised by stratigraphy of the soil profile O – Ah, Am, or Ap (topsoil horizon) – Crk (disintegrated solid rock with the content of carbonates higher than 5%) – Rk (solid rock with the content of carbonates higher than 5%). Especially detrital and surface-decalcified Rendzinas are accompanied by the formation of dark Am-horizons. The formation of Bv-horizons indicates the transitions to Cambisols and Luvisols. The TKSP CR (and already Hraško *et al.* 1991) distinguish the following subtypes of Rendzinas: modal – m: with carbonates in the whole profile; melanic – n: more than 0.25 m thick, dark Am-horizon; cambic – k: up to 0.3 m presence of brown to yellow-brown Bv-horizon under Ah horizon; rubiphic – j: up to 0.3 m presence of rubiphic horizon Br; leached – v: carbonates leached out from fine earth of horizon of organic substances accumulation (at least in its upper part); lithic – t: compact rock in the depth of 0.1–0.3 m; talic – s: talus more than 0.5 m thick, with skeleton content over 80%. The varieties of Rendzinas are: shallow-melanic – n': Am horizon thinner than 0.25 m, and mesobasic – a': saturation of sorptive complex after Kappen is in Bv horizon of forest soils lower than 50% and saturation of sorptive complex after Mehlich is in Bv horizon of agricultural soils lower than 60%.

The subtypes, varieties, and forms of erosion are recorded in Table 4, in the Results and Discussion section.

Like Rendzinas, Pararendzinas also belong to the referential class of Leptosols. Pararendzinas (PR) are soils from weathered and basal as well as shallow main formations of carbonate-silicate consolidated rocks, with skeleton content and with O – Ah (Am) or Ap – Crk – Rk stratigraphy. Gradual leaching and perhaps insufficiently thick layer of the soil formation form conditions for the transition to Kambizem. They occur locally in various climatic conditions, mainly in the areas of cretaceous and flysch consolidated sediments.

Regozems belong to the referential class of Regosols, which are soils formed from non-consolidated sediments, especially from sands and gravelled sands (they are sometimes classified as Arenosols), but also from other substrates. They lack a distinct cambic horizon. They have only common horizons of organic matter accumulation (O – Ah, Ap). The soil type Regozem (RG) represents soils with O – Ah – C or Ap – C stratigraphy, and developed from friable sediments (mainly sands) in flat parts of a relief, where the substrate is poor in minerals (silicic sands etc.) or the short length of pedogenesis prevents a more distinct development of the profile. They are also found, however, on medium and heavy textured substrates, especially in the locations where the soil development is disrupted by water erosion.

The main reason for the complete disappearance of Rendzina from the district of Litoměřice after the reclassification is the fact that in the taxonomic system Rendzina is bound to limestone as the parent material, which results in the disappearance of those soil profiles of Rendzina, whose properties and characteristics would otherwise fall under the type also in the TKSP CR.

Hence it is necessary to discuss the basis of this limitation of Rendzina and to consider its necessity, as in the Czech soil classification, Rendzina is a traditional, though not very widespread, soil type – FAO soil unit Rendzic Leptosols occupies 0.23% of the surface of the Czech Republic (Kozák *et al.* 2000).

The exact wording of the TKSP CR allows the classification of a soil as Rendzina on the following substrates: alluvial, coluvial and deluvial loams, alluvial gravels, recent sands, surfaces of clays and loess denuded by erosion, landslides, recent, silicate, carbonate and basic taluses, limestone, sedimentary and crystalline limestone, dolomites, crystalline dolomites, calcareous tuffits, calcareous sandstones, calcareous and soft shale, arenaceous marls, basic and ultrabasic rocks, quartzite and silica rocks, arkoses and greywacke. The chief author of the TKSP CR believes, however, that Rendzina should be classified only on limestones and dolomites, which can be documented e.g. by the quotation on p. 48 (Němeček *et al.* 2001): "due to a relatively rare occurrence of limestone on the area of the Czech Republic, Rendzinas are represented here only in a very limited extent;" or by the minutes from the 2007 talks with the author. Based on this restriction of the substrate, we can classify Rendzinas under Calcaric Leptosols (WRB), as preferred by the author of the TKSP CR.

Table 1. Soil types and subtypes overview according to the soil map at the scale 1:50 000 for Litoměřice district

TKSP CR	WRB		No. of polyg.	Area	
Sign.	sign.	nomenclature		(ha)	(%)
CCc'	caPH	calcaric Phaeozem	15	367.99	0.46
CCm	glPH	gleyic Phaeozem	15	399.04	0.50
		Phaeozems in total	30	767.03	0.96
CEc	ccoCH	orthicalcic Chernozem	198	17 327.92	21.82
CEl	lvCH	luvic Chernozem	17	706.47	0.89
CEm	ccCH	calcic Chernozem	153	8120.71	10.23
CEr	arCH	arenic Chernozem	42	2030.41	2.56
CEx	glCH	gleyic Chernozem	9	200.45	0.25
CExc'	glccoCH	gleyic orthicalcic Chernozem	23	837.55	1.05
		Chernozems in total	442	29 223.51	36.80
		Phaeozems and Chernozems in total	472	29 990.54	37.76
FLc	caFL	calcaric Fluvisol	32	1366.52	1.72
FLm	haFL	haplic Fluvisol	84	4531.44	5.71
FLq	glFL	gleyic Fluvisol	10	393.09	0.50
FLqc	glcaFL	gleyic calcaric Fluvisol	19	815.22	1.03
		Fluvisols in total	145	7106.27	8.96
GLm	haGL	haplic Gleysol, Gleysols	20	474.20	0.60
HNg	stLV	stagnic Luvisol	19	343.94	0.43
HNl	abLV	albic Luvisol	26	1085.91	1.37
HNlg	abstLV	albic stagnic Luvisol	1	21.40	0.03
HNm	haLV	haplic Luvisol	133	7128.07	8.98
		Luvisols in total	179	8579.32	10.81
LUm	haAB	haplic Albeluvisol, Albeluvisols	9	112.91	0.14
		Luvisols and Albeluvisols in total	188	8692.23	10.95
KAg	stCM	stagnic Cambisol	37	672.74	0.85
KAl	lvCM	luvic Cambisol	98	2547.08	3.21
KAlg	stlvCM	stagnic luvic Cambisol	12	183.85	0.23
KAm	euCM	eutric Cambisol	256	7741.92	9.75
		Luvisols in total	403	11 145.59	14.04
PEm	caCM	calcaric Cambisol	49	1788.63	2.25
		Cambisols in total	452	12 934,22	16.29
PGm	haSG	haplic Stagnosol Stagnosols	26	653.67	0.82
PRk	cmcaLP	cambic calcaric Leptosol	42	1747.16	2.20
PRkr	cmarLP	cambic arenic Leptosol	10	391.65	0.49
PRm	caLP	calcaric Leptosol	196	6102.57	7.69
PRn	cahuLP	calcaric humic Leptosol	16	997.07	1.26
PRr	arLP	arenic Leptosol	22	419.92	0.53
			286	9658.37	12.17
RNm	haLP	haplic Leptosol	22	133.27	0.17
		Leptosols in total	308	9791.64	12.34
RGp	ceRG	clayic Regosol	140	5585.96	7.03
RGr	haAR	haplic Arenosol	4	189.04	0.24
RGy	skRG	skeletic Regosol	85	3989.93	5.02
		Regosols and Arenosols in total	229	9764.93	12.29
		Reference soil groups of the WRB in total	1 840	79 407.70	100.00

WRB – Word Reference Base; TKSP CR – Taxonomic Soil Classification System of the Czech Republic

The Czech version of the international project SOTER methodology (CZESOTER 1:250 000) defines the dominant SOTER units, which places Rendzinas and Pararendzinas into a common category (marked as v) and allows also other parent materials than limestone and dolomite. It corresponds to WRB recommendations, which in no way prescribes to combine Rendzina only with limestone as the parent material: "A basic principle in soil mapping is that the soil surveyor designs the legend of the map so as to best suit the purpose of the survey. If the WRB is designed to support small-scale mapping of the global soil landscapes, it would be advantageous to have a structure that lends itself to support such overview maps. Hence, the discussion on the qualifier listings should not be held in isolation of the overview maps of the soils of the world or the continents in the WRB. Therefore, it is suggested that the WRB qualifiers be linked to small-scale soil maps as follows: prefix qualifiers for mapping between $1/5*10^6$ and $1/10^6$ scale; suffix qualifiers for mapping between $1/10^6$ and $1/250*10^3$ scale" (IUSS Working Group WRB 2006: 7 and e.g. 54, 60, 84–85, 88). The more so in maps with the middle and detailed scales, which are left to national classifications: "For larger mapping scales, it is suggested that, in addition, national or local soil classification systems be used. They are designed to accommodate local soil variability, which can never be accounted for in a world reference base" (IUSS Working Group WRB 2006). Rendzina should not be limited only to limestone.

A digital database of the primary and selected pits in the Litoměřice district and laboratory analyses of the pits from the 2006 soil survey have been used to examine the properties of the soils classified in the GAK KPZP as Rendzinas, and the properties of the soil types and subtypes into which Rendzinas are reclassified in the valid TKSP CR system.

It is necessary to solve the numerous problems which have appeared in the soil reclassification into the TKSP CR because there is no doubt about the importance of the archive KPZP data, about the possibilities of their updating and utilisation in digital mapping; and especially in digital mapping is it necessary to reach a high conversion accuracy between the previous and the valid soil classification systems.

As the pilot district of Litoměřice was the first one to be mapped by means of SOTER methodology on the middle scale, the SOTER soil map highlights the dominant SOTER units containing the given soil type (Figure 5).

The above discussed issue of classification and reclassification of Rendzina is summarised at the end of the article in the form of an extract from the draft of the soils and parent materials convertor.

RESULTS AND DISCUSSION

As follows from Table 1, after the reclassification of Rendzinas from the GAK KPZP into the TKSP CR, the soil type has been not recognised in the Litoměřice district. The following map of TKSP CR-reclassified soils (Figure 2) highlights the soil type most resembling Rendzina found in the district – Pararendzina, which was not defined in the former genetic-agronomic soil classification at all.

When converting the Litoměřice district pits from the GAK KPZP into the TKSP CR, the following occurred:

- Trouble-free conversions, in which the soil pits classified according to the valid system were as exact as the former classification or more exact;
- Conversions which, in order to be re-classifiable, suppressed some of the properties and characteristics of a profile and emphasised others, although in the former classification they were equal;
- Profiles whose reclassification was impossible because TKSP CR does not allow some subtypes of Rendzina soil type to possess a certain property or characteristics.

Examples of a relatively trouble-free conversion as to the existence of a comparable subtype in the valid system are: Rendzina (typic) RA (WRB: rendzic Leptosol – rzLP) converted into Rendzina modal, Rendzina dark RAt (WRB: melani-rendzic Leptosol – merzLP) presently as Rendzina melanic, Rendzina brown RAh (WRB: rhodi-rendzic Leptosol – rorzLP) as Rendzina cambic or flood-plain Rendzina (WRB: melani-dystri-rendzic Leptosol – medyrzLP) RAl as Rendzina melanic and leached (examples No. 1–4 in Table 4).

The conversions which failed to represent the profile properties to the same extent as in the former classification are shown by Sládková (2008) in Table 1. These are again Rendzina (typic), dark, and brown, but in the situation after the

Table 2. Results of laboratory analysis concerning a soil pit from the soil survey of Litoměřice district in 2006

		Pit No. 3 horizon				
		Ad	Ak_1	Ak_2	ACk	C
Soil properties and characteristics	Clay < 0.001 mm (%)	36.1	37.5	39.8	36.1	31.6
	Clay < 0.002 mm (%)	46.9	48.7	51.2	47.8	44.2
	Part. size I < 0.01 mm (%)	70.6	71.2	75.8	73.0	70.3
	< 0.02 mm (%)	80.0	80.4	84.3	83.1	79.0
	< 0.05 mm (%)	91.9	92.6	94.6	94.2	91.8
	Part. size II 0.01–0.05 mm (%)	21.3	21.5	18.9	21.1	21.5
	Part. size III 0.05–0.25 mm (%)	6.4	6.3	4.7	5.4	7.9
	Part. size IV 0.25–2 mm (%)	1.7	1.0	0.7	0.5	0.4
	pH active (–)	7.74	7.78	7.83	8.02	8.12
	pH potential exchangeable (–)	7.30	7.35	7.42	7.48	7.67
	Carbonates (%)	32.0	32.0	33.0	42.0	52.0
	Cox (%)	1.66	1.48	1.26	1.06	0.50
	θ_{mom} (% mass)	14.33	–	–	–	–
	θ_{mom} (% vol.)	23.37	–	–	–	–
	θ_{MKK} (% vol.)	25.72	–	–	–	–
	ρ_z (g/cm^3)	2.64	–	–	–	–
	$\rho_{d\ red}$ (g/cm^3)	1.63	–	–	–	–
	P (% vol.)	38.26	–	–	–	–
	Vz (% vol.)	14.89	–	–	–	–
	K_{MKKVZ} (% vol.)	12.54	–	–	–	–
	θ_{ns} (% vol.)	37.97	–	–	–	–
	θ_{BV} (% vol.)	5.9	–	–		
Potential (cmol/kg)	CEC	26.79	26.55	26.83	23.41	19.12
	S	34.30	34.05	34.61	31.83	27.52
	K	0.90	0.70	0.60	0.56	0.52
	Na	0.48	0.47	0.50	0.49	0.49
	Mg	0.94	1.07	1.06	1.01	0.93
	Ca	31.89	31.69	32.31	29.67	25.47
	Al	0.09	0.12	0.14	0.10	0.11
Efficient (cmol/kg)	ECEC	29.19	28.87	32.07	28.86	20.56
	S	33.52	34.00	36.55	31.55	24.87
	K	0.87	0.76	0.69	0.62	0.58
	Na	0.58	0.60	0.62	0.62	0.61
	Mg	1.06	1.15	1.15	1.16	1.06
	Ca	30.98	31.40	34.03	29.09	22.53
	Al	0.03	0.09	0.06	0.06	0.09

Potential – extract of 0.01M $BaCl_2$ buffered by TEA to pH 8.1; Efficient – extract of not buffered 0.01M $BaCl_2$

assignment of particular parent materials occurring in the area of Litoměřice district. Rendzina (typic) RA: on calcareous sandstones it belongs to Regozem arenic RGr; on calcareous clays and on loess covering loamy sands and gravelled sands it is included in Chernozem modal CEm; on clays it is covered by Pelozem modal PEm; on mixed slope deposits it is included in Regozem pelic RGp.

The conversions of Rendzina dark RAt are also worth noting: on arenaceous marls and hard calcareous marls it involves under Pararendzina melanic PRn, on mixed slope deposits under Regozem

Table 3. The dominant SOTER units with Rendzina and Pararendzina according to soil map SOTER at the scale 1:50 000 for Litoměřice district

Dominant SOTER units Rendzina, Pararendzina – v	Signature (in PUGIS CULS)	Area (ha)
On sedimentary rocks, medium wastes – 18	LD18v	1378.12
	LF18v	4074.12
	LL18v	3182.46
	in total	8634.70
On bench gravel sands, sands, earthenware or to shallow loess overlaid terraces – 01	LD01v	333.07
	LF01v	455.54
	LL01v	22.96
	in total	811.16
Area (ha) in total i.e. 11.82% a.l. of the district		9 445.86

LD – dissected lowlands; LF – flat lowlands; LL – lowlands

pelic RGp (the decisive criterion was the need to emphasise the parent material; humus in topsoil horizon was not considered). Other conversions can reclassify Rendzina brown RAh: on arenaceous marls and hard calcareous marls it is classified as Pararendzina cambic PRk, on calcareous sandstones as parent material (Regozem arenic, which would be preferable for calcareous sandstones in terms of the soil texture, does not allow cambic horizon) it is classified as Regozem psefitic RGy, as is the case with non-loamy sands and gravelled sands on arenaceous marls and hard calcareous marls; on calcareous marls it is classified as Pelozem modal PEm (pelic horizon is a harder-soil-texture analogue of cambic horizon), just like on mixed slope deposits (ex. No. 5–15 in Table 4).

The solution to the problems mentioned below in conversions of RAt 9, Rendzina dark on mixed slope deposit, RAh 15, Rendzina brown on calcareous marl, RAh 19, Rendzina brown on calcareous sandstone and RA 23, Rendzina (typic) on arenaceous marl, has been already validated by laboratory analyses of soil samples in the Central laboratories of the Research Institute for Soil and Water Conservation in Prague and can be considered as acceptable for the incorporation into the valid system:

– RAt 9 → RGp, ..., Regozem pelic on mixed slope deposit – it is recommended to add a symbol for mixed slope deposit into the valid system;
– RAh 15 → RGp, SN, Regozem pelic on calcareous clay – the characteristics of Regozem pelic do not allow the existence of Bv-horizon – it is recommended to incorporate it into the system;
– RA 19 → PRr, PSc, Pararendzina arenic on calcareous sandstone – its classification as Regozem arenic can be unambiguously ruled out;
– RAh 19 → PRkr, PSc, Pararendzina cambic and arenic on calcareous sandstone – its classification as Regozem cambic and arenic can be unambiguously ruled out;
– RA 23 → PRm, O, Pararendzina modal on arenaceous marl – it should be emphasised that it is possible to determinate a modal subtype of Pararendzina on arenaceous marl only after the condition of appropriate particle size distribution is met – pH (sandy loam), H (loam), rH (silty loam), R (silt);
– RA 23 → PRr, O, Pararendzina arenic on arenaceous marl – it should be emphasised that it is possible to determine an arenic subtype of Pararendzina on arenaceous marl only after the condition of appropriate particle size distribution is met – P (sand), hP (loamy sand).

Some former Rendzinas have thus been transferred into Regozem and Pararendzina. In this respect, it is necessary to consider the parameters of the Regozem type (eventually Pararendzina) – to what degree is this soil type ready to accommodate part of the profiles of former Rendzinas:

– If the valid classification in practice requires the classification of part of former Rendzinas and sod soils as Regozems, a carbonated variety should be delimited in this soil type, as the requirement of more than 3% of carbonates throughout the profile (Němeček *et al.* 2001) for a carbonated subtype is too strict. Moreover,

Table 4. The sample from the work version of the convertor of soils and parent materials concerning to Rendzinas

Genetic-agronomic classification (1967)			Taxonomic Soil Classification System of the Czech Republic (2001)		
Parent material		soil sign.	parent material		soil sign.
Number	description		sign.	description	
Subtype: Rendzina (typic)		RA	**type: Rendzina, subtype: modal**		RZm No. 1
Rocks with high content of one or more mineral nutrients					
06	basic igneous rocks (many 2+ bases) – basalt, basanite, diabase, melaphyr, spilite	RA	uVV (Č), bVV (DB, MF, ST)	slope deposits from weathered ultrabasic magmatic rocks (basalt) and basic magmatic rocks (diabase, melaphyr, spilite)	CEmc
08	tuffs and tuffites from basic igneous rocks (many 2+ bases)	RA	bTF, TT	tuffs and basic ashes, tuffites	CEmc
Sediments with medium content of $CaCO_3$					
14	cretaceous arenaceous marls and hard marlites of Chernozems (Ch)	RA	O, SC	arenaceous marls, marlites	PRm
14/15	cretaceous arenaceous marls and hard marlites of Ch/cretaceous calcareous sandstones of Ch	RA	O, SC/PSc	arenaceous marls, marlites/calcareous sandstones	PRm
14/16	cretaceous arenaceous marls and hard marlites of Ch/cretaceous calcareous clays	RA	O, SC/SN	arenaceous marls, marlites/calcareous marls	PRm
14-16	cretaceous arenaceous marls and hard marlites of Ch-cretaceous calcareous clays	RA	O, SC-SN	arenaceous marls, marlites-calcareous marls	PRm
14/59	cretaceous arenaceous marls and hard marlites of Ch/terraces mainly from acid material	RA	O, SC/kHP	arenaceous marls, marlites/polygenetic acid loams	RGya’
14-59	cretaceous arenaceous marls and hard marlites of Ch-terraces mainly from acid material	RA	O, SC-kHP	arenaceous marls, marlites-polygenetic acid loams	RGya’
14/71	cretaceous arenaceous marls and hard marlites of Ch/siliceous and kaolinitic cuboidal sandstones	RA	O, SC/PSq, PSk	arenaceous marls, marlites/siliceous sandstones, kaolinitic, cuboidal sandstones	PRt
15	cretaceous calcareous sandstones of Ch	RA	PSc	calcareous sandstones	RGcr No. 5
15-24	cretaceous calcareous sandstones of Ch-medium loesses	RA	PSc-SP	calcareous sandstones-loesses	RGcr
16	cretaceous calcareous clays	RA	SN	calcareous marls	CEmcp No. 6 No. 26
16-14	cretaceous calcareous clays-cretaceous arenaceous marls and hard marlites of Ch	RA	SN-O, SC	calcareous marls-arenaceous marls, marlites	CEmc
24/14	medium loesses/cretaceous arenaceous marls and hard marlites of Ch	RA	SP/O, SC	loesses/arenaceous marls, marlites	CEmc

Genetic-agronomic classification (1967)			Taxonomic Soil Classification System of the Czech Republic (2001)		
Parent material		soil sign.	parent material		soil sign.
Number	description		sign.	description	
25/59	white loesses/terraces mainly from acid material	RA	SP/kHP	loesses/polygenetic acid loams	CEm No. 7
25-59	white loesses-terraces mainly from acid material	RA	SP-kHP	loesses-polygenetic acid loams	CEm
Not calcareous or weakly calcareous Quaternary deposits					
59	terraces mainly from acid material	RA	kHP	polygenetic acid loams	RGya’
59/14	terraces mainly from acid material/cretaceous arenaceous marls and hard marlites of Ch	RA	kHP/O, SC	polygenetic acid loams/arenaceous marls, marlites	RGya’
59-14	terraces mainly from acid material-cretaceous arenaceous marls and hard marlites of Ch	RA	kHP-O, SC	polygenetic acid loams-arenaceous marls, marlites	RGya’
59-16	terraces mainly from acid material-cretaceous calcareous clays	RA	kHP-SN	polygenetic acid loams-calcareous marls	RGya’
Slope deposits					
63a	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material	RA	SC	slope deposits from weathered marlites (Litoměřice district – LT)	CEcp No. 27
63a/14	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material/cretaceous arenaceous marls and hard marlites of Ch	RA	SC/O, SC	slope deposits from weathered marlites (LT)/arenaceous marls, marlites	RGcp
63a/16	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material/cretaceous calcareous clays	RA	SC/SN	slope deposits from weathered marlites (LT)/calcareous marls	CEcp No. 28
63a/24	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material/medium loesses	RA	SC/SP	slope deposits from weathered marlites (LT)/loesses	CEcp No. 29
63a/59	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material/terraces mainly from acid material	RA	SC/kHP	slope deposits from weathered marlites (LT)/polygenetic acid loams	RGpa’ No. 8
63b	slope deposits, heavy loams to clayey sands with smaller skeleton, from basic material	RA	bVV	slope deposits from weathered basic magmatic rocks	RGpe’

Table 4 to be continued

Genetic-agronomic classification (1967)			Taxonomic Soil Classification System of the Czech Republic (2001)		
Parent material		soil sign.	parent material		soil sign.
Number	description		sign.	description	
Subtype: Rendzina (typic), phase: accumulated		RA ak	**type: Rendzina, subtype: modal, accumul. phase: accumulated**		RZm ak
Sediments with medium content of $CaCO_3$					
14	cretaceous arenaceous marls and hard marlites of Ch	RA ak	O, SC	arenaceous marls, marlites	PRm ak
Slope deposits					
63a	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material	RA ak	SC	slope deposits from weathered marlites (LT)	CEcp ak
Subtype: Rendzina (typic), phase: denuded		**RA sm**	**type: Rendzina, subtype: modal, degradation phase: denuded**		**RZm sm**
Sediments with medium content of $CaCO_3$					
16	cretaceous calcareous clays	RA sm	SN	calcareous marls	CEmcp sm
Slope deposits					
63a	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material	RA sm	SC	slope deposits from weathered marlites (LT)	CEcp sm
Variety: R. (t.) and dark		RAt	**type: Rendzina, subtype: melanic**		RZn No. 2
Sediments with medium content of $CaCO_3$					
14	cretaceous arenaceous marls and hard marlites of Ch	RAt	O, SC	arenaceous marls, marlites	PRn No. 9
14/16	cretaceous arenaceous marls and hard marlites of Ch/cretaceous calcareous clays	RAt	O, SC/SN	arenaceous marls, marlites/calcareous marls	PRn
14-27	cretaceous arenaceous marls and hard marlites of Ch-terraces mainly from carbonated material	RAt	O, SC-cHP	arenaceous marls, marlites-polygenetic carbonated loams	PRn
16	cretaceous calcareous clays	RAt	SN	calcareous marls	CEmcp No. 30
Not calcareous or weakly calcareous Quaternary deposits					
59-14	terraces mainly from acid material-cretaceous arenaceous marls and hard marlites of Ch	RAt	kHP-O, SC	polygenetic acid loams-arenaceous marls, marlites	RGya’
59-16	terraces mainly from acid material-cretaceous calcareous clays	RAt	kHP-SN	polygenetic acid loams-calcareous marls	RGya’
59-25	terraces mainly from acid material-white loesses	RAt	kHP-SP	polygenetic acid loams-loesses	RGya’

Genetic-agronomic classification (1967)			Taxonomic Soil Classification System of the Czech Republic (2001)		
Parent material		soil sign.	parent material		soil sign.
Number	description		sign.	description	
Slope deposits					
63a	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material	RAt	SC	slope deposits from weathered marlites (LT)	CEcp No. 31
63a/14	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material/cretaceous arenaceous marls and hard marlites of Ch	RAt	SC/O, SC	slope deposits from weathered marlites (LT)/ arenaceous marls, marlites	RGcp No. 10
63a/16	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material/creaceous calcareous clays	RAt	SC/SN	slope deposits from weathered marlites (LT)/ calcareous marls	CEcp No. 32
63a/25	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material/white loesses	RAt	SC/SP	slope deposits from weathered marlites (LT)/ loesses	CEcp No. 33
Variety: R. (t.) and slightly stagnic		RA(g)	this soil equivalent not exists in the TKSP CR (2001) No. 16		
Slope deposits					
63a	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material	RA(g)	SC	slope deposits from weathered marlites (LT)	CEcpg’
Variety: R. (t.) and slightly gleyic		RA(G)	this soil equivalent not exists in the TKSP CR (2001) No. 17		
Slope deposits					
63a	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material	RA(G)	SC	slope deposits from weathered marlites (LT)	RGqcp
Subtype: R. brown		RAh	**type: Rendzina, subtype: cambic**		RZk No. 3
Rocks with high content of one or more mineral nutrients					
06	basic igneous rocks (many 2+ bases) – basalt, basanite, diabase, melaphyr, spilite	RAh	uVV (Č), bVV (DB, MF, ST)	slope deposits from weathered ultrabasic magmatic rocks (basalt) and basic magmatic rocks (diabase, melaphyr, spilite)	PEme’
Sediments with medium content of $CaCO_3$					
14	cretaceous arenaceous marls and hard marlites of Ch	RAh	O, SC	arenaceous marls, marlites	PRk No. 11
15	cretaceous calcareous sandstones of Ch	RAh	PSc	calcareous sandstones	RGcy No. 12
16	cretaceous calcareous clays	RAh	SN	calcareous marls	PEme’ No. 14
24	medium loesses	RAh	SP	loesses	CEm

Table 4 to be continued

Genetic-agronomic classification (1967)			Taxonomic Soil Classification System of the Czech Republic (2001)		
Parent material		soil sign.	parent material		soil sign.
Number	description		sign.	description	
Not calcareous or weakly calcareous Quaternary deposits					
59-14	terraces mainly from acid material-cretaceous arenaceous marls and hard marlites of Ch	RAh	kHP-O, SC	polygenetic acid loams-arenaceous marls, marlites	RGya' No. 13
Slope deposits					
63a	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material	RAh	SC	slope deposits from weathered marlites (LT)	PEme'
63a/14	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material/cretaceous arenaceous marls and hard marlites of Ch	RAh	SC/O, SC	slope deposits from weathered marlites (LT)/ arenaceous marls, marlites	PEme'
63a/59	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material/terraces mainly from acid material	RAh	SC/kHP	slope deposits from weathered marlites (LT)/ polygenetic acid loams	PEma' No. 15
63b	slope deposits, heavy loams to clayey sands with smaller skeleton, from basic material	RAh	bVV	slope deposits from weathered basic magmatic rocks	PEme'
63b/16	slope deposits, heavy loams to clayey sands with smaller skeleton, from basic material/cretaceous calcareous clays	RAh	bVV/SN	slope deposits from weathered basic magmatic rocks/ calcareous marls	PEme'
Subtype: R. brown, phase: accumulated		RAh ak	**type: Rendzina, subtype: cambic, accumul. phase: accumulated**		RZk ak
Slope deposits					
63a	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material	RAh ak	SC	slope deposits from weathered marlites (LT)	PEme' ak
Variety: R- brown and slightly stagnic		RAh(g)	this soil equivalent not exists in the TKSP CR (2001) No. 22		
63a	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material	RAh(g)	SC	slope deposits from weathered marlites (LT)	PEmg'e'
Variety: R. brown and slightly gleyic		RAh(G)	this soil equivalent not exists in the TKSP CR (2001) No. 23		
Slope deposits					
63a/16	slope deposits, heavy loams to clayey sands with smaller skeleton, from carbonated material/cretaceous calcareous clays	RAh(G)	SC/SN	slope deposits from weathered marlites (LT)/ calcareous marls	PEm-e'

Subtype: R. anthropogenic		RAan	**type: Antropozem**		AN
Genetic-agronomic classification (1967)			Taxonomic Soil Classification System of the Czech Republic (2001)		
Parent material		soil sign.	parent material		soil sign.
Number	description		sign.	description	
Subtype: flood – plain R.		RAl	**type: Rendzina Interfer. of subtypes: melanic and leached**		RZnv No. 4
Sediments with medium content of $CaCO_3$					
14	cretaceous arenaceous marls and hard marlites of Ch	RAl	O, SC	arenaceous marls, marlites	PRnv
Subtype: R. stagnic		RAg	this soil equivalent not exists in the TKSP CR (2001) No. 19		
Sediments with medium content of $CaCO_3$					
16	cretaceous calcareous clays	RAg	SN	calcareous marls	CExcp
Subtype: R. gleyic		RAG	this soil equivalent not exists in the TKSP CR (2001) No. 21		
Interfer.: R. (typic) and stagnic		RAg	this soil equivalent not exists in the TKSP CR (2001) No. 18		
Interfer.: R. (typic) and gleyic		RAG	this soil equivalent not exists in the TKSP CR (2001) No. 20		
Interfer.: R. brown and stagnic		RAhg	this soil equivalent not exists in the TKSP CR (2001) No. 24		
Slope deposits					
63c/16	slope deposits, heavy loams to clayey sands with smaller skeleton, from acid material/cretaceous calcareous clays	RAhg	kVV/SN	slope deposits from weathered acid magmatic rocks/calcareous marls	PEg
Interfer.: R. brown and gleyic		RAhG	this soil equivalent not exists in the TKSP CR (2001) No. 25		

the other categories in the system do not always allow distinguishing the influence of the parent material with and without carbonates.

– For the reason mentioned above – the relocation of former Rendzinas and sod soils – it is possible to recommend also the introduction of a melanic subtype to Regozem. It is often impossible to make a compromise and place soils in Pararendzinas, considering the inappropriate parent material.

– It is recommended do not bound medium parent materials by the absence of carbonates (modal Regozem has to originate from medium parent materials without carbonates – Němeček *et al.* 2001), because then a modal subtype cannot be defined on loess, calcareous terraces etc., even if the other soil characteristics agree with this classification.

– If the sialitisation process is manifested in Regozems on light or hard parent materials, it is impossible to mark the corresponding subtypes 'arenic' and 'pelic' because brown metamorphic horizon is forbidden for these subtypes (Bv absence – Němeček *et al.* 2001).

As stated by Sládková (2008), the conversions of the soil types and subtypes from the former one into the valid classification system, which does not consider the parent materials, show that there are Rendzina profiles in the Litomerice district with no equivalent subtype or variety in the TKSP CR. From Rendzinas they are in particular: Rendzina (typic) and slightly stagnic RA(g) (WRB: hypostagni-rendzic Leptosol – wstrzLP), and (typic) and slightly gleyic RA(G) (WRB: hypogleyi-rendzic Leptosol – wglrzLP), (typic) and stagnic as interference of subtypes and stagnic as a subtype – RAg (WRB: stagni-rendzic Leptosol – strzLP), (typic) and gleyic as interference of subtypes and gleyic as a subtype – RAG (WRB: gleyi-rendzic Leptosol – glrzLP), followed by Rendzina brown and slightly stagnic RAh(g) (WRB: hypostagni-rhodi-rendzic Leptosol – wstrorzLP), Rendzina brown and slightly gleyic RAh(G) (WRB: hypogleyi-rhodi-rendzic Leptosol – wglrorzLP), Rendzina brown and stagnic RAhg (WRB: stagni-rhodi-rendzic Leptosol – strorzLP), and Rendzina brown and gleyic RAhG (WRB: gleyi-rhodi-rendzic Leptosol – glrorzLP) (example 16–25 in Table 4). The question is to what degree the features of mottling and gleying process should be representative. Every generalisation should be carefully accounted for and the reasons should be published.

Figure 3. Detail of a typographical map – Slatina

By far the largest practical problem of Rendzinas classification, however, seems to be the soil type boundedness to limestone as the parent material. Some Rendzinas in the GAK could be Rendzinas also in the more general TKSP CR, were it not for the restriction on parent material. Cf. Němeček *et al.* (1967) with Němeček *et al.* (2001), with the pit No. 3 in Figure 4, and example No. 26–33 in Table 4. It is possible to extend the parent materials admissible for Rendzina (ex. calcareous clay or carbonated slope deposit).

The pits of the 2006 soil survey also focused on the inaccuracies in the valid classification system, particularly on the changes in Rendzinas classification, on the refinement of Chernozems parameters, on a more accurate differentiation between the soil types Rendzina and Chernozem, and on the completion of the data for the new type Pelozem. For examples serve pits No. 3, 8, 9.

Pit No. 3: Location – cadastre Slatina, coordinates: X-764.869,76; Y-1.000.306,30
Map sheet: Libochovice 5-0
Classification – GAK KPZP: RA 16
Classification – TKSP CR: RZ, SN
Soil profile: Ad-Ap1-Ap2-AC-C

Soil profile stratigraphy:	GAK KPZP	TKSP CR	WRB
0–19 cm	d	Ad	A
19–34 cm	H1	Ak1	A
34–46 cm	H2	Ak2	A
46–54 cm	H/P	ACk	AC
> 54 cm	P	C	C

Reasons for the selection:

– Profile characteristics correspond to Rendzina also according to the new system, only the parent material does not → it is proposed to combine

Figure 4. Profile appearance in the pit No. 3

Rendzina in TKSP also with other parent materials, not only with limestone.
– The research into local ultrabasic hard-textured parent materials.
– The same parent material as in pit No. 1 and the vicinity of pits No. 1 and 2 (similar conditions).

Figure 3 represents a detail of the map around the pit No. 3; Figure 4 visualises the profile of the pit No. 3.

Pit No. 8

Reasons for the selection:
– The change in the classification of former Rendzinas.
– The collection of the material for the soil type which is newly defined in the TKSP CR without any predecessors in older Czech soil classification systems.
– Carbonate content over 5% throughout the profile → it is proposed to define a new subtype Pelozem calcareous.
– The research into local ultrabasic hard-textured parent materials.
– A part of the district was mapped incorrectly in the General survey of agricultural soils (there are flood-plain soils according to the archive groundwork).

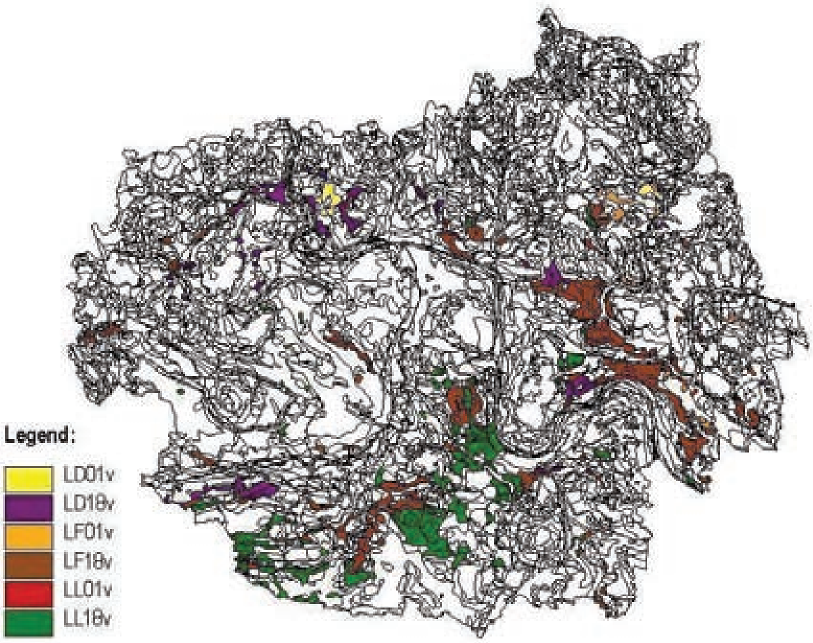

Figure 5. Dominant SOTER units including Rendzinas and Pararendzinas on the soil map SOTER at the scale 1:50,000 of Litoměřice district

Table 5. Soil conversions from the Czech soil classification systems to the WRB

Genetic-agronomic classification (1967)	Taxonomic Soil Classification System of the Czech Republic (2001)	World Reference Base (1998, 2006)
Rendzina (typic)s	Rendzina modal	rendzic Leptosol – rzLP
Rendzina (typic) and accumulated	Rendzina modal and accumulated	cumulirendzic Leptosol – crzLP
Rendzina (typic) and denunded	Rendzina modal and denunded	moderately eroded rendzic Leptosol – d3rzLP
Rendzina (typic) and dark	Rendzina melanic	melani-rendzic Leptosol – merzLP
Rendzina (typic) and slightly stagnic	–	hypostagni-rendzic Leptosol – wstrzLP
Rendzina (typic) and slightly gleyic	–	hypogleyi-rendzic Leptosol – wglrzLP
Rendzina brown	Rendzina cambic	rhodi-rendzic Leptosol – rorzLP
Rendzina brown and accumulated	Rendzina cambic and accumulated	cumulirhodi-rendzic Leptosol – crorzLP
Rendzina 'brown and slightly stagnic'	–	hypostagni-rhodi-rendzic Leptosol – wstrorzLP
Rendzina brown and slightly gleyic	–	hypogleyi-rhodi-rendzic Leptosol – wglrorzLP
Rendzina anthropogenic	Antropozem	technic Leptosol – teLP
flood – plain Rendzina	Rendzina melanic and leached	melani-dystri-rendzic Leptosol – medyrzLP
Rendzina stagnic	–	stagni-rendzic Leptosol – strzLP
Rendzina gleyic	–	gleyi-rendzic Leptosol – glrzLP
Rendzina (typic) and stagnic	–	stagni-rendzic Leptosol – strzLP
Rendzina (typic) and gleyic	–	gleyi-rendzic Leptosol – glrzLP
Rendzina brown and stagnic	–	stagni-rhodi-rendzic Leptosol – strorzLP
Rendzina brown and gleyic	–	gleyi-rhodi-rendzic Leptosol – glrorzLP

Pit No. 9

Reasons for the selection:

– The change in the classification of former Rendzinas.
– The research into local ultrabasic hard-textured parent materials.
– A part of the district was mapped incorrectly in the General survey of agricultural soils (there are flood-plain soils according to the archive groundwork).

Table 2 features the results of laboratory analyses concerning the pit No. 3.

The dominant SOTER units on the soil map SOTER including the discussed soil type are highlighted (Figure 5) and described (Table 3).

What follows is an extract from the draft version of the convertor of soils and parent materials related to Rendzinas (Table 4). Table 5 includes the soil conversions from the Czech soil classification systems to the WRB.

The article is a contribution to the discussion on the need for further development of the valid soil classification system and increase in its precision with regard to practical needs as well as the possibility of using the data from the original, more detailed system, which has been used for a long time and has proved suitable for the practice. At the same time, it is necessary to preserve the interconnection between the valid system, the international classification WRB system, and the international project SOTER.

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