

Acta Geodyn. Geomater., Vol. 14, No. 4 (188), 463–474, 2017 DOI: 10.13168/AGG.2017.0026

journal homepage: https://www.irsm.cas.cz/acta



ORIGINAL PAPER

CORRENSITE IN ALBIC LUVISOL AT PODMOKLY (KŘIVOKLÁTSKO PROTECTED LANDSCAPE AREA, CZECH REPUBLIC)

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ABSTRACT

ARTICLE INFO

Article history: Received 30 June 2017 Accepted 18 October 2017 Available online 8 November 2017

Keywords:

Skryje-Týřovice Basin Buchava Formation Albic Luvisol Loess Volcanic rocks Clay minerals Corrensite The study was performed in the territory of the Skryje-Týřovice Basin, in the Buchava Formation. The study area falls within the Křivoklátsko Protected Landscape Area. Samples were collected from Albic Luvisol. Parent material was characterized on the basis of thin section study. Soil development was evaluated by parameters such as macromorphological analysis, particle size distribution, pH, base saturation, cation exchange capacity, soil organic matter and mineral composition of clay fraction. Results of the analyses, especially the thickness of Bt horizon and distribution of clay fraction in the soil profile, confirm the process of intensive pedogenetic clay differentiation. Trioctahedral 1:1 regularly interstratified mineral (R=1) containing chlorite and smectite layers (low-charge corrensite) was described for the first time in the soils of the Czech Republic. Corrensite was detected in the Ah horizon of Albic Luvisol under weakly acid reaction conditions in the increasing amount of organic matter using the X-ray diffraction analysis. The distribution of clay minerals in Albic Luvisol showed that soil development is influenced by loess and also volcanic rocks in the lower part of the profile.

INTRODUCTION

The mineral composition of soils is complicated and closely linked with the parent material. The presence of corrensite in soils has not been frequently mentioned, and has not been particularly well described. Reynolds (1988) characterized corrensite as a trioctahedral, 1:1 regularly interstratified mineral (R=1), containing chlorite and smectite layers (lowcharge corrensite) or chlorite and vermiculite lavers (high-charge corrensite). This mineral is the second most widespread mixed structure of chlorite. Corrensite was artificially prepared by Caliére and Hénin (1949). As a chloritic clay mineral of unusual type, corrensite in a natural system was documented from the Triassic in England (Stephen and MacEwan, 1951). This structure was first described under the name corrensite by Lippmann (1954) from the Triassic in Germany. Lipmann (1956) also determined other finds, showing that this mineral comes from different stratigraphic member within the Triassic. Then, this mineral was reported in other papers (Lucas and Ataman, 1968; Braitsch, 1971). Corrensite was accepted as a specific, regularly interstratified clay mineral after thirty years (Bailey, 1982). The occurrence of corrensite in soils was reported by only

a few papers (Johnson, 1964; Miles and de Kimpe, 1988; Carnicelli et. al., 1997; Righi et al., 1999; Bain and Griffen, 2002; Bain, 2007).

The presence of corrensite has not been reported yet from soils of the Czech Republic. The aim of this study was therefore to characterize the conditions of the presence of corrensite in soils developed on loess in the Skryje-Týřovice Basin, which lies in the Křivoklátsko Protected Landscape Area.

GEOLOGICAL SETTING

The closest vicinity of the village of Podmokly is formed by rocks of Proterozoic age of the Barrandian area. The oldest of them are Upper Proterozoic (Ediacaran) in age. They are mostly represented by greywackes, siltstones and claystones. Siltstones and claystones are dominated by quartz, feldspars, muscovite and high-crystallinity illite.

Proterozoic rocks of the Kralupy group are overlain by marine sediments of Skryje-Týřovice Basin, formed by sedimentary and igneous rocks of Cambrian age (Fig. 1). They are exposed in a significant strip elongated NE–SW in the northwestern part of the Paleozoic of the Teplá-Barrandian region. The sedimentary sequence consists

Cite this article as Žigová A, Šťastný M, Novák F, Hájek P, Šrein V: Corrensite in Albic Luvisol at Podmokly (Křivoklátsko Protected Landscape Area, Czech Republic). Acta Geodyn. Geomater., 14, No. 4 (188), 463–474, 2017. DOI: 10.13168/AGG.2017.0026



Fig. 1 Geological map of the wider area. The study area is marked by a frame (modified from Kachlík, 2003).

of several lithotypes of the Buchava Formation (Fatka et al., 2011) – see Figure 2. The thickness of sediments in the Skryje area reaches 250 m and decreases to a few tens of meters towards the NE (Havlíček, 1971). The Skryje-Týřovice Basin includes the Mileč Member, the Slapnice Member and the Skryje Member.

The Mileč Member is represented by granule to cobble conglomerates, breccias and by sandstones dominated by quartz (Kukal, 1971; Fatka et al., 2011). This member has a small thickness and is located in the central and northeastern parts of the basin. The Slapnice Member consists of conglomerates whose clasts include shales, sandstones, spilites, silicites and other rocks of Proterozoic and Cambrian age (Kukal, 1971). This member also includes sandstones and siltstones. It is exposed in the NE part of the basin. The Skryje Member is dominated by claystones, siltstones and occasional sandstones (Kukal, 1971). Besides clay minerals, these rocks also contain quartz and feldspar (Fatka et al., 2011).

The Buchava Formation is covered with volcanic rocks of andesite and rhyolite-dacite type and their tuffs (Mašek et al., 1997). This ~500 Ma volcanic complex, called the Křivoklát-Rokycany Complex, forms a strip elongated NE–SW (Havlíček, 1980; Drost et al., 2004) – see Figure 3. The oldest rock type is massive dacite (e.g., along the Zbirožský potok Creek) and andesite (e.g., Týřovické skály Cliffs), followed by dacite with phenocrysts and rhyolite (Kohoutov). These rocks are characterized by the smectite type of weathering. Their hardness, strength and resistance to weathering led to the formation of a ridge. Tertiary and Quaternary sediments were described in detail by Ložek and Žák (2011). Sediments of Tertiary age cover only small areas and primarily consist of fluvial sands and gravels. Quaternary deposits are represented mainly by Pleistocene river terraces, loess and related sediments, Pleistocene to Holocene peat-bog and swamp sediments, Pleistocene to Holocene slope sediments, Late Glacial to Early Holocene cemented talus sediments and Holocene tufa.

MATERIAL AND METHODS

The study area lies approximately 80 km to the southwest of Prague, at the altitude of 405 m. Basic information about climate was provided by Quitt (1971). Climatic conditions of this area correspond to the moderately warm region MW11 (140-160 days with mean temperature ≥ 10 °C, 90–100 days with precipitations ≥1 mm and 50-60 days with snow cover). The area is covered by forest consisting predominantly of beech and oak. The most widespread soil types in the Křivoklátsko Protected Landscape Area are Cambic Leptosols, Haplic Cambisols, Albic Luvisols and Luvic Stagnosols (Žigová, 2011). Present research was conducted at a site where soil is developed on loess (Fig. 4), 49°56'32"N and 13°44'21"E. Morphological description and horizon designation follow Jahn et al. (2006). Colors of individual soil horizons were identified using the Munsell Soil Color Charts (2000). Soil was classified according to the World Reference



Fig. 2 A stratigraphic scheme of the Buchava Formation (modified from Vokáč, 2002; Fatka, 2004; Fatka et al., 2011)

Base for Soil Resources (IUSS Working Group WRB, 2015). Samples for soil analyses, except for the O horizon, were collected from the soil profile.

The fraction of 0.125–0.5 mm of the Ck horizon was used for the determination of heavy minerals. Light and magnetic fractions were removed. Heavy minerals were separated using bromoform and methylene iodide (Ewing, 1931; Friedman and Sanders, 1978).

Thin sections of rocks were examined using the OLYMPUS BX51 polarizing microscope with the DP70 digital camera.

Properties of soil horizons, such as the particle size distribution, pH values, CaCO₃ contents, base saturation and cation exchange capacity were determined using the methods of van Reeuwijk (2002). Organic carbon was determined by procedures involving wet combustion of the soil with a mixture of potassium dichromate and sulphuric acid and total nitrogen using the Kjeldahl method. Hot-water extractable carbon determination followed the method of Ghani et al. (2003) with a modification by Krejčová (personal communication, 2006). 50 ml of distilled water were added to 2 g of soil in 100 ml Erlenmeyer bootles in the first stage of preparation. The samples were placed into a dryer for 24 hours at the temperature of 80 °C. In the course of warming, heated samples were stirred five times. Carbon was determined in filtered extracts.

Powder samples of heavy minerals and clay fraction of soils were prepared for X-ray analyses. The analyses of soil samples were preceded by a removal of organic matter by 30 % H₂O₂. Carbonates were removed by 0.1 M chloroacetic acid. The samples were then washed with distilled water. Mineral composition was determined for soil fraction of clay, separated by sedimentation in distilled water, and mounted on oriented slides using the methods of Jackson (1979). The specimens were first studied airdried, and then saturated in ethylene glycol at 80 °C for four hours in a dry box, and finally heated to 550 °C for four hours in a muffle furnace. X-ray diffraction spectra were obtained using the Philips PW 3710 diffractometer under the following working conditions: CuKa radiation, 40 kV, 55 mA, goniometric shift 1° . min⁻¹, 2 Θ . The determination of individual minerals was evaluated according to the Joint Committee on Powder Diffraction Standards (1980). Semiquantitave values were calculated based on the height of individual mineral basal peaks using coefficients correction (Melka, personal communication, 2013).

RESULTS

PETROGRAPHY OF ROCKS

Rocks from the studied locality were subjected to petrographic studies in thin sections.

Andesite (Fig. 5) is formed by microcrystalline groundmass which contains microliths of plagioclase, microscopic grains of pyroxene and opaque mineral. Andesite has porphyritic structure and contains hypidiomorphic phenocrysts of quartz (white), pyroxene (brown) and opaque minerals (black). Pyroxene crystals are altered, affected by chloritization.

Quartzose siltstone (Fig. 6) is very fine-grained with massive irregular structure. The texture is aleuritic with clay-dominated matrix with dispersed A. Žigová et al.



Fig. 3 A simplified geological map of the Buchava Formation in the Skryje-Týřovice Basin around the study area (modified from Mašek et al., 1997; Fatka et al., 2011).

ferruginous cement. The individual silt-sized particles consist mostly of quartz, feldspars and micas. Occasionally, very fine rock fragments are present.

The matrix of loess (Fig. 7) is composed of clay minerals, quartz, micas, feldspars and calcite. Quartz of various sizes occurs in the form of solid or crushed grains. Clay coatings are occasionally present in the matrix. Channels of decomposed roots are filled with calcite. Matrix contains also sparite. Some pores are filled with minute acicular crystals.

The Podmokly area is characterized by andesite, siltstone and loess. At this site, soil cover is developed primarily on loess.

HEAVY MINERALS OF LOESS

Determination of heavy minerals from the Ck horizon was performed with the aim to find possible variations in loess deposition. Samples from this horizon revealed the same minerals, namely goethite, hematite, ilmenite, rutile and anatase. The results showed that loess was deposited in a single, uninterrupted cycle. According to Ložek and Žák (2011) this loess originated in the last Glacial.

SOIL MORPHOLOGY

Morphological description of the studied profile is presented in Table 1. Examination and description of individual horizons provide reliable information on soil morphology. This information serves as the basis



Fig. 4 Soil profile in Albic Luvisol in the study area; each step on the scale bar corresponds 10 cm (photo by A. Žigová).



Fig. 6 A photomicrograph of a thin section of quartzose siltstone (photo by A. Žigová and M. Šťastný).

for soil classification. The thickness of the O horizon is 2 cm; it is dominated by organic material consisting of partially decomposed leaves. Higher abundance of roots was recorded only in the Ah horizon. Other biological features such as insect nests, worm cats etc. were not recorded. The features most important for the classification are the presence of E horizon and abundance of clay illuviation features. Surfaces of individual structural elements were covered by clay



Fig. 5 A photomicrograph of a thin section of andesite (photo by A. Žigová and M. Šťastný).



Fig. 7 A photomicrograph of a thin section of loess (photo by A. Žigová and M. Šťastný).

coatings. These coatings are rare in the EBt horizon and numerous in the Bt horizon. Pseudomycelia and soft concretions occurred only in the Ck horizon. This horizon contains few small fragments of volcanic rocks. Morphological analysis showed that the studied soil profile has higher clay content in the Bt horizon than in the E horizons as a result of pedogenetic processes. The identified relatively high intensity of pedogenetic clay differentiation is typical for Albic Luvisol.

PARTICLE SIZE DISTRIBUTION OF THE SOIL PROFILE

Data on particle size distribution and texture classes are summarized in Table 2. The soil profile is dominated by silt fraction, which is characteristic for soils developed on loess. The proportion of sand fraction is small. Elevated proportion of clay fraction in the Bt horizon indicates the process of pedogenetic clay differentiation. This fact was also documented by the results of morphological analysis. Soil texture classes were evaluated according to Soil Survey Staff (2014). Three texture classes were determined in the studied soil profile. The Ah and Ck horizons were

Horizon	Ah	Е	EBt	Bt	Ck
Depth (cm)	0-15	15-26	26-50	50-111	111-172
Munsell color	10YR 2/2	10YR 5/6	10YR 4/6	7.5YR 4/6	10YR 8/4
Structure	SB	AB	AB	PR	CO
Consistence	FR	FR	FI	VFI	FR
Abundance of roots	С	F	VF	VF	Ν
Clay coatings	Ν	Ν	F	С	Ν
Forms of carbonates	Ν	Ν	Ν	Ν	PM, SC
Boundary distinctness	А	CL	CL	CL	
Boundary topography	S	S	S	S	

 Table 1 Morphological properties of the soil profile.

SB – subangular blocky, AB – angular blocky, PR – prismatic, CO – columnar, FR – friable, FI – firm, VFI – very firm, C – common, F – few, VF – very few, N – none, PM – pseudomycelia, SC – soft concretion, A – abrupt, CL – clear, S – smooth

 Table 2 Particle size distribution in the soil profile.

Depth	Clay	Silt	Sand	Texture class						
cm	%	%	%							
0-15	26.1	55.8	18.1	silt loam						
15-26	29.4	59.4	11.2	silty clay loam						
26-50	32.3	60.9	6.8	silty clay loam						
50-111	44.2	49.1	6.7	silty clay						
111-172	22.0	62.8	15.2	silt loam						
Clay - < 0	Clay - < 0.002 mm, silt - 0.002 - 0.05 mm,									

sand – 0.05–2 mm

classified as silt loam. The E and EBt horizons belong to the silty clay loam category. The Bt horizon corresponds to the silt loam texture class. The distribution by texture classes of individual horizons reflects soil development in this area.

CHEMICAL PROPERTIES AND ORGANIC MATTER IN THE SOIL PROFILE

Data on soil chemical properties and organic matter are summarized in Table 3. The pH values were assessed by the scale of Baize (1993). The studied Albic Luvisol shows a weakly acid reaction in the Ah and Bt horizons. The pH values are acid in the E and EBt horizons and basic in the Ck horizon. Lower values of base saturation were obtained for the E horizon. This value reaches 100 % only in the Ck horizon. The values of cation exchange capacity range from 15.1 to 27.4 mmol⁺/100 g. The highest cation exchange capacity was found in the Bt horizon. The observed trend in the values of cation exchange capacity throughout the profile is probably connected with the content of clay fraction. The results of chemical analyses indicate that soil development of Albic Luvisol proceeded in predominantly acid conditions.

A gradual reduction of total carbon and nitrogen contents was found with increasing soil depth in the studied profile. This is typical for many soils in humid and semi-humid climates. A similar trend was observed in the case of hot-water extractable carbon (C_{hw}) whose contents decrease from 1152 mg/kg in the Ah horizon to 159 mg/kg in the Ck horizon. According to Ghani et al. (2003), this fraction of organic carbon positively correlates with soil microbial biomass C and total contents of carbohydrates in the A horizons. Nevertheless, the increasing Chw/Cox ratio with an increasing soil depth suggests that the highly mobile humus fraction (e.g. fulvic acids) also significantly contributes to the C_{hw} fraction in deeper soil horizons. Other organic C inputs to the subsoil include root exudates and particulates translocated from the upper horizon (Schmidt et al., 2011). The C/N ratio progressively decreased with soil depth, which reflects an increasing contribution of microbial products to the detriment of plant exudates (Torn et al., 2002). Somewhat low C/N values, typical rather for field than forest soils, can indicate relatively high ecosystem saturation by

 Table 3 Chemical properties and organic matter in the soil profile.

Depth	рН _{н20}	рН _{ксі}	CaCO ₃	BS	CEC	Cox	Nt	C/N	C _{hw}	C _{hw}
cm			%	%	mmol ⁺ /100 g	%	%		mg/kg	in % C _{ox}
0-15	5.30	4.10	0	43	19.21	2.26	0.20	11.30	1152.24	4.70
15-26	4.67	3.36	0	30	16.49	0.85	0.11	7.73	581.45	6.06
26-50	4.74	3.34	0	49	17.70	0.36	0.07	5.14	329.69	6.73
50-111	5.10	3.70	0	78	27.44	0.20	0.06	3.33	248.07	6.53
111-172	8.02	7.38	11.5	100	15.13	0.12	0.05	2.40	158.76	7.22

BS – base saturation, CEC – cation exchange capacity, C_{ox} – organic carbon, N_t – total nitrogen,

C_{hw} – hot water extractable carbon

Depth	Со	Sm	Ι	K	Ch	Q	Kf	Plg	Le
cm	%	%	%	%	%	%	%	%	%
0-15	19	0	17	14	0	35	8	7	C
15-26	0	8	18	14	4	37	13	5	1
26-50	0	0	18	17	6	39	10	9	1
50-111	0	7	12	18	8	33	12	10	(
111-172	0	28	12	19	12	25	0	4	C

Table 4 Mineral composition of the clay fraction in the soil profile.

nitrogen. Extremely low C/N ratios in deep horizons (2-3), however, could be due to a less-precision determination of low N concentrations, estimated with the accuracy to one significant digit only.

MINERAL COMPOSITION OF THE SOIL PROFILE

Mineral composition of the clay fraction of the studied Albic Luvisol is given in Table 4. The Ah horizon contains kaolinite and illite, and corrensite appears at the expense of chlorite. This supports one of the theories saying that corrensite originates from degradation of chlorite (Briggati and Poppi, 1984). A very similar mineral composition, except for the absence of smectite in the E horizon, was found in the E and EBt horizons. The Bt horizon is characterized by relatively high contents of K-feldspar and plagioclase. Smectite was also identified in this horizon. The Ck horizon contains relatively high amounts of kaolinite, which was formed by the decomposition of feldspars. Plagioclase contents are lower and K-feldspar is absent from the Ck horizon. The source of the elevated chlorite contents and high proportions of smectite in this horizon are volcanic rocks. The relatively high contents of illite and

kaolinite indicate the influence of loess on pedogenesis.

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All horizons of the studied Albic Luvisol have a polymineral composition. This soil is characterized by the presence of clay minerals, quartz, K-feldspar and plagioclase. The clay minerals are represented by illite, kaolinite, chlorite, smectite and relatively rare mixed-layer structure of chlorite-smectite (corrensite), which is identified for the first time in soils of the Czech Republic. Soil development is influenced by loess and also by volcanic rocks in the lower part of the profile.

IDENTIFICATION OF CORRENSITE

Corrensite is the second most widespread clay mixed-layer structure in sedimentary rocks. Most structures correspond to type R1 with 50 % chlorite (Ch) and 50 % smectite (S) component or to type R0 where the S component is less than 30 % and the rest belongs to the Ch component. The subject of the present study is regularly organized trioctahedral chlorite-smectite, i.e. low-charge corrensite (Fig 8). Another option is organized trioctahedral chloritevermiculite, i.e. high-charge corrensite.



Fig. 8 Schematic structure models of chlorite, and smectite, and resulting mixed structure of corrensite (modified from Shau et al., 1990).



Fig. 9 An X-ray diffractogram of clay fraction in the Ah horizon. AD – air–dried, EG – ethylene glycol solvated, Co – corrensite, I – illite, K – kaolinite, Q – quartz, Kf – K-feldspar, Plg – plagioclase.

Corrensite was identified on the basis of basal reflection 2.91 nm in natural state, 3.21 nm after solvation with ethylene glycol, and 2.40 nm after heating at 550 °C (Fig. 9). Then corrensite was identified at the longer step of the goniometer. Corrensite with the composition of 50 % Ch/50 % S and arrangement R1 in natural state to dry at ambient temperature produced a rational spectrum. In this case $d(001)^*$ of superstructure is 1.42 + 1.50 = 2.92 nm. Futher reflections are 1.37 and 0.71 nm. After solvation with ethylene glycol, the sample created a superstructure with d $(001)^*$: 1.42 + 1.69 = 3.11 nm, and 1.56 nm and 0.78 nm (Fig. 10). The other diffraction maxima are positioned according to the Bragg law. This means that a regular positional succession is observed besides the basal diffraction of higher order. A typical property of corrensite saturated with ethylene glycol is (004)* diffraction at 0.78 nm (11.3° 20 CuKa, Fig. 10). Another confirmation of the presence of corensite was based on sample heating at 375 °C for four hours; this caused a collapse of smectite component at ~ 0.98 nm. A new superstructure was formed with $d(001)^*: 0.98 + 1.42$ = 2.40 nm and then 1.21 and 0.80 nm. These lines appeared after heating (Fig. 10). Corrensite occurs finely dispersed in the soil, and its presence can be

therefore confirmed mainly by comparing X-ray diffraction data. X-ray data of low-charge corrensite of different origins and from different sites are given in Table 5 for comparison.

DISCUSSION

The presence of corrensite has been frequently reported from low to intermediate temperature conditions in different geological formations. This mineral has been most often described in evaporite pools or limestone (e.g., Grim et al., 1959; Kopp and Fallis, 1974). It has been also identified in lagoons or restricted pools (e.g., April, 1981; Bodine and Madsen, 1987). The possible formation of corrensite by diagenetic or hydrothermal alteration of basalt or andesite their pyroclastics and and lowmetamorphosed equivalents has been described by, e.g., Shirozu et al. (1975), Shau et al. (1990), Bettison-Varga et al. (1991) and Robinson et al. (1993).

Corrensite is formed by various processes. Commonly recognized is the transformation of smectite to chlorite during diagenesis or lowtemperature metamorphism. The conversion of smectite to chlorite usually proceeds through a sequence of mixed structures of chlorite and smectite. An increase

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Fig. 10 An X-ray diffractogram of clay fraction in the Ah horizon. AD – air-dried, EG – ethylene glycol solvated, corrensite – value in nm, I – illite, K – kaolinite, Q – quartz, Kf – K-feldspar, Plg – plagioclase.

1		2		3		4		5		hkl
Ι	d _m	Ι	d _m	Ι	d _m	Ι	$d_{\rm m}$	Ι	d _m	
60	2.924	30	2.926				2.950	30	2.900	001
40	1.429	100	1.454		1.390		1.450	100	1.400	002
		5	0.964		0.948		0.970			003
70	0.710	15	0.723		0.715		0.725	60	0.708	004
5	0.470	10	0.482		0.481		0.485	30	0.472	006
		10	0.457		0.460			30	0.462	020, 110
40	0.355	10	0.360		0.354		0.363	60	0.353	008
		5	0.324				0.325	10	0.334	009
		5	0.292		0.258		0.289	30	0.283	0010
								10	0.266	130, 300
		10	0.154		0.155		0.154	30	0.154	060, 330

 Table 5
 X-ray diffraction data of corrensite.

1 – Ah horizon of Albic Luvisol, Podmokly, Czech Republic, 2 – Veitsivaara, Finland (Linquist and Harle, 1991), 3 – Joonghua, Taiwan, (Shau et al., 1990), 4 – Sparta, Tennessee, USA (Peterson, 1961), 5 – Eastern Otago, New Zealand (Data Book, 1998), I – intensity, d_m – measured inter-stratal distance in nm, hk ℓ – crystal face

in the proportion of chlorite layers continues until reaching chlorite as a stable phase. This may even proceed in steps through a direct transformation of smectite to chlorite. Another important process is weathering, when corrensite is an intermediate product of weathering of chlorite to smectite. This process involves a loss of iron and manganese in such ratio that chlorite gradually loses its trioctahedral character and transforms into the end-dioctahedral member of smectite.

Corrensite formation in soils is less perfectly known. Brigatti and Poppi (1984) described the process of corrensite formation by degradation of chlorite. Bain and Griffen (2002) defined the formation corrensite as a result of weathering of chlorite in soils developed on slate. Bain (2007) described these trends and supposed that minor, but significant, differences in clay mineralogy may be due to the effects of different land use.

Morrison and Parry (1986) assumed that corrensite is a product of chlorizitation of smectite. A transformation of trioctahedral smectite to chlorite in conditions rich in Mg can create a mixed structure of corrensite type. Chloritization of smectite, usually with corrensite as a transition phase, is a basic process of a change for 2:1 trioctahedral clay minerals (Ca and Mg smectite).

Chlorite occurring in the soil can be transformed to smectite through a mixed structure, e.g. chloritesmectite. The occurrence of a mixed structure shows that smectite may form as a result of a partial dissolution of chlorite in acid soil environment. This hypothesis is supported by the herein published results.

A decrease in the content of chlorite or its complete decomposition have been observed in the A horizons of Podzol several times (e.g., Righi et al., 1999). This process takes place in acid weathering environment. In these conditions, chlorite becomes unstable and dissolves easily (e.g., Brandt et al., 2003). The decomposition of chlorite is especially influenced by the presence of organic acids (e.g., Hamer et al., 2003). These acids are present in larger amounts in the A horizons. The dissolution processs probably passes simultaneously with the conversion of chlorite to secondary minerals.

Primary chlorite is unstable in nature under acid weathering conditions. This chlorite is transformed into regularly or irregularly mixed structures due to the preferred leaching of Fe and Mg cations from its layers. Then it gradually loses its trioctahedral character and transforms into the end-member smectite.

The absence of chlorite in the Ah horizon of Albic Luvisol at Podmokly is probably due to its transformation into corrensite. This also corresponds with the characteristics of the Ah horizon with weakly acid pH values and elevated contents of C_{ox} .

A precise characteristic of the environment makes it easier to explain the origin of corrensite. This environment has been described in detail in only a few soil studies. Such information must include data about diagnostic horizons, soil type and parent material. The designation of soil horizons, soil types and pedogenesis was originally varied in previous papers. For clarity, the terminology was adopted from Jahn et al. (2006) and IUSS Working Group WRB (2015). The arrangement of diagnostic horizons in the profile allows classifying of soil types and characterizing pedogenesis. Soil development is connected with different types of specific pedogenetic processes. Only the processes of accumulation and transformation of organic debris into specific humus compounds are present in all soils. Humification can be the main

process or may accompany specific pedogenetic process. This study characterizes only those soil types in which corrensite was identified. Cambisol is characterized by weathering of parent material and by the absence of appreciable quantities of illuviated organic matter, aluminium and/or iron clay, compounds in the Bw horizon. The development of Luvisol is characterized by pedogenetic differentiation of clay content, with lower contents in the topsoil and higher contents in the Bt horizon without any prominent leaching of base cations or advanced weathering of high-activity clays. The loss of iron oxides together with clay minerals led to the presence of the E horizon between the Ah or Ap and Bt horizons, but Luvisol lacks the retic properties. Pedogenesis of Podzols is connected with migration of aluminium, iron and organic compounds from the surface soil downwards with percolating rainwater to the Bs horizon. The overlying E horizon remains bleached. This E horizon is usually overlain by a thin mineral with high contents of organic matter. Miles and de Kimpe (1988) identified low-charge corrensite in the Ap, Ah and Bw horizons of Cambisols developed on till derived from granitic rocks and till derived from marble with high amount of granitic and gneissic rocks. The presence of low-charge corrensite in the Ah horizon of Luvisol developed on loess was also detected at the studied site of Podmokly. Carnicelli et al. (1997) determined high-charge corrensite in the BC horizon of Podzol developed on sandstone-dominated lithotypes of turbidity currents. Righi et al. (1999) described high-charge corrensite in the Ah horizon of Cambisol, in the Ah horizon of Podzol and also in the E horizon of other Podzol, where soils are developed on morainic material constituted by granite. Bain and Griffen (2002) documented high-charge corrensite in the C horizon of Cambisol where the parent material is till derived from schist. Although in the above mentioned works corrensite was identified in the soil profile, not in all cases was the corrensite origin result of pedogenesis. The C horizon is parent material which is a starting point for the process of soil formation. It can be assumed that only the presence of corrensite in the A, E and B horizons is the result of pedogenesis. From the above information, it appears that the occurrence of corrensite can be associated with different types of specific pedogenetic processes. The occurrence of corrensite in the Ah horizon is probably connected with the process of humification. This was found in the case of Albic Luvisol in the study area and also in the case of Cambisol and Podzol reported by other authors. The presence of corrensite in the Bw horizon of Cambisol and in the E horizon of Podzol is probably connected with pedogenesis of these soil types.

CONCLUSIONS

Mineral composition of Albic Luvisol was studied in the Buchava Formation in the Skryje-

Týřovice Basin. Typical rocks for the study area are andesite, quartzose siltstone and loess. Loess was deposited in a single uninterrupted cycle.

Morphological analysis and distribution of clay fraction in the soil profile confirmed the process of pedogenetic clay differentiation. The thickness of Bt horizon connected with this process is 61 cm. Distribution of texture classes corresponds to the type of parent material.

The observed trends show weakly acid reaction in the upper part of the soil profile and a basic reaction in the Ck horizon. The values of cation exchange capacity throughout the profile correspond to this type of pedogenesis.

A gradual reduction of total carbon and nitrogen contents and hot-water extractable carbon (C_{hw}) with increasing soil depth was found in the studied profile.

The clay fraction of Albic Luvisol contains predominantly clay minerals, quartz and feldspar. Relatively high contents of illite and kaolinite are present in the whole profile. The Ck horizon contains higher amounts of chlorite and smectite. Corrensite is described for the first time from soils of the Czech Republic: it was detected in the Ah horizon of Albic Luvisol by X-ray diffraction analysis. Basal reflection showed that it is a trioctahedral 1:1 regularly interstratified mineral (R=1), containing chlorite and smectite layers (low-charge corrensite). The formation of corrensite is probably attributed to weathering of chlorite under weakly acid reaction conditions in the increasing amount of organic matter. The distribution of clay minerals in the Albic Luvisol showed that soil development is influenced by both loess and volcanic rocks in the lower part of the profile.

ACKNOWLEDGMENTS

This study was supported by the research plan RVO 67985831 (Institute of Geology of the Czech Academy of Sciences). The authors thank J. Rajlichová for technical assistance.

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