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FEATURES OF CUTANS COMPLEX IN ALBELUVISOLS OF THE UKRAINIAN PRECARPATHIANS

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Cutans occurring in Albeluvisols of the Precarpathians in the Ukraine were studied. The morphology of the cutans and their components were described. The obtained results show that the studied cutans are composed mainly of colloidal clay. Clay cutans in the studied soils are characterized by smooth surface, microlamination, and clear optical orientation of clay domains. It was found that the microlamination of the clay cutans is a result of cyclic material deposition due to translocation of colloids (i.e. eluviation-illuviation). Complex layered cutans containing layers of pure clay, microlaminated clay and silt were also found. It was shown that the colour of clay cutans depends on their composition. Domination of brown, dark brown and rusty-brown cutans indicates that clay minerals and Fe-oxides are main component of such microstructures. Several morphotypes of cutans were determined: sandy-silty, clay, humus-clay, humus-silty-clay, silty-clay, and iron-clay. Most of the identified morphotypes of cutans are a result of mobilization, translocation, and accumulation of colloids within the studied soil profiles. Based on the cutans complex it was concluded that the genesis of the studied soils is related to illimerization (lessivage) and gley-eluvial processes.

Keywords: cutans, gley-eluvial process, illimerization (lessivage), micromorphology, Albeluvisols, Precarpathians.

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ОСОБЛИВОСТІ КУТАННОГО КОМПЛЕКСУ АЛЬБЕЛЮВІСОЛЕЙ УКРАЇНСЬКОГО ПЕРЕДКАРПАТТЯ

Досліджено кутанний комплекс альбелювісолей Українського Перекарпаття та описано його морфологічну різноманітність. Виявлено, що домінуючим типом кутан є кутани, у складі яких переважає глиниста складова. Для глинистих кутан досліджуваних ґрунтів характерні гладка флюїдальна поверхня, шарувата мікробудова з оптичною орієнтацією шарів. Встановлено, що шарувата мікробудова глинистих кутан пов'язана із періодичністю відкладення тонкодисперсного матеріалу, головним чином внаслідок глеє-елювіального процесу. Діагностована наявність складношаруватих кутан, з прошарками чистої глини, мікроламінованої глини та мулу. Показано, що забарвлення глинистих кутан залежить від речовинного складу. Кольорова гама визначалася глинистими мінералами, оксидами Fe і Mn. Домінували бурі, темно-бурі, золотисті і жовто-золотисті відтінки. Діагностовані піщано-пилуваті; глинисті; гумусово-глинисті; гумусово-пилувато-глинисті; залізисто-глинисті морфотипи кутан. Встановлено, що більшість виявлених морфотипів кутан є результатом послідовної мобілізації, суспензійної міграції і ілювіальної акумуляції дисперсної частини ґрунту. На основі кутанного комплексу діагностовано протікання лесиважу та глеє-елювіального процесів ґрунтотворення.

Ключові слова: кутани, глеє-елювіальний процес, мікроморфологія, лесиваж, альбелювісолі, Передкарпаття.

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ОСОБЕННОСТИ КУТАННОГО КОМПЛЕКСА АЛЬБЕЛЮВИСОЛЕЙ УКРАИНСКОГО ПРЕДКАРПАТЬЯ

Исследован кутанный комплекс альбелювисолей Украинского Предкарпатья и описано его морфологическое разнообразие. Выявлено, что доминирующим типом кутан являются кутаны, в составе которых преобладает глинистая составляющая. Для глинистых кутан исследуемых почв характерна гладкая флюидальная поверхность, слоистое микростроение с оптической ориентацией слоев. Установлено, что слоистое микростроение глинистых кутан связано с периодичностью отложения тонкодисперсного материала, главным образом вследствие глее-элювиального процесса. Диагностировано наличие сложнослоистых кутан, с прослойками чистой глины, микроламинированной глины и ила. Показано, что окраска глинистых кутан зависит от вещественного состава. Цветовая гамма определялась глинистыми минералами, оксидами Fe и Mn. Доминировали бурые, темно-бурые, золотистые и желто-золотистые оттенки. Диагностированы песчано-пылеватые, глинистые, гумусово-глинистые, гумусово-пылевато-глинистые, железисто-глинистые морфотипы кутан. Установлено, что большинство выявленных морфотипов кутан являются результатом последовательной мобилизации, суспензионной миграции и иллювиальной аккумуляции дисперсной части почвы. На основе кутанного комплекса диагностировано протекание лессиважа и глее-элювиального процессов почвообразования.

Ключевые слова: кутаны, глее-элювиальный процесс, микроморфология, лессиваж, альбелювисоли, Предкарпатье.

In recent decades the concept of soil as a memory of environment (i.e. soil as a recording and memorizing system) was developed in soil science (Targulian, 2004). This concept is based on the assumption that soil is a natural-historical body resulting from factors and processes leading to its formation. It is related to specific mechanisms occurring in soil which are responsible for recording and memorizing information. This information is recorded in soils on solid surfaces, which form a complexity but are organized in hierarchical system of diagnostic features and soil properties from microscale like molecules and minerals to macroscale like the soil cover. In this sense it can be identified mineralogical memory, humus memory, soil structural memory, or the memory of soil neoformations, etc. One of the most significant components of soil, which can play a crucial role in paleoenvironment reconstruction as well as indicators of present processes occurring in soil are cutans (Bronnikova, 2005). Such structures occur within Albeluvisols of the Precarpathians in the Ukraine (Szymański, 2012a, 2012b). Such soils are called brownish-podzolic soils in the Ukrainian national classification system (Polchyna, 2008; Nikorych, 2012a) and show very complex mode of their formation. According to Nazarenko et al. (2005) the soils are result of 5–6 different soil forming processes including accumulation, eluviation, illuviation, and transformation. In effect, unambiguous determination of genesis of such soil is very difficult. In order to properly determine the genesis of the studied soil profiles, micromorphological observations and analyses of soil material were done. The present paper emphasises on complexity of cutans occurring in the soils of the Precarpathians.

There are still problems with the identification and quantitative determination of cutans at macro and micromorphological studies. Bronnikova and Targulian (2002, 2005) pointed out a number of difficulties associated with the identification of cutans. Such problems occur especially in clayey soils containing high amount of swelling clay minerals as well as in soils showing initial stage of illuviation. In addition to genetic importance, cutans play a significant role in soil classification. In many national soil classification systems including Soil Taxonomy in the USA (Soil Survey Staff, 2006), Russian Soil Classification (Russian Soil Classification, 2004), Polish Soil Classification (Systematyka gleb Polski, 2008) and World Reference Base for Soil Resources (IUSS Working Group WRB, 2006) one of the diagnostic criteria for illuvial horizon is the presence of clay cutans. In the Ukrainian soil science this issue is still unresolved.

MATERIALS AND METHODS

The studies were carried out within the Precarpathians in the Ukraine. Ten representative soil profiles were excavated in the field and very carefully described. The studied Albeluvisols show sequence of genetic horizons as follows: Ho+He+Egl+Eigl+Igl+PiGl (in WRB system: Stagnic Fragic Albeluvisol (Epidystric, Siltic) O+AEg+Eg+Btx+Btg+BC). Table 1 shows the field description of morphology of the archetype of the studied soil profiles.

Table1

Field description of morphology of the archetype of the studied soil profile

Index horizon		Colour (moist)	Structure	Consistence	Roots	Fe-Mn nodules	Clay coatings
UKR	WRB						
Ho	O	n.a.*	n.a.	n.a.	n.a.	n.a.	n.a.
He	AEg	10YR 5/3	Subangular blocky	Soft	+	Few	Absence
Egl	Eg	10YR 5/4	Subangular blocky	Slightly hard	Few	+	+
Eigl	Btx	10YR 5/6; 10YR 6/2	Subangular blocky	Slightly hard	Absence	++	+++
Igl	Btg	10YR 5/6; 10YR 6/2	Prismatic	Slightly hard	Absence	+++	+++
PGl	BC	10YR 5/6; 10YR 8/1	Prismatic	Very hard	Absence	++	++

* Not analyzed

Micromorphological observations and analyses were used to describe of cutans complexity in the studied Albeluvisols. The thin sections were made according to Parfenova et al. (1977). The thin sections were described using terminology given by Stoops (2003). The thin sections were studied using polarizing microscope Nikon Eclipse E600Pol.

Macro- and micromorphological description of cutan complexity was made according to Bronnikova and Targulian (2005).

The studies were conducted in Department of Soil Science of Yuriy Fedkovych Chernivtsi National University and in Department of Pedology and Soil Geography of the Jagiellonian University (Krakow, Poland). Thin sections were prepared in Oles Gonchar Dnepropetrovsk National University.

RESULTS AND DISCUSSION

Macromorphology of cutan complex.

Surface horizons: No cutans present.

Eluvial horizons: Surface of peds are coated with very thin grayish and brownish fragments of clay cutans. On the surface of clay cutans there are light brownish-white sandy-silty cutans. The surface of cutans is sporadically shattered by the polygonal network of cracks. Such aggregates consist of fragments of cutans, network of cracks and underlying microblock of intra-aggregate mass (IAM).

Illuvial and transition to parent material horizons. The most common are pale-brown, brown and glaucous light brown silty-clay cutans up to 1 mm thick. They cover almost all pores of intra-aggregate mass (IAM). Clay cutans are sometimes covered by fragments of light grayish-white sandy-silty cutans up to 1 mm thick. In addition, there are reddish-brown iron-clay cutans from 0.5 to 1 mm thick. On the surface of peds there are iron-manganese cutans, which often developed on the top of clay and iron-clay cutans. Cutans are underlain by strongly gleyed glaucous, bluish or olive-bluish layer of intra-aggregate mass (IAM) about 1-5 mm thick. Intensity of bleaching of cutans and thickness of gleyed zone of intra-aggregate mass (IAM) beneath them gradually increase down the horizon. Such complexity of colour of the studied cutans indicates the need of micromorphological studies (Fig.1).

Fig. 1. **Visualization of cutan complex on the mesomorphological level**

Mesomorphology of cutan complex. According to the recommendations given by Bronnikova and Targulian (2005), the walls of the largest cracks and surfaces of aggregates of second order (with differentiation of upper, lower and side surfaces) as well as aggregates of first order (i.e. the smallest units discernible in mesomorphological description) and intra-aggregate mass (IAM) of aggregates of first order in each horizon were described.

Surface horizons: No cutans present. The exception was the St-1 profile, which had a small amount of coatings probably connected with agroturbation (this is a crop soil).

Eluvial horizons. Usually no large cracks.

Aggregates of II order. Colour of the surface of aggregates is rather homogeneous: the predominant colour is grayish-brown with a few dark brown spots.

Upper faces of aggregates. Covered by sandy-silty cutans up to 0.1 mm thick, which cover most of the pores. The surface of aggregates is rough, microrelief is somewhat smoothened by the coatings. There are areas where cutans on the surface form a striated image. On the walls of the root moves that come to the surface of aggregates, there are also observed sand and silt cutans.

Lower faces of aggregates. The surface is not uniform in colour, i.e. more brown spots. Many small pores and small cracks were not covered cutans.

The side faces of aggregates. On the surface visible ribs aggregates of lower orders. Straight flat interaggregate pores-cracks are apparent. Sandy-silt cutans are unevenly distributed. Interaggregate cracks are sometimes covered by sandy-silty cutans. The material forming cutans is loose. There are fragments of light brown iron-clay cutans that occupy small areas of surface of aggregates.

Aggregates of I order. Upper faces of aggregates. White and light grey sandy-silty cutans that cover the surface occur. The cutans are more compacted than the cutans occurring on the surfaces of aggregates of II order. There is often an expressed striated microrelief of the surface of cutans. In brown microareas the surface of aggregates is covered by thin translucent fragments of iron-clay, clay-humus and clay cutans showing brown, dark brown, or reddish-brown colour. *Lower faces of aggregates*. There is no significant difference between the upper and lower faces of aggregates. At the bottom of the aggregates the large area is occupied by iron-clay, humus-clay, and clay cutans. There are ferruginous nodules on the surface.

Intra-aggregate mass (IAM). IAM is compact. In aggregate pores there are yellow-brown translucent iron-clay cutans. In the tubular pores (root burrows) dominate brown, dark brown, and gray-brown clay and humus-clay cutans, especially in the forest soils.

Illuvial and transition to parent rock horizons (Fig. 1). *Surfaces of main cracks*. Almost all walls of cracks are covered by silty-clay, clay (reddish-gray color), iron-clay (bright brown), and along the root burrows humus-clay (dark brown) cutans. The thickness of cutans varies from 0.05 to 1 mm (especially in the area of distribution of root burrows). One-piece or silt fragmentary cutans, sometimes with sand fractions occur almost everywhere over the clay, silty-clay and humus-clay cutans. Along the root burrows cutans contain a lot of humus.

Aggregates of I and II order. Cutans show the best development on the surfaces of aggregates. Clay and silty-clay cutans prevail. Along the root burrows cutans that are coloured with humus occur. In some areas these cutans are solid, more often fragmented: in the form of spots or growths of colomorf clay. *Upper faces of aggregates.* Silt cutans are predominant. In places where the roots come out of IAM to the surface there are some fragments of clay cutans. *Lower faces of aggregates*. Clay, humus-clay, and iron-clay cutans are very thin (<0.05 mm). Cutans can be found mainly near the root burrows. Pores more than 0.1 mm thick are not covered by cutans. Edges of pores and uneven surfaces of microrelief are sharply outlined. There may be found some fragments of iron and manganese cutans. *The side faces of* *aggregates*. Coated with one-piece silty-clay cutans with the inclusion of grains of sand fractions, layers of silt material, microareas of underlying IAM. Thickness of such cutans is from 0.05 to 0.3–0.4 mm. Surface of such cutans is rough and matt. Underneath the cutans there sometimes lies a slightly bleached layer of IAM up to 0.2 mm thick. On the surface, silty-clay cutans and fragmentary silty cutans up to 0.1 mm thick occur. There are also clay and iron-clay cutans with a glossy surface. There is pronounced aggregation of material forming cutan of underlying IAM layer: the surface of the aggregate is divided into polygons with side of 3–10 mm to a depth of about 0.5–1 mm. *Intra-aggregate pores.* The walls of most pores are coated with clay, iron-clay, iron-manganese cutans and less often sandy-silty cutans. The latter occur over cutans of other morphotypes. Ferruginous and manganese cutans often form a thin layer within clay and iron-clay cutans.

Micromorphology of studied soils and features of cutans complex at the microlevel. Averaged micromorphological description of the studied soils is given in Table 2.

Table 2

Generalized micromorphological description of studied soils

Microstructure and porosity	Groundmass			Organic matter	Pedofeatures
	Skeleton	Coarse material	Fine material		
Surface horizons: Subangular, angular blocky microstructure **Eluvial horizons:** Massive microstructure **Illuvial and transients to P (C) horizons:** Angular blocky microstructure **Porosity:** packing voids planes and channels	Lack	* Angular and subangular grains of quartz Micas Feldspars *(plagioclases, microcline)* Glauconite Zircon Weathered fragments of shale Most of the components belong to silty and fine sand fractions	Amorphous humus Colloidal clay Orientation of micromass: Porostriated b-fabric (max in I) and granostriated b-fabric (max in Pi) Colouring plasma in: - surface and eluvial horizons – gray-brownish; - illuvial and transients to P (C) horizons: from gold to brownish-gold	**Surface horizons:** Organ residues (many, varying degrees of decomposition) **Eluvial horizons:** Organic residues (few) **Illuvial and transients to P (C) horizons:** Lack	*Cutans: clay and Fe-clay coatings* (few in surface horizons, many in I and Pi horizons) I horizons: clay in situ Fe and Fe-Mn concretions (surface and eluvial horizons: in embryonic form, an I and Pi) Depletion zone Fragmented cutans (rare)

** A more detailed mineralogical description is given in Nikorych (2012, b).*

Surface horizons of the studied soils are characterized by subangular blocky and channel microstructures, packing voids and channels. Corse material of the groundmass is composed of subangular and angular grains of quartz, plagioclases, K-feldspars (mainly microcline), and micas (mainly muscovite). Additionally, weathered fragments of shales and subangular pellets of glauconite were present. Mineral grains and fragments of shales belong to coarse silt, very fine sand, and fine sand fractions. In some cases subangular pellets of glauconite were observed. Fine material of the groundmass (i.e. micromass) consists of amorphous humus. In the surface horizons organic rsidues, tissues, fragments of roots and in some cases iron nodules were observed.

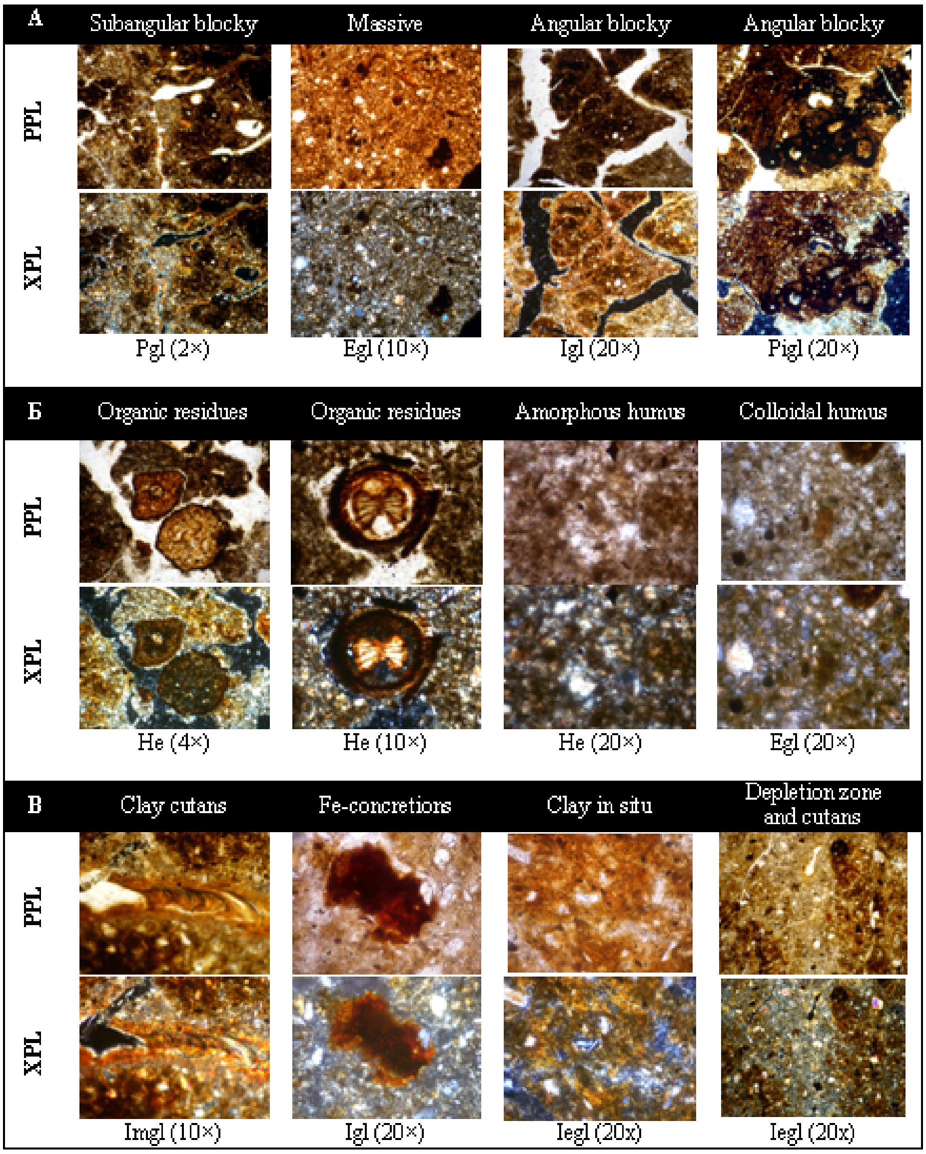

Fig. 2. **Micromorphological properties of studied soils:**
A – types of microstructures; Б – organic remnants and amorphous and colloidal humus; B – pedofeatures

Eluvial horizons exhibit channel, subangular blocky, platy, and massive microstructures. Angular and subangular grains of quartz, plagioclases, K-feldspars, micas and fragments of shales are main components of coarse material. Eluvial horizons are characterized by very small amount of micromass, which consists mainly of grey amorphous humus and rusty-brown iron oxides. Within eluvial horizon occur a lot of iron and iron-manganese nodules showing sharp or gradual external boundaries and undifferentiated internal fabric. In addition, depletion zones and impregnative pedofeatures occur. Few clay cutans were present in Eg horizons.

Illuvial horizons are characterized by channel, subangular, and angular blocky microstructures. Channels and vertical planes prevail. Coarse material of the groundmass is composed of angular and subangular grains of quartz, plagioclases, K-feldspars, micas, subangular pellets of glauconite, and weathered fragments of shales. Micromass consists of colloidal clay and iron oxides. Colloidal clay shows porostriated, granostriated, and speckled b-fabric. A lot of iron and iron-manganese nodules as well as depletion zones and impregnative pedofeatures were observed. This part of the soil profiles studied show the highest amount of clay, iron-clay, silty-clay, and humus-clay cutans.

Clay cutans in brownish-podzolic soils are characterized by the following features:

1. Smooth and glossy surface (Fig. 3);

Fig. 3. **Surface of clay cutans**

2. Sharp boundary (Fig. 4.);

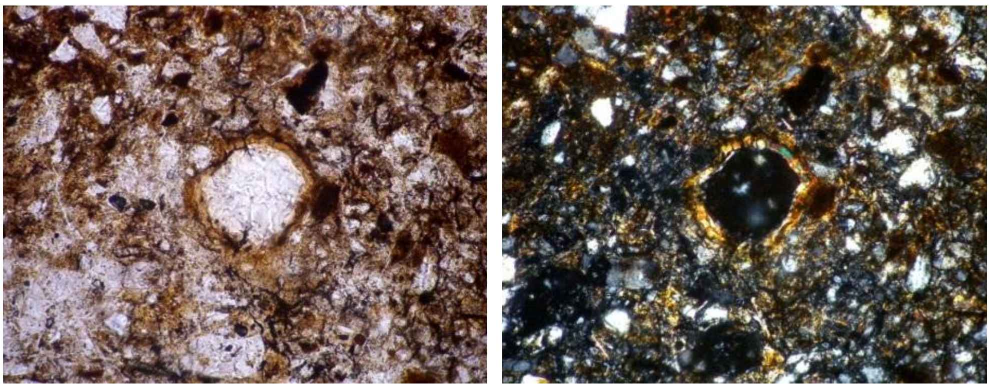

Fig. 4. **Nature of boundaries of clay cutans**

3. Microlamination microstructure with the orientation of layers, predominantly parallel to the walls of pores (Fig. 5);

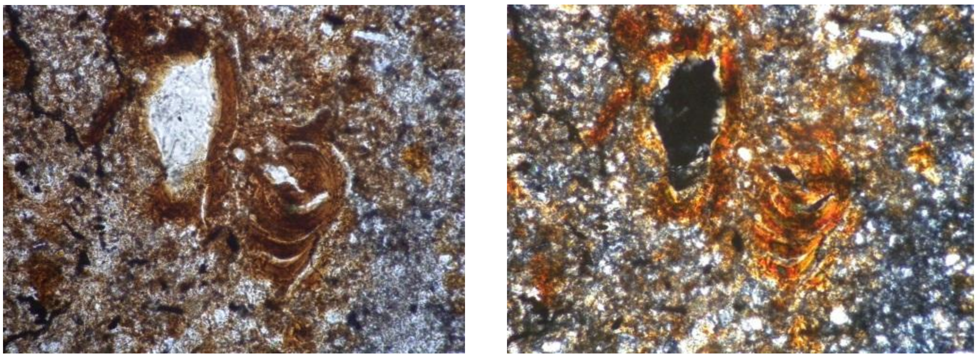

Fig. 5. **Microlamination microstructure of clay illuviation cutans**

4. Optical anisotropy and high birefringence (Pic. 6).

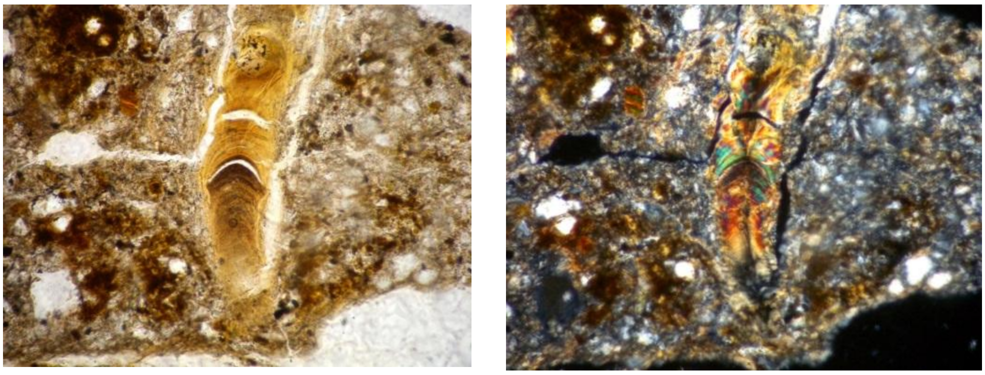

Fig. 6. **Optical anisotropy of clay illuviation cutans**

Microlamination of clay and silty-clay cutans is associated with the periodicity of material deposition. Layers of the cutans are usually arranged parallel to each other and to the original surface of the pores, peds, cracks, or at a certain angle to the surface.

Colour of clay cutans is connected with their composition. Brown, dark brown, and rusty-brown cutans prevail indicating that clay minerals, Fe- and Mn-oxides are main component of such structures. In some cases, the cutans show grey colour due to amorphous humus.

The following morphotypes of cutans in the studied soils were found (Fig. 7):

1) sandy-silty (with quartz and feldspars);

2) silty-clay;

3) clay (found mainly in metamorphosed horizons);

4) humus-clay (occurring mainly in the surface horizons);

5) iron-clay (occurring mainly in illuvial horizons, which contain, in addition to iron, probably manganese).

Most of the cutans are related to mobilization of colloids, their translocation down the soil profile, and accumulation in the lower soil horizons.

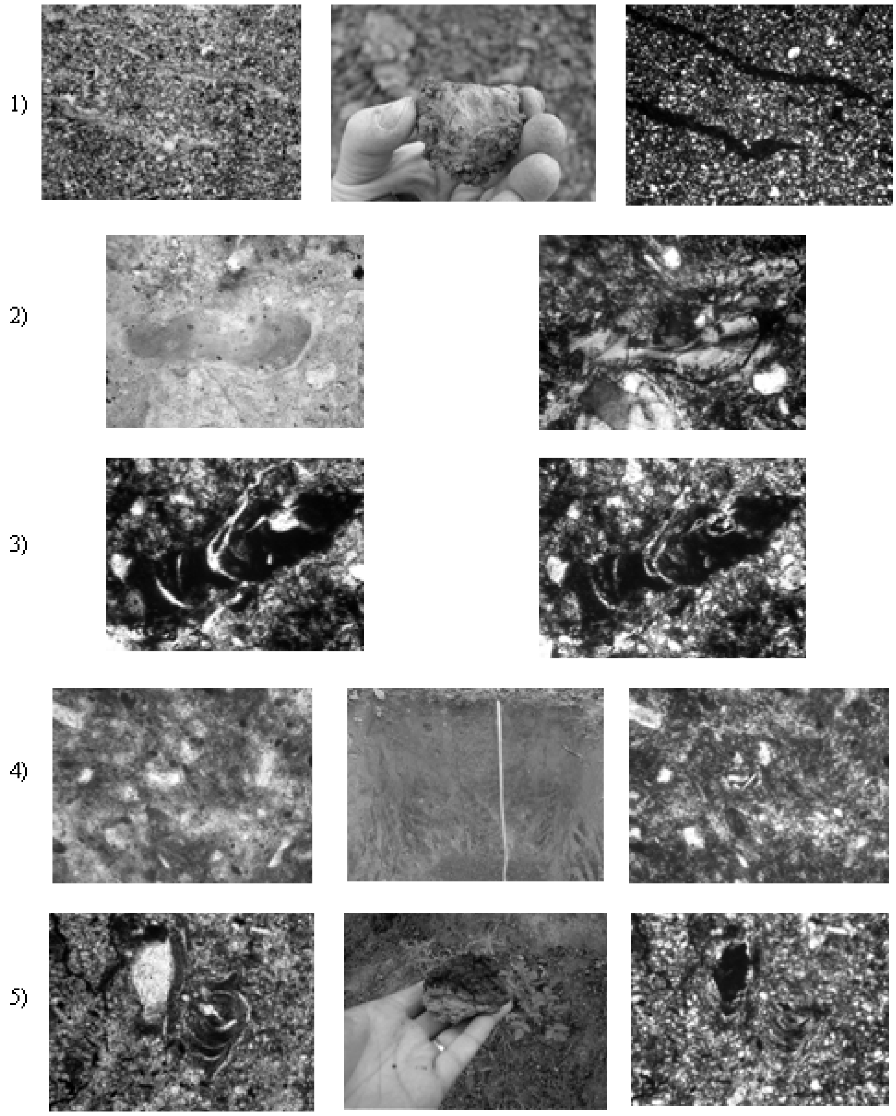

Fig. 7. **Morphotypes of cutans of the studied soils:**
1) sand-silty, 2) silty-clay, 3) clay 4) humus-clay, 5) iron-clay

The role of cutans in the functioning and biological productivity of Albeluvisols of the Ukrainian Precarpathians. Occurrence of cutans has a direct influence on the size and shape of voids and permeability of soil profiles. Clay cutans occurring on the surfaces of aggregates show different morphology, texture, and chemical composition in comparison with IAM. This is the reason of heterogeneity of soil material. Presence of cutans on the surface of aggregates limits penetration of soil solution and diffusion of solutes from pore space into the aggregates.

This increases the efficiency of mechanical absorption capacity of the soil and slows the filtration capabilities. In addition, clay cutans increase the cation exchange capacity and accumulation of biophylic elements.

Another feature of the cutan complex is constant presence of morphochromatic signs of gleyification. In our opinion, this fact creates difficulties in the field diagnostics and indexing of the genetic horizons.

CONCLUSIONS

1. Cutans occurring in Albeluvisols of the Ukrainian Precarpathians show clear morphological diversity. Clay cutans clearly prevail within the studied soils. Such cutans exhibit smooth and glossy surfaces, distinct boundaries, microlamination, and clear optical orientation of clay domains.
2. Microlamination of clay and silty-clay cutans is associated with intervals of material translocation.
3. Colour of clay cutans is related to their composition. Brown, dark brown, and rusty-brown cutans prevail indicating that clay minerals, Fe- and Mn-oxides are main component of such structures.
4. In Albeluvisols of the Precarpathians in the Ukraine occur sandy-silty, clay, humus-clay, humus-silty-clay, and iron-clay cutans. Most of the cutans are related to mobilization of colloids, their translocation down the soil profile, and accumulation in the lower soil horizons.
5. Based on the obtained results it is concluded that the genesis of the studied soils is related to illimerization (lessivage) and gley-eluvial processes.

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REFERENCES

Bronnikova M. A. Cutan complex of texture-differentiated soil / M. A. Bronnikova, V. O. Tarhulyan. – M. : ICC «Akademkniha», 2005. – 197 p.

Classification and diagnostics of soils in Russia / Compiled by L. L. Shishov, V. D. Tonkonohov, I. I. Lebedeva, M. I. Herasimova. – Smolensk, 2004. – 342 p.

IlluviaSols Clay eluviation/illuviation processes in soils / E. Fernández, C. Dorronsoro-Fdez, J. Aguilar, B. Dorronsoro, G. Stoops, C. Dorronsoro Díaz –http://edafologia.ugr.es/iluv/indexw.htm

Nazarenko I. I. Problems of classification, nomenclature identity, diagnostics of elementary soil processes and ecological condition of background soils of Precarpathians / I. I. Nazarenko, I. S. Smaga, S. M. Pol`chyna, V. A. Nikorych, Yu. M. Dmytruk, M. A. Berbets, R. I. Bespalko // Scientific Bulletin of Chernivtsi University. – Chernivtsi : Ruta – 2005. – Vol. 251. Biology. – P. 3-26.

Nikorych V. Micromorphological diagnosis mineral composition brownish-podzolic gleyed soil station «Storozhynets» / V. Nikorych, O. Kryzhanivsky, M. Mykytyuk // Scientific Bulletin of Chernivtsi University. «Biological systems». – V.4, Issue 3. – Chernivtsi : Chernivtsi National University Press, 2012b. – S. 319-326

Nikorych V. Morphogenetic features of Albeluvisols Polish and Ukrainian Precarpathians / V. Nikorych, S. Polchyna, S. Skiba, W. Szymanski // Scientific Bulletin of Chernivtsi University. «Biological systems». – V.4, Issue 1. – Chernivtsi : Chernivtsi National University Press, 2012a. – P. 65-71

Parfenova E. I. Guide to micromorphological studies in soil science / E. I. Parfenova, E. A. Yarylova. – M., «Science». – 1977. – 198 p.

**Pol`chyna S. M.** Brownish-podzolic gleyed soils of Precarpathians in WRB system / S. M. Pol `chyna, I. V. Savitska, I. V. Dumih. – Agrochemistry and soil science. – Vol. 69. – Kharkiv, 2008. – P. 75-79.

Soil Map of the World. Reviced legend. – Rome : FAO-UNESCO, 1985. – 116 p.

Soil Taxonomy. Abasic system of soil classification for making and interpreting soil surveys. 2nd ed. Washington: Soil Survey Staff, US Government Printing Office, 1999.

Stoops G. Guidelines for Analysis and Description of Soil and Regolith Thin Sections / G. Stoops. – Madison, WI : Soil Science Society of America, 2003. – 184 p.

Systematyka gleb Polski. Wersja pierwsza wydania 5. – Wydawnictwo : Uniwersytet Przyrodniczy w Poznaniu, 2008. – 215 str.

Szymański W. Gleby płowe (Luvisols) pogórza i przedgórza karpackiego z obszaru Polski i Ukrainy / W.Szymański, S.Skiba, V. Nikorych, S. Polchyna // Roczniki Bieszczadzkie 2012 (20). – Str. 268-280.

Szymański W. Similarity of micromorphological properties of the fragipan horizon in Albeluvisols of the Carpathian Foothills in Poland and the Precarpathian in the Ukraine / W. Szymański, V. Nikorych // Proceedings of the 14th International Working Meeting on Soil Micromorphology. Lleida 8-14 July 2012. – P. 18-21

Targulian V. O. Sequence of illuviation cutans' formation in Albeluvusols / V. O. Targulian, M. A. Bronnikova // 17th World Congress of Soil Science. 14-21 August 2002, Bangkok, Thailand. Transactions Papers. CD-ROM.

Targulian V. O. Soil memory: types of record, carriers, hierarchy and diversity / V. O. Targulian, S. V. Goryachkin // Revista Mexicana de Ciencias Geologicas. – 2004. – Vol. 21, N 1. – P. 1-8.

World reference base for soil resources 2006 – ftp://ftp.fao.org/docrep/fao/009/a0510e/a0510e00.pdf

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