Journal of Geology, Geography and Geoecology

Journal home page: geology-dnu-dp.ua

ISSN 2617-2909 (print)
ISSN 2617-2119 (online)

Journ.Geol.Geograph. Geology, 28(2), 327–347.
doi: 10.15421/111932

Micromorphological peculiarities of the Pleistocene soils in the Middle Pobuzhzhya (Ukraine) and their significance for paleogeographic reconstructions

Zh.M. Matviishyna, S.P. Doroshkevych

Institute of Geography, National Academy of Sciences of Ukraine, Kyiv, Ukraine, e-mail: dsp.paleo.geo@i.ua

Received: 10.02.2019
Received in revised form: 09.04.2019
Accepted: 29.04.2019

Abstract. The basic micromorphological features of fossil Pleistocene soils of the Middle Pobuzhzhya region are revealed. The early Neopleistocene (Shyrokyne, Martonosha, Lubny) and Middle Pleistocene Zavadivka soils are characterized by bright brownish, reddish and brownish colors of plasma, compact composing structural separations in the form of cleave blocks with densely packed nodular formations of ferruginous matter, cracksman ship of the mass, a significant amount of ferruginous, manganese and carbonate new formations. In the soils of the early optimum of the Kaydaky stage, signs of the eluvial-illuvial processes were observed (impoverished on the thin clays and humus fields with the «washed» grains of the mineral skeleton, the destroyed microaggregates in the eluvial and the impregnation of the plasma by calomorphic clays in the form of streaks, films, streams in the illuvial horizons). In the Pryluky soils there is a well-expressed microagregation of the mass, a branched net of twisted pores, humus coagulation in the humus and humus transition horizons, various forms of carbonate new formations as the impregnation and plasma cementation by microcrystalline calcite, presence of isolated crystals of crypto-, micro- and small crystalline calcite. The specific individual features of the Vytachiv soils are cleave block microstructure, the presence of the nodular concentric organo-iron-clay formations, and microorsteins. Dofinivka soils are characterized by a loose microstructure, fuzzy rounded microaggregates, a developed system of twisted pores, and enrichment of mass on carbonates. In order to clarify the genetic types of fossil Pleistocene soils of the Middle Pobuzhzhya, identification of the signs of elementary soil formation processes was carried out on the basis of micromorphological analysis data. The significance of the results of micromorphological researches for paleogeographical reconstruction is outlined. It has been established that certain groups of soil formation processes are characteristic for fossil soils of separate paleogeographical stages. In the soils formed up to the Dnieper glaciation (Shyrokyne, Martonosha, Lubny and Zavadivka), signs of processes of claying, rubbification, ferralization, cleaving were displayed, but weakly expressed humus formation, though carbonization were diagnosed. In the soils formed after the maximum glaciation (Kaydaky, Pryluky, Vytachiv, Dofinivka), signs of the such processes as humus formation, podzolization, lessive, leaching, damp-meadow soil formation on floodplain, migration of carbonates, etc., are established. It is processes which are predominating in the modern soils of the territory of Ukraine. Assertaintment of elementary soil-forming processes, diagnosed in multi-annual fossil soils, have made it possible to identify their genetic types and as a result, to reconstruct the soil cover in separate stages of the Neopleistocene, to establish regional patterns of evolutional stadial changes and the natural environment in the Pleistocene on the territory of the Middle Pobuzhzhya.

Key words: Pleistocene, fossil soils, micromorphology, soil formation processes, paleogeography.

Мікроморфологічні особливості плейстоценових ґрунтів Середнього Побужжя та їх значення для палеогеографічних реконструкцій

Ж.М. Матвіїшина, С.П. Дорошкевич

Інститут географії Національної академії наук України, м. Київ, Україна, e-mail: dsp.paleo.geo@i.ua

Анотація. Виявлено основні мікроморфологічні особливості викопних плейстоценових ґрунтів території Середнього Побужжя. Для ґрунтів раннього неоплейстоцену (широкинських, мартоноських, лубенських) і середньоплейстоценових завадівських, ґрунтів характерні яскраві буруваті, червонуваті та коричнюваті відтінки забарвлення плазми, компактне складення маси, структурні виокремлення у вигляді злитих блоків із щільно упакованими нодульними утвореннями залізисто-глинистої речовини, тріщинуватість маси, значна кількість залізистих, манганових і карбонатних новоутворень. У ґрунтах раннього оптимуму кайдацького етапу зафіксовано ознаки елювіально-ілювіальних процесів (збіднені на мул і гумус ділянки з «відмитими» зернами мінерального скелета, зруйновані мікроагрегати у елювіальних горизонтах; у ілювіальних – просочення плазми коло-

морфними глинами у вигляді натеків, плівок, потічків). У прилуцьких ґрунтах проявляється добре виражена мікроагрегованість маси, розгалужена сітка звивистих пор, скоагульованість гумусу типу муль у гумусових і гумусово-перехідних горизонтах, різноманітні форми карбонатних новоутворень у вигляді просочень та цементації плазми мікрокристалічним кальцитом, виокремлення кристалів крипто-, мікро- та дрібнокристалічного кальциту. Специфічними індивідуальними ознаками витачівських ґрунтів є блокова мікробудова, наявність нодульних стяжінь органо-залізисто-глинистої речовини, мікроорштейнів. Дофінівські ґрунти вирізняються пухкою мікроструктурою, нечіткими округлими мікроагрегатами, розвинутою системою звивистих пор, карбонатність маси. З метою уточнення генетичних типів викопних плейстоценових ґрунтів Середнього Побужжя проведено ідентифікацію ознак елементарних ґрунтоутворювальних процесів на основі даних мікроморфологічного аналізу. Окреслено значення результатів мікроморфолоічних досліджень для проведення палеогеографічних реконструкцій. Встановлено, що для викопних ґрунтів конкретних палеогеографічних етапів характерні певні групи ґрунтоутворювальних процесів. У ґрунтах, які формувались до дніпровського зледеніння (широкинських, мартоноських, лубенських та завадівських) діагностовано ознаки процесів оглинення, рубефікації, фералітизації, злитизації, слабко вираженого гумусоутворення, карбонатизації. У ґрунтах, що сформувалися після максимального зледеніння (кайдацьких, прилуцьких, витачівських, дофінівських), установлено ознаки тих самих процесів (гумусоутворення, опідзолення, лесиважу, вилуговування, олуговіння, міграції карбонатів тощо), які переважно властиві сучасним ґрунтам території дослідження. Діагностовані у різновікових викопних ґрунтах елементарні ґрунтоутворювальні процеси надали змогу ідентифікувати генетичні типи викопних плейстоценових ґрунтів і як наслідок – реконструювати ґрунтові покриви у окремі етапи неоплейстоцену, встановити регіональні закономірності еволюційних змін ґрунтів і природного середовища у плейстоцені на території Середнього Побужжя.

Ключові слова: плейстоцен, викопні ґрунти, мікроморфологія, ґрунтоутворювальні процеси, палеогеографія.

Introduction. Micromorphological studies of Pleistocene fossil soils are an important trend in contemporary world researches. It is evidenced by a large number of international publications on this topic, that initiated micromorphological studies in the 40's of the twentieth century. The Austrian scientist V. Kubiena (1938), who formulated the main methodological principles of micromorphology, proved the importance of using micromorphological analysis for the development of soil diagnostics and systematics (Kubiena, 1970). Significant contribution to the development of micromorphology was made by R. Brewer (developed a classification of soil microstructure components) (1964), B. Baratt, E.A. Fitzpatrick and others. The first Russian-language works, in which the methodology of micromorphological research of modern soils was covered, became monographs of O.I. Parfenova and K.A. Yarilova (1962, 1977). General theoretical and practical questions of micromorphological researches were developed by I.P. Gerasimov, G.V. Dobrovolsky, S.V. Zonn, V.O. Targulian, M.I. Gerasimova, S.V. Gubin, S.O. Shoba, E.I. Gagarina and others. Under the microscope, modern soils were studied by I.I. Feofarova, E.K. Nakaidze, L.K. Tselishcheva, B.P. Gradusov, T.F. Urushadze, V.V. Medvedev, A.M. Poliakov, A.I. Romashkevich, N.I. Matynian, N.A. Bilova and al.

Micromorphological studies of fossil Pleistocene soils of European part of Russia conducted by T.D. Morozova. Micromorphological peculiarities of microstructure components, with access to the genesis of Quaternary deposits, were considered by O.A. Chichagova (composition of humus), N.G. Glushankova (microforms of humus), T.A. Halcheva (forms of carbonates). Micromorphological signs of cryogenesis were studied by L.A. Gugalinskaya. Questions of Pleistocene soil formation in the basin of the upper Don, using micromorphological data, were studied by A.I. Tsatskin. Micromorphological data in the study of Quaternary deposits of France was used by Y.B. Jamagne; England – P. Bullock; Czech and Slovakia – L. Smolikova; Poland – T. Madeyska, P. Mroshec, T. Mroshec; Central Asia – N.G. Minashina; China – R.A. Kemp, A. Bronger; Canada – P.G. Jungerius; New Zealand – Y.B. Dalrympl and others. Micromorphological studies of deposits older than the Quaternary, conducted by V.I. Chalyshchev, A.P. Feophilova et al.

In Ukraine, for the first time, a micromorphological analysis for the study of fossil Pleistocene soils and loesses was used by M.F. Veklych (1958). To find out the individual peculiarities and issues of the genesis of the Pliocene and Pleistocene fossil soils and sediments successfully uses the micromorphological analysis Zh.M. Matviishyna (Veklych et al, 1979; Matviishyna, 1992; Matviishyna et al, 2010). The question of the Pleistocene evolution of soil coverings and landscapes, based on paleopedological data with widespread use of micromorphological analysis, is reflected in later publications by Zh.M. Matviishyna and her students (Matviishyna, Parkhomenko, 2008; Matviishyna et al., 2009; Matviishyna, Doroshkevych, 2011; Doroshkevych, Matviishyna, 2012). The features of zonal changes of Upper-Pleistocene and modern soils, based on micromorphological data, are covered in the monograph by S.P. Karmazynenko (Karmazynenko, 2010). Paleogeographical reconstruction of the Pleistocene nature, carried out on the basis of paleopedological data with the active use of micromorphological analysis, is devoted to the

monograph of S.P. Doroshkevych (Doroshkevych, 2018) on the territory of Pobuzhzhya.

Materials and methods of research. The basis of the study is the complex paleopedological method, the main task of which is to reconstruct the paleoenvironment of the ancient soils formation. An important role during paleopedological investigation is given by micromorphological analysis, which demonstrates good efficiency in the study of fossil soil through the diagnosis of ancient elementary soil formation processes.

During the study, as a stratigraphic basis, we used a scheme of paleogeographic stage for the plain territory of Ukraine (Veklych M.F. et al, 1993). It is this scheme that remains unified for Ukraine today, although, over the past 20 years, many issues have emerged that require clarification and improvement. In particular, the issues of absolute age (especially for the late Pleistocene horizons), the affiliation of the horizons to the Pleistocene units, the establishment of the lower bound of the Pleistocene, etc., are very acutely debated. According to the stratigraphic code (Stratigraphic ..., 2012), the Pleistocene (Neopleistocene) is divided into 16 paleogeographic stages, the stages of Eopleistocene are not considered in the work.

Regarding the territory of the Middle Pobuzhzhya, there are several approaches to the allocation of its boundaries: tectonic (within the boundaries of the Ukrainian shield, from Medzhybizh to Alexandrovka), geomorphological and hydrological (from Vinnitsa to Aleksandrovka) (Denysyk H.I. et al, 2002), landscape (Medium-Pobuzhzhya Highland region according to modern physics-geographical division into districts) (National Atlas of Ukraine, 2007), etc. From the standpoint of paleogeographic studies, in our opinion, the most expedienly to study the territory that developed on a common tectonic basis, that's why under the Middle Pobuzhzhya, we consider the territory of the basin of the Southern Bug river within the boundaries of the Ukrainian shield (Figure 1).

During the last 10 years, we have investigated

Fig. 1. Territory of Middle Pobuzhzhya within Ukraine

17 new sections of the Pleistocene deposits (11 of which are within natural outcrops and quarries, 6 on archaeological sites (Doroshkevych, 2018; Zalizniak et al, 2013; Matviishyna, Doroshkevych, 2011; et al). These are sections near the city of Medzhybizh and the village of Trebukhivtsi (Khmelnytsky region), villages of Bezimenne, Stryzhavka, Yakushyntsi, Sabariv, Raihorod and Tyvriv (Vinnytsia region), Uman cities (Cherkasy region), villages of Andriivka, Korobchyne (two sections), Likareve (section Vyss), Ozerove, Troianove (Kirovograd region), cities of Pervomaisk and the village of Pankratove (Mykolaiv region) (Figure 2, 3).

Results and their analysis. According to modern physic-geographical division into districts, the territory of the Middle Pobuzhzhya is located within three natural zones: broadleaf forests, forest-steppe and steppe. Each of these zones has its typical natural features (National Atlas of Ukraine, 2007). Particularly interesting is the estate of modern soil cover, which is considered as a kind of indicator of modern physic-geographical conditions. After all, the formation of one or another genetic type of soil from on the interaction of the main natural factors of soil formation: the lithological composition of soil formation bed rocks, geomorphological position, climate, vegetation, geological age and duration of soil formation. All these factors, in turn, predetermine a specific set of elementary soil formation processes under the influence of various interactions under which a certain genetic type of soil is formed.

Accordingly, modern zonal soils of the Middle

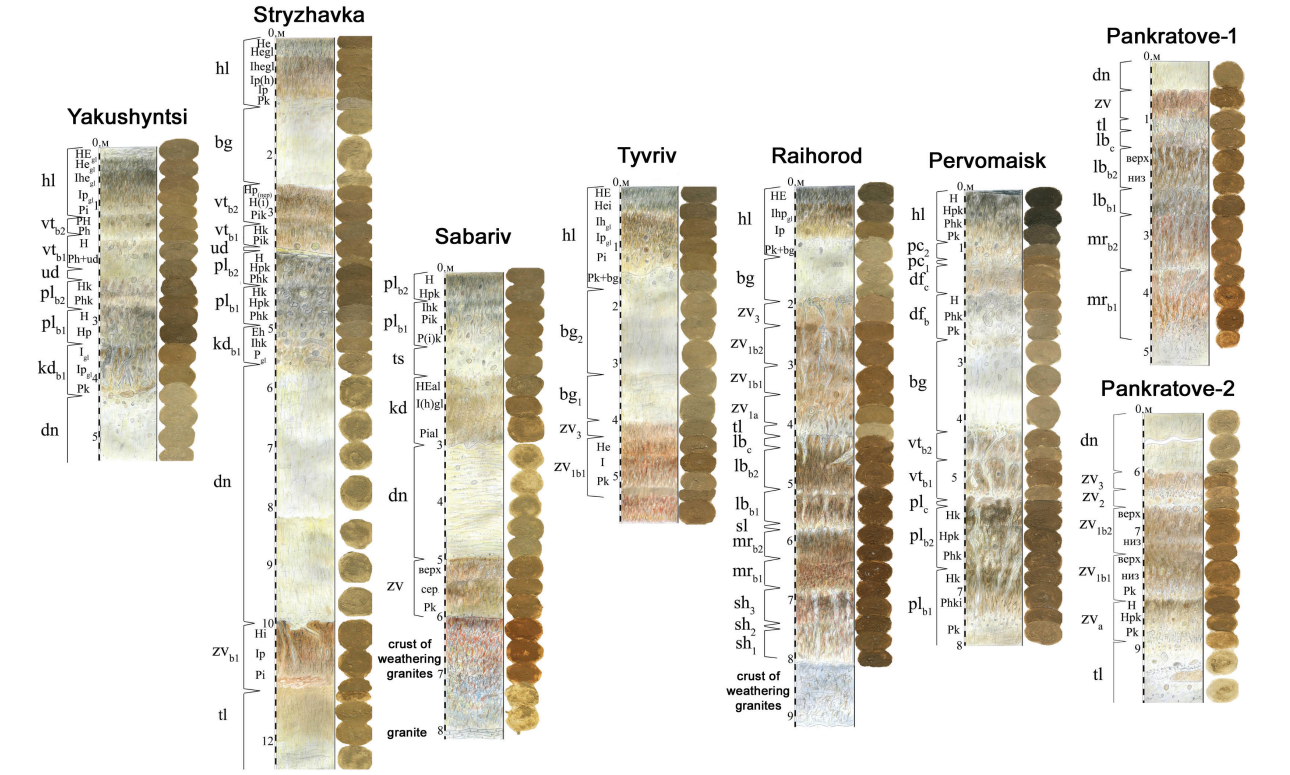

Fig. 2. The field scetches of the section with samples of natural material of the Middle Pobuzhzhya Pleistocene deposits (after Zh. Matviishyna). (On the top – name of the section. From left to right: indexes of the stratigraphical horizons; genetic horizons; deep in m; lithological column; samples of the natural materials).

Pobuzhzhya is represented by light gray, gray and dark gray podzolized, chernozems degrated, podzolized, typical (in the forest-steppe zone) and chernozems ordinary (in the steppe zone). Locally distributed sod, sod-podzolic, meadow-chernozem, meadow, peat-swampy and other azonal soils (National Atlas of Ukraine, 2007). The modern genetic types of soils are the basis for paleogeographic reconstruction, peculiar standards for comparison with the genetic types of fossil soils in the studied sections of the Pleistocene deposits. Performed reconstruction of the natural conditions of the territory of Middle Pobuzhzhya in Pleistocene are based on paleopedological data, that is, peculiar «records» about the natural conditions of the past, preserved in the form of specific properties and features of fossil Pleistocene soils, soils rocks, loesses and other layers.

As you know, the formation of any genetic type of soil depends of the nature soil formation processes. Possessing knowledge about manifestation of soil formation processes, one can observe their diagnostic features under a microscope, which provides an opportunity to restore the chronology of soil formation processes to clarify the genesis of deposits and to conduct genetic identification of the soils.

Separate possibilities of micromorphological diagnostics of elementary soil formation processes, based on their own and of precursors data, are shown in Table 1.

To solve the problems of paleogeographical reconstruction, we used the data of micromorphological analysis as part of the complex paleopedological method. In particular, the method of micromorphological research has been adapted to detect the diagnostic features of primary soil formation processes in the fossil soils of the Middle Pobuzhzhya in order to find out the issues of the genesis of deposits (Doroshkevych, Matviishyna, 2012).

The signs of the following groups of elementary ones have been found in the fossil Pleistocene soils of the Dofinivka (df), the Vytachiv (vt), the Pryluky (pl), the Kaydaky(kd), the Zavadivka (zv), the Lubny (lb), the Martonosha (mr) and the Shyrokyne (sh) soil-forming processes (SFP) (classification of groups by Rozanov, 2004) (Figure 4).

Biogenic-accumulative SFP (humus formation, humus accumulation, bedding, peat formation, etc.) caused by direct influence of living organisms, products of their life activity and dead remains (Figure 4 a-d). In thin sections with undisturbed structure under microscope biogenic and accumulative processes are characterized by dark, dark brown or brown humus-clay plasma, structural formations in the form of simple and complex microaggregates, well-defined

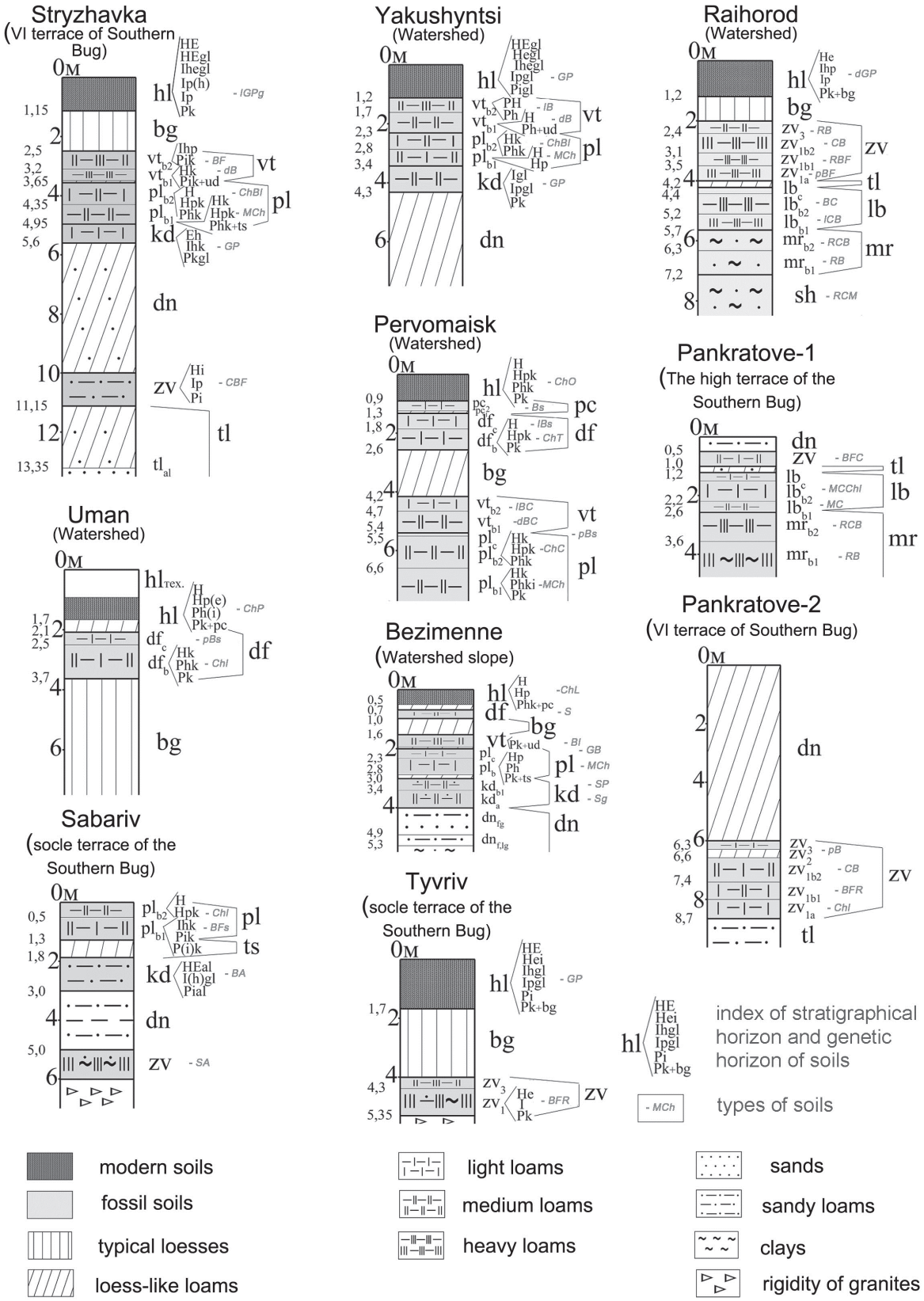

Fig. 3. Lithologic-stratigraphical columns of separate sections of the Pleistocene deposits of the Middle Pobuzhzhya.
Types of soils: S – sod; SP – sod- podzolic; Sg – sod gleyed; GP – grau podzolized; lGPg – light-grau podzolic gleyed; dGP – dark-grau podzolic; GB – grau-brown; Bl – brown-liked; BF – brown forest; BFC – brown forest cinnamonish; BFR – brown forest reddish; CBF – cinnamon-brown forest; RB – reddish-brown; RBF – reddish-brown forest; RCB – reddish-cinnamon-brown; RCM – reddish-cinnamonish meadow; BFs - brown forest with sign of steppe; dB – dark-brown; dBC – dark-brown cinnamonish; BC – brown cinnamonish; CB – cinnamonish-brown; lB – light-brown; lBC – light-brown cinnamonish; lCB – light-cinnamonish brown; pBF – pale-brown forest; pBs – pale-brown steppe; pB – pale-brown; Bs – brown steppe; MC – meadow cinnamon; BA – brown alluvial; Chl – chernozem-liked; ChP – chernozem podzolized; ChL – chernozem leaching; ChT – chernozem typical; ChO – chernozem ordinary; MCh – meadow chernozem; ChBl – chernozem brownzem-liked; ChC – chernozem cinnamonish

Table 1. Micromorphological diagnostics of soil formation processes in fossil Pleistocene soils of the Middle Pobuzhzhya (Doroshkevych, 2018)

Elements of microstructure	Micromorphological signs and traces of ancient soil formation	Conditions, processes of formation
Microstructure	Compact, dense, merged, with rounded clutches of organo-clay substanses	Soil formation took place under favorable climatic conditions, where there was a sufficient amount of moisture and heat. Properties for the Lower Pleistocene soils
	Cubs, loose, soft, grains of the skeleton are proportional to each other	Soil formation - in relatively arid conditions, a fairly warm climate. The microstructure is characteristic for rocks of light granulometric composition, characteristic of Upper Pleistocene soils, as well as forests ones
Aggregation	Aggregates	They are formed by biogenic-accumulative processes caused by direct influence of living organisms, products of their vital activity, as well as cracking at drying of soil mass, microsedimentation, microerosion
	Complex grainy microaggregates of II-IV order, black or almost black, separated by a grid of vorticular pores	The presence of humic acids in the composition of organic matter, high saturation of soil mass in the basics. In the overwhelming majority it is the products of the life of worms (excrements). Characteristic of the humus horizons of chernozem. Complex microaggregates of chernozem type are observed in the horizons df, pl, kd_{b2}, lb of soils
	Simple and complex (to the third order) microaggregates of dark color	Actual for gray forest soils
	Fuzzy micro aggregates of dark or brownish color	Intrinsic to podzolic soils, in the eluvial horizon often acquire puff formation
	Oval, simple and complex (to the third order) micro aggregates	This is mainly faecals of mites fauna. Own chestnut soils. It is characterized by zonal southern soils of Dofinivka and Pryluky time
	Tightly packed structural isolations of the 1st-2nd order	Actual brown soils
	Cleave blocks	Formed in the case of reloading of soils, when the surface of the cracks converge as a result of swelling and form a cleave mass. Variable wet-dry conditions. Characteristic of vt, zv, mr soils
Porosity	Branched net of pores	Active livelihoods of soil biota and favorable conditions for soil aeration. Properties for forests and soils of chernozem type
	Pores-cracks	They are formed for successive swelling of clay mass under humid conditions, and then compression due to the drying of the soil mass. Intrinsically enriched soils
Optical orientation	Optical orientation of clay substances	The course of illuvial processes
	Isolation of clay substances in the form of scaled gutters, incrustations on the walls of pores, clay streams, impregnation of plasma by the calomorphic clays	Formation of soils of washing (podzolic, pseudo-podzolic, brown forest, gray forest, red and yellow earth) or periodically humid regimen of wetting (solonetses, tacier, malt). The mentioned signs occur in the fossil soils of the forest genesis
	Transparent and bright streaks	The processes of podzolizations. These traits for characteristic of podzolic and turf-podzolic soils
	Influxes are enriched on finely dispersed humus and clay particles	The process of podzolization and lessive. Signs are characteristic for gray forest soils
	Influxes of red color, not transparent, much ferruginous, occur throughout the profile	Processes of lessive (illimerizations). Actual for brown forest soils
	Impoverished on mulles and humus («washed») microplots	The course of eluvial processes of moving organo-clay substances down the profile. Manifested in eluvial horizons
	Clay substance that is not oriented or oriented in the form of rings located near individual minerals or aggregates	Complicated conditions for the course of illuvial processes and leaching
	There is not expressed optical orientation of clay substances	Formation of soils under constantly dry conditions (grayzems, typical loesses, southern zone of the Dofinivka soil formation
Organic matter	Dispersed brown humus, which is closely combined with clay	Characteristic for soils of forest genesis, of Early Pleistocene
	The organic substance is coagulated in the form of clots and lumps, which are combined into complex microaggregates	Intense biogenic and accumulative processes. Particularly good expressed in the chernozems-liked soils, gray forest of Middle and Late Pleistocene soils
	Brown humus in the form of cinnamon or light clots	Displays the effect of relatively arid climate, closed to dry-steppe

Elements of microstructure	Micromorphological signs and traces of ancient soil formation	Conditions, processes of formation
New formation of easily dessolved salts	Needled calcite-lublinit	Characteristic for soils with intensive seasonal migration of carbonates
	Micro-calcite, concentrated on the walls of pores	Relatively fast, intense evaporation and high concentration of carbonates in the soil solution
	Fine-grained calcite, concentrated on the walls of pores	Gradual evaporation and slight migration of carbonates
	Increased carbonate content	Dryer conditions characteristic of steppe type soils
	Insignificant carbonate content	More wet conditions of soil formation, which are characteristic for forest types of soils
	Gypsum	Display of hotter climatic conditions
Iron and manganese neoplasms	Presence of ferruginous and manganese new formations	Surface or ground soils overwetting. Processes related to release, migration and concentration of hydroxides of iron and manganese
	Microorsteins	Seasonal changes in the humidity conditions
	Compact microfiber with clear edges	Formed in ungleyed or deeply gleyed sod-podzolic soils
	Friable microorsteins with fuzzy, blurred edges	Formed in gley soils
	Ferruginations of walls pores	Encreasing gleying in the illuvial horizon
Other	Carbonate-clayey loess particles are commensurate with the seeds of primary minerals, wrapped with transparent films and membranes, separated by a developed pore net	Characteristic for typical loesses
	The accumulation of sand-aleurite particles, micro-polygons in the form of rings, sorting of sand and large alyurite particles	The course of cryogenic processes, the existence of freezing-thawing out conditions

inter- and inside-aggregate cavity space with a developed net of pores and cracks. Organic matter in the soil mass is in the form of humus (of coagulated, dispersed, coprolite, microbial mass, weakly, medium or strongly depleted residues of tissues of plants or animals, organo-mineral compounds, etc.).

Eluvial SFP (podzolisation, illimerization, leaching, etc.) are associated with the destruction or transformation of soil material in the eluvial horizon with the subsequent removal from it of products of destruction (transformation) into the lower disposed horizons (Figure 4 e-h). In the thin sections from the eluvial horizons of fossil soils, the dominance of the skeleton particles over the plasma is observed, the destroyed composite microaggregates are found, the «washed» (without clay films) seeds of primary minerals, which in some fields are cemented with amorphous plasma (by humus, silica). In the illuvial horizon there are signs of the removement of organo-clay substances in the form of numerous scalene streaks of polynite (calomorphic clays) on the walls of pores and cracks, films around the grains of the mineral skeleton.

Illuvial-accumulative SFP is the processes associated with the accumulation of substances in the middle part of the genetic profile of eluvial-illuvially differentiated soils (Figure 4 i-l). Depending on the type of accumulated substances (silt, humus, carbonates, iron oxides, aluminium, etc.), the processes are also distinguished. For example: clay-illuvial, humus-illuvial, carbonate-illuvial, feruginous-illuvial and the like. Under the microscope, illuvial-accumulative processes are diagnosed with various forms of influxes and streams confined to the cavity space, with films around the grains of the skeleton and other new formations of the polynite (calomorphic clays).

Hydrogen-accumulative SFP is a group of processes that are related to the influence of ground water on the formation of a soil profile with various forms of gyps, calcite, easily soluble salts new formation, etc. (Figure 4 m-p). In the thin sections with undisturbed structure of fossil soils, diagnostic signs of enriching on gypses processes (micro, fine, medium grained, rhombus, lensliked and other gyps new formations), carbonatization (crypto-, micro- and small-grained calcite, lublynite, etc.) can be detected, salinization (forms of easy soluble salts), ore formation (spots, flakes, films, diffuse rings, microorsteins, incrustations and other forms of iron and manganese hydroxides), meadow formation processes (high content of humus, in the lower part of the profile – gray-blue spots of hydroxides, iron, microorsteins, leaching of mass from carbonates, etc.).

Metamorphic SFP is a group of processes for the transformation of rock-forming minerals inside

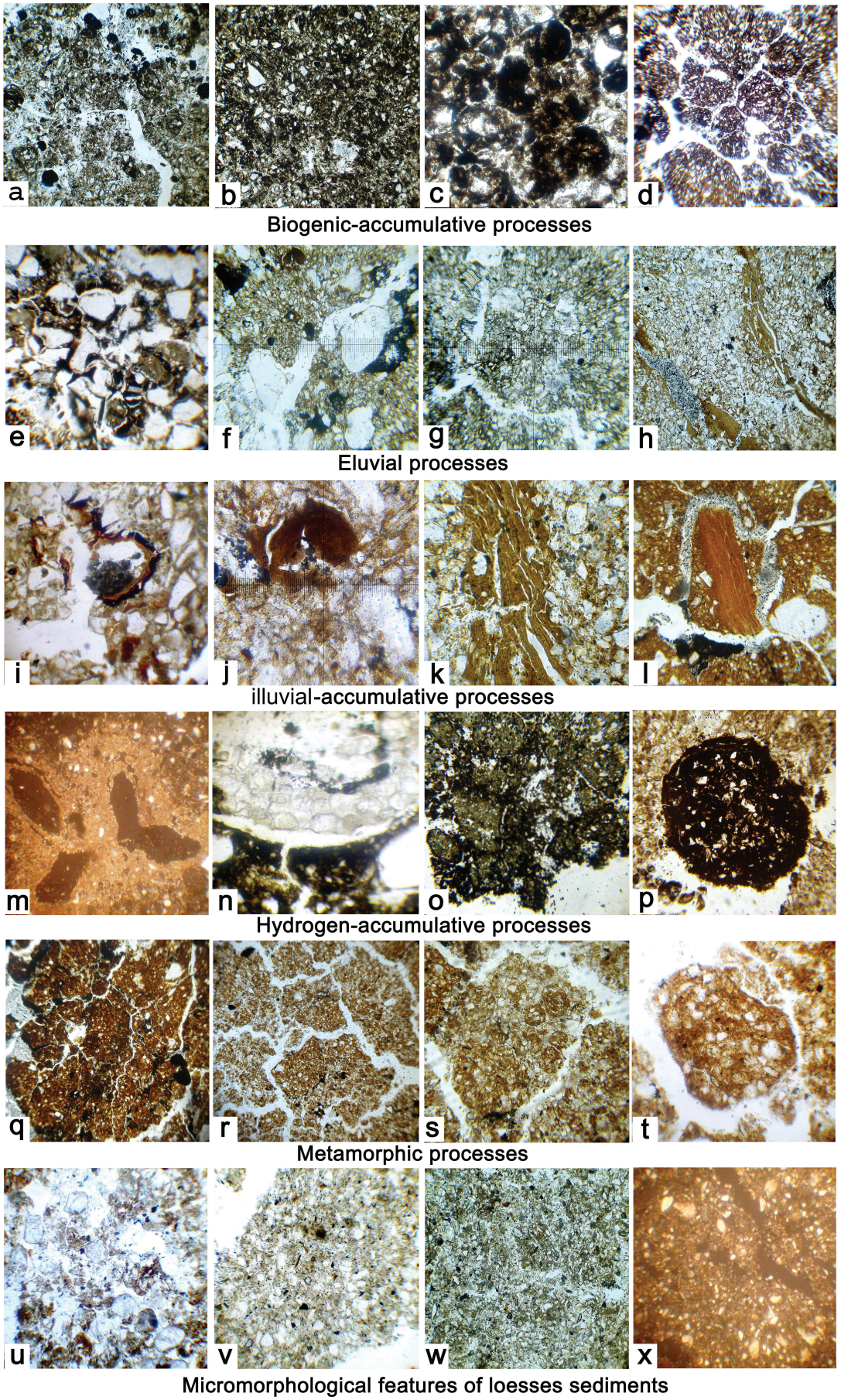

Fig. 4. Certain typical micromorphological diagnostic features of the main groups of soil formation processes in the differ aged Pleistocene soils of the Middle Pobuzhzhya processes:

Biogenic-accumulative: a) complex microaggregation of chernozem of brownzem-liked (pl_{b2}; Yakushyntsi) /magn. 100/; b) microstructure of the humus horizon of meadow chernozem (pl_{b1}; Yakushyntsi) /magn. 100/; c) humus coagulated in the form of humons in the humus horizon of meadow chernozem (pl_{b1}; Yakushyntsi) /magn. 400/; d) coprolites of rain worms combined in the complex microaggregates, separated by a net of twisted pores, in the humus horizon of the meadow chernozem (pl_{b1}; Pervomaisk) / magn. 70/ (nic.||).

Eluvial: e) microstructure of the humus-eluvial horizon of sod-podzolic soils (kd_{b1}; Bezimenne) /magn. 70/; f, g) «washed» grains of the mineral skeleton are cemented with amorphous plasma in the eluvial-humus horizon of gray podzolized soil (kd_{b1}; Stryzhavka) /magn. 80/; h) new formations of polynite (calomorphic clay) in the form of scaly streaks on the pore walls (kd_{b1}; Yakushyntsi) /magn. 100/ (nic.||).

Illuvial-accumulative: i) manganese-ferruginous-clayey calomorphic clay formation on the walls of pores of sod-gleyd soil (kd_a; Bezimenne) /magn. 70/; j) scale influx of calomorphic clays in the brown podzolized forest soil (kd_{b1}; Stryzhavka) /magn. 400/; k) the influx of calomorphic clays in the illuvial horizon of gray podzolized soil (kd_{b1}; Yakushyntsi) /magn. 400/; l) terruginous-clayey influx of calomorphic clays in the pore of reddish-brown meadow soil (sh; Raihorod) /magn. 100/ (nic.||).

Hydrogen-accumulative: m) concentrations of microcrystalline around the pore in the lower part of the brown soil (vt_{b2}; Medzhybizh) /magn. 70/; n) microconcentration of fine crystalline calcite in the pore of brown soil (vt_{b2}; Vyss) /magn. 140/; o) films and flakes of hydroxides of iron and manganese in reddish-cinnamonish brown soils (mr_{b2}; Raihorod) /magn. 100/; p) dense glandular-manganese concentric microorstein in dark brown soil (vt_{b1}; Yakushyntsi) /magn. 100/ (n-p – nic.||, m – nic. +).

Metamorphic: q) cinnamon-brown ferruginous-clay plasma, with a small fraction of the dusty grains of the skeleton, in the reddish-brown meadow soils (sh; Raihorod) /magn. 100/; r) cleave block microstructure of brown forest soils (zv_{1b1}; Raihorod) / magn. 40/; s) the ferruginous-clay substance is segregated into nodular formations, which are tightly packed in cleave blocks in brown forest soils (zv_{1b1}; Raihorod) /magn. 100/; t) the nodule of the ferruginous-clay substance from the middle part of the brown soil (vt_{b2}; Ozerove) /magn. 140/ (nic.||).

Micromorphological features of loesses sediments: u) microstructure of the Prychernomorya loess, the proportion of loess particles with seeds of primary minerals, large calcite crystals (Pervomaisk) /magn. 140/; v) the seeds of primary minerals are commensurate with the loess particles, covered with carbonate-clay films (Bezimenne) /magn. 140/; w) friable microstructure of the Dnipro loess (Yakushyntsi) /magn. 100/; x) dust-plasmic microstructure of the Uday loess, mass is impregnated with microcrystalline calcite (Korobchyne) /magn. 70/ (u-w – nic.||, x – nic. +).

of sediments («in situ»), without eluvial-illuvial redistribution of components in the soil profile (Figure 4 q-t). The metamorphic processes of soil formation are best displayed in the soils of the Early and Middle Pleistocene. Can see under the microskope signs of enrichment on the iron hydroxides processes (reddish, brownish, and yellowish-brown tints of the plasma) of claying (an decreasing in the percentage of mineral skeleton grains – an increasing proportion of plasma mass, a dense microstructure in the form of cleave blocks, mass compactness, sharp edges of pores-cracks), cleavisation (dense block microstructure, segregation of organo-clay substances into nodular formations in side of the middle of fused blocks), rubbification (specific cinnamonic color of plasma, films and spots of iron oxides, goethite and haematites grains) inside soils weathering (corrosion mineral grains) and others.

Under a microscope in the thin sections from the typical loess horizons there are no signs of the above-mentioned soil formation processes. Loesses are characterized by a dust-plasmic elementary microstructure, a loose mass composition, a carbonate-clayey plasma, a developed system of cavities, and the seeds of primary minerals coated with transparent carbonate-clay films and shells that are commensurable with the loesses particles (Figure 4 u-x).

Summarizing the above, it should be noted that the micromorphological analysis, through the study of soil samples in thin sections with undisturbed structure, provides the opportunity to consider the soil as a system at the microscopic level. It is known that the formation of one or another type of soil depends on the nature of the manifestation of soil formation processes, which are the result of the joint action of the main factors of soil formation. Possessing knowledge about the natural peculiarities of certain primary soil forming processes, one can determine their diagnostic features under a microscope. This, in turn, makes it possible to restore the chronology of the soil formation processes in the Pleistocene sediments, to identify signs of diagenesis and the stage of development of the soil, to establish a genetic type of soil and to carry out paleogeographical reconstruction. In many cases, the micromorphological data can also be used for stratigraphic purposes, since the different age-old Pleistocene horizons are characterized by their individual specific singularizes.

Paleopedological studies of different age-old Pleistocene soils, carried out on the territory of the Middle Pobuzhzhya, with the active use of micromorphological data, allowed to obtain the following results.

The Shyrokyne horizon is correlated with 37-21 isotopic-oxygen stages (Matviishyna et al., 2010; Lindner et al, 2004), Balashovsky (Velychko et al., 1997) and Mikhailovsk horizons (Rekovez, 1994), Late Raiver (Veklych, 1968), Gunz-Mindel (Veklych, 1990). Presented by the deposits of the

first warm stage of the Pleistocene, which have a rather limited distribution, since they are found at high geomorphological levels of watersheds and, in the form of an alluvium of the warm phase, compose the VIII floodplain terrace. Deposits of the subaerial facies consist of heavy-sandy-clayey eluvial-deluvial formations of the aqual of fossil soils suits, the deposits of the subaqual facies are sands, sandy loams, loams, gravel, and the like.

The Shyrokyne deposits are investigated in the section of Raihorod, where the thickness of sediments is relatively conditionally divided into three soils suits. In the thin sections from Shyrokyne soils, by means of a micromorphological analysis, the processes of intensive claying (reduced proportion of primary grains of the mineral skeleton, cleave block microstructure, mass compacting, sharp edges of pore-cracks walls), enrichment on hydroxides of iron (cinnamonish, reddish, brownish shades of plasma color) , weathering (a large proportion of medium- and fine-dusty grains of the skeleton, clayey mass), partial leaching, intensive periodic surface and ground moisture (various forms of ferruginous and manganese new formations). Oodic and nodule forms of segregations of organic-ferruginous-clayey substances with concentric building indicate the existence of at least short dry periods, when organo-clay substances could be segregated from ground solutions in round and oval knitting-nodules (Figure 5).

The Martonosha horizon is correlated with 19 to 17 isotopic-oxygen stages (Matviishyna et al., 2010; Lindner et al, 2004), the Gremiachiv and Semilutsk interglacials (Bolihovskaja, 1995), Rzhaksyno soil (Velychko et al, 1997), Illyinsk time (Hlushankova, 2008; Rekovez, 1994), Tegelensk interglacial (Veklych, 1968), Mindel 1-2 (Veklych, 1990). It is widespreaded in the subaeral strata of the Pleistocene deposits at high geomorphological levels of watersheds and their gentle slopes, above the seventh floodplain terrace. Deposits are represented by eluvial-deluvial heavy-loamy soils, often clayey fossil soils. In the subaqual thickness, the Martonosha soils correlate with the lower pack of alluvium of the warm phase of the seventh floodplain terrace.

The Martonosha deposits are investigated in sections of the Pleistocene deposits near villages of Raihorod and Pankratove. In the studied sections, the Martonosha formations are represented by soils suits consisting of two soils of climatic optimum. In the section Raihorod is a reddish-brown soil of substage mr_{b1} and reddish-brownish-brown of substage mr_{b2}; in the section Pankratove – it is a reddish brown meadow of early optimum (mr_{b1}) and reddish-cinnamonish-brown meadow soil of late optimum (mr_{b2}). The soils are monolithic, clay-sandy, dense, gleyed and ferrugenous, with fine silicious-carbonate concretions, the number of which grows in the lower soil.

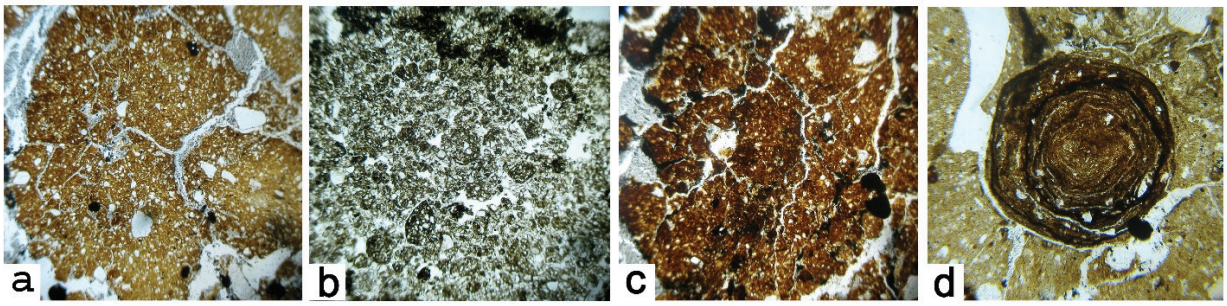

Fig. 5. Microstructure of Shyrokyne soils in the section near the village Raihorod: a) dense block microstructure of the Shyrokyne horizon /magn. 40/; b) structural nodular segregation in the organ-iron-clay plasma /magn. 40/; c) ferruginous-clay plasma in the lower part of the soil /magn. 40/; d) glandular microorstein of a concentric structure in the form of diffuse rings /magn. 100/ (nic. ||).

Macro- and micromorphological features allow us to talk about the formation of the Shyrokyne age soils in the most warm and humid conditions in the Pleistocene, and indicate the similarities of the fossil soils signs with brown and cinnamon ones. At the same time, the relative leaching of the soil profile from carbonates, various forms of ferruginous and manganese new formations are signs of soil formation in sufficiently damp, possibly meadow conditions. We relate the soils of the Shyrokyne time to the type reddish-cinnamonic meadow of warm-temperate climate.

Micromorphological analysis of Martonosha soils fixes their significant claying, cleaving of microstructures in the form of cleave blocks, separated by pores-cracks, the presence of round-oval segregational nodular concentrations of organic-clay substance, indicating on their formation under periodically-changing conditions of moistening. For Martonosha soils, especially of the early optimum, the partial mobility of the most subtle colloidal particles of the silt and their separation in the form of reddish-brown influxes and streams, the filling by the material colloidal substance of pores and impregnation by

them of clay material in the middle and lower part of the profiles is characteristic. All these are signs of the course of illuvial and illimerization processes. Soils of the late optimum are characterized by good microaggregacy, which manifests itself throughout the profile. This may indicate an intensive development of biogenic and accumulative processes. Significant claying of the mass and a large number of ferruginous new formations (spots, flakes, microorsteins, diffuse rings) indicate the processes of gleying, enrichment on hydroxides of iron and meadow process development (Figure 6).

The horizon is investigated in sections of the Pleistocene deposits of Raihorod, Korobchyne-quarry and Pankratove. Studied Lubny soils in sections are represented by complicated polygenetic formations consisting of two soils of the climatic optimum and the soils-pedosediments of the final stage. In the section, Raihorod a light-cinnamon-brown forest soil of the lb_{b1} substage and brownish-cinnamon substage lb_{b2} are represented; in the sections of the Korobchyne-quarry, this is a cinnamonish-brown forest soil of early optimum (lb_{b1}), dark-cinnamonish meadow weakly saltish soil of late optimum (lb_{b2})

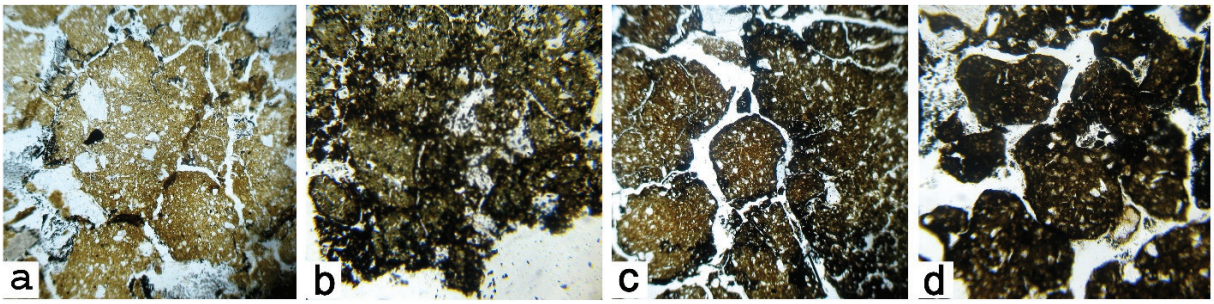

Fig. 6. Microstructure of Martonosha soils in the section near the village Raihorod: a) micro-building in the form of cleave blocks, which are separated by a system of pore-cracks in the soil mr_{b2} /magn. 40/; b) films and flakes of iron and manganese hydroxides outlined ooid-like segregations in the cleave earth mass mr_{b2} /magn. 100/; c) cleave block microstructure mr_{b1}; separate blocks consist of densely packed nodular iron-clay formations; iron and manganese oxides in the form of films are concentrated on the walls of the pores /magn 40/; d) nodule joints of organo-ferruginous-clay substances in soil mr_{b1} /magn. 100/ (nic. II)

Paleopedological data indicate that the climate of Martonosha time was moderately warm, in the first half of the climatic optimum it was wet, but in the second half it was variable-humid. At this time, the climatic conditions were probably close to the changing and wet conditions of modern subtropics, with the summer maximum of humidity, which contributed to the development of the meadow processes (the formation of thick profiles with a high degree of dispersion of the mineral mass), which, in combination with periodic aridity, caused the cleaving of soils.

The Lubny horizon is correlated with 15-13 isotopic-oxygen stages (Matviishyna et al., 2010; Lindner et al, 2004), Muchkap interglacial (Bolihovskaia, 1995), the Voronsky soil complex (Velychko et al, 1997), the Belovezhsky horizon (Rekovez, 1994), the Kromer interglacial (Veklych, 1968). Displaced in the subaerial layers of the Pleistocene deposits at high geomorphological levels of watersheds and their slopes, beginning from the seventh floodplain terrace. In the subaerial straties is represented by eluvial-deluvial deposits – mostly heavy-loamy fossil soils. The stratigraphic equivalent of fossil soils in the subaqual facies is the alluvium of the warm phase of the sixth floodplain terrace.

and brownish-cinnamonic dry-steppe soil of the final stage (lb_c); in the section Pankratove it is a meadow-cinnamonic soil of the floodplain facies of the early optimum (lb_{b1}) and meadow-cinnamonic chernozem-liked soil of late optimum (lb_{b2}). The soils are monolithic, dense, enriched on clayes, but to a lesser extent than the Martonosha, enriched on hydroxides of iron, broken by frost-free cracks, inside of which there are hard, hollow in the middle, silicon-carbonate nodules concretions. In the south, gypsum concretions have been detected.

The micromorphological analysis fixes the characteristic features of the Lubny soils – a significant cleaving of the microstructure in the form of blocks, separated by pores-cracks, claying, segregation of the organo-ferruginous-clay substance in the form of ooids-nodules. The latter ones indicate the periodically changing conditions for the formation of soils, when the conditions of intensive moisture environment necessary for the transition of chemicals substances into solutions, were changed in the dry periods, during which the segregation of chemicals from solutions took place. For soils of the early climatic optimum, the partial mobility of the most subtle colloidal particles of the silt and their isolations in the form of influxes and streaks, pore filling, and plasma

impregnation in the middle and lower sections of the profiles is characteristic, indicating the course of the illuvial processes. In the soils of the late optimum, good aggregation of the mass is recorded, available carbonate formations (Figure 7).

and of horizon widespread distribution of these deposits indicate intense and long-term soil formation processes that took place during this stage.

In the sections Raihorod and Pankratove, the Zavadivka horizon is represented by the soils of

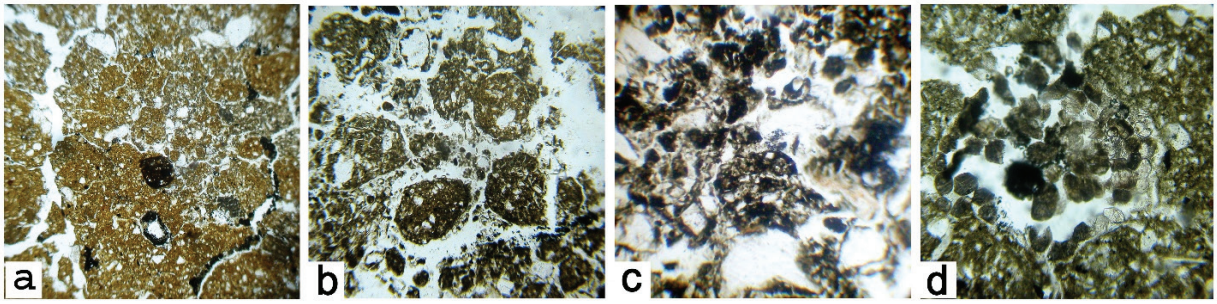

Fig. 7. Microstructure of Lubny soils: a) the blocks are separated by cracking pores in the soil of lb_{b1}, densely packed and with carbonate-clay new formations (section Raihorod) /magn. 40/; b) segregation nodular formations of organo-ferruginous-clay substance in the lb_{b2} section Raihorod /magn. 100/; c) humus-clay soil microaggregates of lb_{b2}, section Pankratove /magn. 70/; d) accumulation of fine crystalline calcite in the pore of the lb_c soil in the section Raihorod /magn. 100/ (nic. II)

The considerable claying and enrichment on iron hydroxides of the mass, a large number of primary minerals weathered grains, indicates not only wet but also sufficiently warm conditions for the formation of Lubny soils. The genetic types of these soils indicate the soil formation under environment of a warm-temperate climate, which is was more temperate that in Martonosha time.

The Zavadivka horizon is represented by the deposits of the first warm stage of the Middle Pleistocene, which correlates with the Lykhvino interglacial (Velychko et al., 1997; Rekovez, 1994), the Mindel-Riss interglacial (Veklych, 1990), 11-7 isotopic-oxygen stages (Matviishyna et al, 2010). Deposits of the Zavadivka stage are widespread in the subaerial straties of the Pleistocene deposits on inter-rivers spaces and their slopes, in the valleys of the rivers since the sixth floodplain terrace. In the subaerial facies eluvial-deluvial deposits are represented by mostly medium-heavy loam fossil soils. The stratigraphic equivalent of fossil soils in the subaqueous facies is the alluvium of the warm phase of the fifth floodplain terrace.

The horizon is investigated in sections of the Pleistocene deposits of Stryzhavka, Sabariv, Tyvriv, Medzhybizh, Raihorod, Korobchyne-quarry, Pankratove-1 and Pankratove-2. Zavadivka deposits are often represented by complex polygenetic soils suits. The structure of the full suit is as follows: zv_a is the soil of the initial stage, zv_{1b1} is the early soil of the optimal stage, zv_{1b2} is the late soil of the optimal stage, zv_2 is the loesses layers (Oril) and zv_3 is the soil of the final stage (Potiahailivsky). The horizon's thickness ranges from tens of centimeters to almost 6 m and averaged around 2 m. Significant thickness all stages. In the section Raihorod it is a yellowish-brown forest soil of the initial stage, reddish brown forest of early optimum, cinnamonish-brown forest of late optimum and short-profile reddish-brown soil of the final stage. In the context of Pankratove-2, the suit consists of chernozem-liked soil of the initial stage, brown forest reddish soil of early optimum, cinnamonish-brown soil of late optimum, loess-like layer and yellowish-brown soil of the final stage. In addition, Zavadivka soils are investigated in sections Stryzhavka (cinnamon-brown forest), Sabariv (sod-alluvial), Tyvriv (brown forest soil of climatic optimum and soil-pedosediment of the final stage), Medzhybizh (reddish-brown alluvial) and Pankratove-1 (brown forest cinnamonish).

Zavadivka soils are dense, clayed and enriched on iron hidrooxides, secondary carbonated, with ferruginous-manganese films on the edges of structural separations, often broken up by freezing cracks to which confined carbonate new formations, have a differentiated profile. The micromorphological analysis fixes a cleave block microstructure, a significant claying of mass, new formations of polynite (calomorphic clays) in the form of influxes, streaks and streams, plasma impregnation (signs of illuvial processes), gray-blue spots, diffuse rings, microorsteins (signs of gleyiness); unlike of Lubny soils, rounded ooidic segregations of organo-clay substances are fuzzy, weakly concentric, occur less frequently (Figure 8).

Enrichment on iron oxides of soil material in complex with over thickness of profile indicate the formation of cleave soils-pedosediments under the influence of intensive weathering processes in a warm and humid climate. The soils, formed in the early

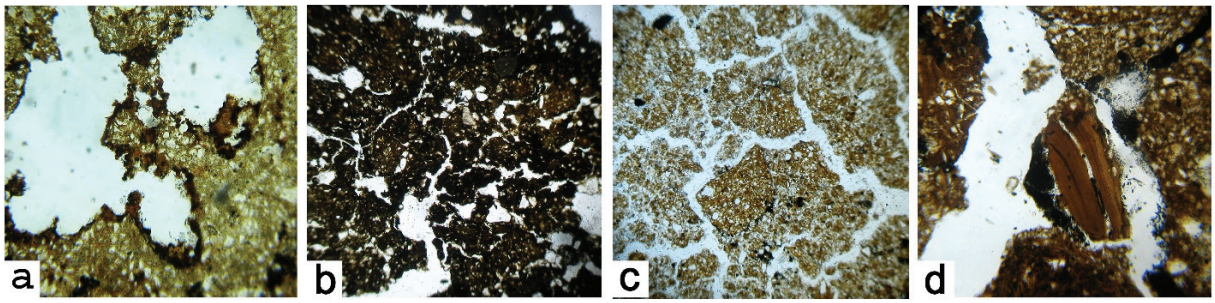

Fig. 8. Microstructure of Zavadivka soils: a) incrustation of pores with hydroxides of iron in the zv_3 soil of the section Raihorod / magn. 100/; b) compact microstructure with a dense packing of grains of the mineral skeleton in a plasma of zv_{1b2} soil section Raihorod /magn. 100/; c) dense blocks are separated by a system of twisted pore-cracks in the zv_{1b1} soil section Raihorod /magn. 40/; d) scaly ferruginous-clayey outflow of polynite in the zv_{1b1} soil, section Raihorod /magn. 100/ (nic. II)

optimum, are mainly of forest genesis, with traits of brown forest soils of warm facies. In the late optimum the soils with transient features from brown forest to brown and reddish-brown were formed. Comparing the micro-morphological features of brown forest-cinnamonish Zavadivka soils with the modern brown forest soils of the Eastern Caucasus, their remarkable similarity (Matviishyna, 1982) is noted, despite of the large differences between the soil-formation bed rocks.

Kaydaky horizon – represented by deposits of the first warm stage after Dnieper glaciation. Stratigraphically it correlates with the first interglacial or the 1-st Warsaw glacial, the Drenthe, the second interstadial of Riss glacial (Veklych, 1968), the Korshiv fossil soil complex (Shelkoplias et al, 1986), or the soil of the first phase of Gorohiv soil formation (Lanczont M. et al, 2015), Saalian the soils of the Mezyn complex (Velychko et al, 1997), the Eemian pedocomplex, the isotope-oxygen substage 5e (Matviishyna et al, 2010). This horizon is widespread in the subaerial strata of the Pleistocene deposits above the fifth terraces, which is represented by eluvial-deluvial sediments – fossil soils. It lies predominantly on the Dnipro deposits, overlapped by thickets of loess and loess liked loams, often by Pryluky soils. On low geomorphological levels and gentle slopes of the watersheds, where favorable conditions for the fossilization of the Kaydaky soil formations were provided, they are represented by the suits of fossil soils. At inter-river spaces and other high lands, the only illuvial horizon of the soil of the early optimum is often remained from the suit of Kaydaky soils, the other part of the profile, as rule, is mainly transformed or reworked by the processes of the Pryluky soil formation. In the subaqual facie the Kaydaky fossil soil is correlated with the alluvium of the warm phase of the IV floodplain terrace.

The horizon is investigated in sections of Pleistocene deposits Bezimenne, Medzhybizh, Stryzhavka, Yakushyntsi, Sabariv, Korobchyne-quarry. The horizon's thickness changes from a dozen centimeters to more than 3 meters. The granulometric composition is mostly medium loam, less commonly-light or heavy.

We studied the following genetic types of Kaydaky soils: sod-podzolic (Bezimenne), sod-podzolic alluvial (Medzhybizh), broun alluvial (Sabariv), meadow-chernozem (Korobchyne-quarry) and illuvial horizons of brown (Stryzhavka) and gray (Yakushyntsi) of forest soils. For sod-podzolic and alluvial soils, the sandy composition is characteristic, small containing of humus substance, the presence of stains of iron hydroxides and claying ortzand layers. In the illuvial horizons of brown and gray forest soils, the micro-morphological features of the illuvial processes (podzolization, illimerization) are clearly traceable: depleted on the mulles and humus fields in the upper part of the profile, the influxes of transparent yellowish calomorphic clays sometimes with inclusions of coarse clay and humus particles in the middle part, signs of gleying and claying, structural separations in the form of blocks separated by wide pores (Fig. 9).

According to paleopedological data, the stage of the Kaydaky soil formation is clearly recorded, manifested in the natural general changes in the soil cover. So, at the initial stage, soddy and turf-podzolic soils were formed; in the substage of the early climatic optimum, the soils of the forest and forest-steppe genesis are soddy-podzolic, brown forest, brown forest gleyey, podzolic and pseudo-podzolic, light gray, gray forest and their varieties, dark gray forest, chernozems podzolized; in the substage of late optimum – soils of sod, meadow or chernozem types: chernozems leached and podzolized, meadow-chernozem, chernozem-like.

During the Kaydaky time, the soils, which were similar to modern ones, began to form in Pleistocene for the first time and were established close to the present soil zones. During this stage there is a stageness of soil formation, which manifests itself in changing

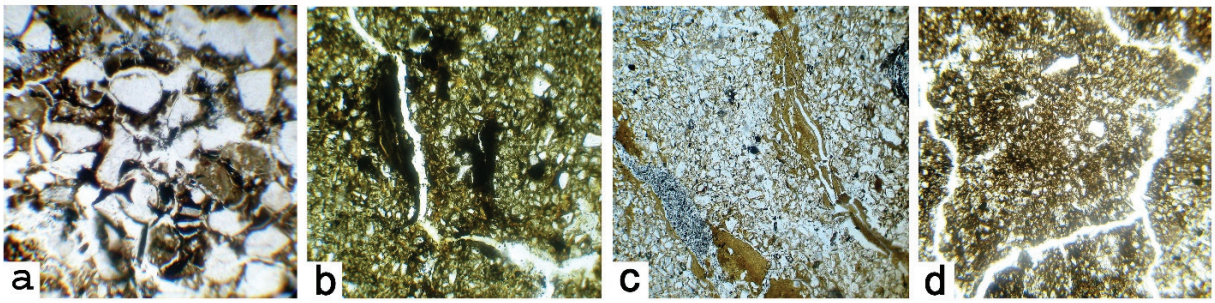

Fig. 9. Microstructure of Kaydaky soils: a) microstructure of eluvial horizon in the kd_{b1} soil, section Bezimenne: alternating «washed» fields with enriched on humus, dark brown clouds /magn. 70/; b) humus-clay dark-colored influxes, enriched by the coarse clays and humus particles of the upper part of the illuvial-humus horizon of the kd_{b1}, section Yakushyntsi /magn. 100/; c) dense microstructure of the Ip_{gl} horizon, the clay substance is mobile, is separated in the form of influxes, films and streams in the kd_{b1} soil, section Yakushyntsi /magn. 100/; d) structural aggregates-blocks, separated by twisted pores in the horizon Pk_{gl} soil kd_{b1}, section Stryzhavka /magn. 80/ (nic. ||)

of the genetic types of soils in time. In the initial stage (kd_a), turf and turf podzolic soils were formed, under the age of the early climatic optimum (kd_{b1}) – the soils of forest and forest-steppe genesis (turf podzolic, brown forest, brown forest glayed, podzolic and pseudopodzolic, light gray, gray podzolic and their gleyed varieties, dark gray podzolic, chernozems podzolized), in the late optimum (kd_{b2}) – the soils are with more developed signs of steppe regime (sod, chernozems leached and podzolized, meadow chernozem, chernozem-like).

Thus, in the Kaydaky time, for the first time in the Pleistocene, not only began to form the soils very similar to the modern ones, but also established the soil zonality most close to the present, which was due to the restructuring of the climate after the Dnieper glacier in the direction of changes in natural conditions from close to subtropical (in the early Pleistocene) to more moderate. Typologically, the soils of the Kaydaky time are more similar to the soils of the subboreal temperate – warm climate, more humid than modern ones.

The Pryluky horizon is represented by the deposits of the warm stage, which is characterized by active processes of soil formation. Stratigraphically correlated with the Eemian, II Mazowetsky interglacial, Riss-Wurm interstadial (Veklych, 1968), Horohiv complex (Shelkoplias et al, 1986; Lanczont M. et al, 2015), is part of the Mesyn complex (Velychko et al., 1997), Brerup-Amersfoort and Odderade, isotopic-oxygen substages of 5 a-c (Matviishyna et al, 2010). In the subaerial strata of the Pleistocene deposits, on the geomorphological levels above the fourth terraces, the horizon is represented by eluvial-deluvial deposits – fossil soils that lie on the Tyasmyn loesses and loess-like loams, often on the Kaydaky soils; are covered with Uday loesses and loess-like loams, or, that is often observed in investigated sections – Vytachiv soils. In the sections the horizon is often represented by soil suits or separate soils. In the subaquale facie, the stratigraphic equivalent of the Pryluky fossil soils is the alluvium of the warm phase of the III floodplain terrace.

The horizon is investigated in sections of the Pleistocene deposits Bezimenne, Medzhybizh, Trebukhivtsi, Stryzhavka, Yakushyntsi, Sabariv, Korobchyne-quarry, Pervomaisk. The thickness of the horizon ranges from 0.5 m to 2,4 m. The granulometric composition is mainly medium loam, and rarely light or heavy. Preferably, the horizon consists of one or two soils of the optimum and the soil of the final stage. Thus, in the first substage of the optimum, the meadow chernozem soils (Bezimenne, Stryzhavka, Yakushyntsi, Pervomaisk), brown forest with signs of steppe (Sabariv) and near to the chernozem ordinary (Korobchyne-quarry) have been developed. For meadow-chernozem soils is characteristic a significant thickness of the soil profile (about 1 m), intense dark gray color, humus «tails» deeply penetrating into the lowering horizons, and the gray-bluish gleyey spots, some times, the existing of layer of meadow carbonates.

The micromorphological analysis records the good microagregation of the entire profile, with the development of complicated microaggregates up to the IV order, separated by the branched system of the twisted pores, coagulation of thin humus (type of mulles) in clear clots and thickening, small lumps, the presence of microorsteines in the lower part of the profile (Fig. 10).

In the second substage of the optimum was investigated chernozems brownzem-like (Medzhybizh, Stryzhavka, Yakushyntsi), chernozem-like soils (Trebukhivtsi, Sabariv) and chernozem-like, brownish soils (Pervomaisk, Korobchyne-quarry). For these soils, there are signs that indicate

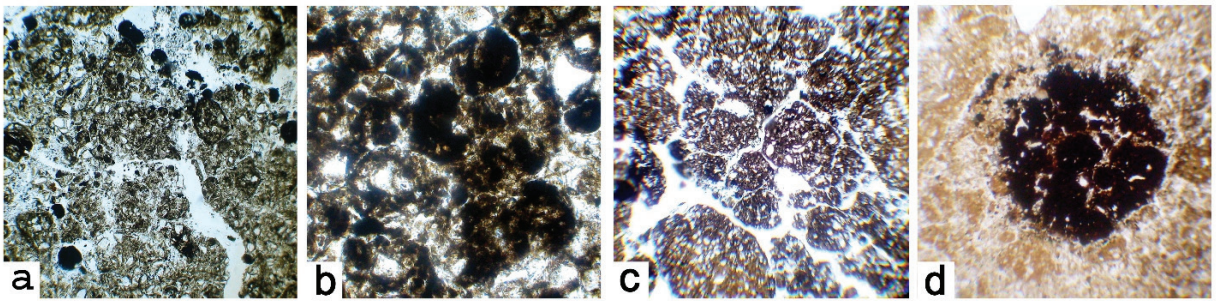

Fig. 10. Microstructure of Pryluky soils: a) complicated microaggregates to IV order are separated by a net of twisted pores and small iron concentrations in the soil, of pl_{b2}, section Yakushyntsi /magn. 100/; b) humus is encapsulated in the form of humons, which form composite microaggregates up to the IV order in the humus horizon of the pl_{b1}, section Yakushyntsi /magn. 400/; c) complex micro aggregates separated by a net of pores in the humus horizon of the soil pl_{b1}, section Pervomaisk /magn. 70/; d) ferruginous manganese microorstein in the lower part of the pl_{b1} soil, section Pervomaisk / magn. 70 / (nic. ||)

their formation in warmer and more arid conditions, in comparison with the soil of the early optimum. High humus containing, various forms of carbonate new formations, more brownish, and in the south even cinnamonish shades of profile color, gradual transitions between genetic horizons, numerous molles and wormholes; in micro-morphology, developed complicated microaggregates, with the cluster and lumps combined with thin humus type mull, absence of signs of redistribution of substances on the profile, plasma cementation by microcrystalline calcite, filling by it of pores – all this indicates the climatic changes in direction more dry steppe conditions in soil formation in the late climatic optimum in comparison with the early.

Short-profile soils were formed in the final stage of the Pryluky soil formation in the transition from warm and wet interglacial to cold and dry periglacial. Sod-carbonate (Medzhybizh), turf (Trebukhivtsi), gray-brown (Bezimenne) and pale-brown steppe (Pervomaisk) soils were prevailed in the soil cover. On dry-steppe conditions of soil formation, under the influence of the weakened sod process, indicates a slight humus mass, short profile, carbonate, mole and worm holes, good microagregation. The small thickness is also due to diagenetic changes in the soil of the final stage, which, at the end of the stage, served as a kind of protective screen for optimum soils.

In Pryluky time types of soils were formed close to modern ones, which, however, are not their complete analogue. During this stage, the stageness of soil formation is clearly recorded, it was manifested in the formation of a soil suits of 1-2 m, consisting as rule, of two soils of the optimal stage and the soil of the final. The soils of the early climatic optimum (pl_{b1}) were formed in the conditions of forest, forest-steppe and meadow-forest-steppe soil formation (brown and gray forest, chernozem leached, meadow chernozem), which as in the late optimum (pl_{b2}) evolved towards the meadow, meadow steppe and steppe soil formation (chernozems brownish, leached, meadow, micellar-carbonate, brownish). In the final stage (pl_c), soil formation was carried out under conditions of a warm dry-steppe regime (turf, grayish-brown chernozem-like, chernozem brownzem-like). Such a set of genetic types of soils is an indicator of warmer as modern and relatively humid temperate climate. Soil zonality, in comparison with the modern, was shifted to the north, especially in the late climatic optimum.

The Vytachiv horizon is represented by the deposits of the warm stage of the late Pleistocene, which stratigraphically correlates with the Bryansk interstadial (Velychko et al., 1997), the Brerup, the interstadial Amersfoort of the Vistulian glacial, the Lower Wurm interstadial (Veklych, 1968), the Dubnivsky soil (Shelkoplias et al, 1986; Lanczont M. et al, 2015), interstadials of Hosselo, Hengelo, Huneborg, Denekamp, 3-rd isotope-oxygen stage (Matviishyna et al, 2010). In the subaerial stratum of the Pleistocene deposits, at the geomorphological levels above the second floodplain terraces, the Vytachiv horizon is represented by eluvial-deluvial deposits – fossil soils that lie on the Uday loesses and loesses-like loams (often, especially on elevated elements of the relief, on the Pryluky soils) and overlap with Bug loesses. In the subaquale facie the stratigraphic equivalent of the Vytachiv soils is the alluvium of the warm phase of the II floodplain terrace.

The horizon is investigated in sections Bezimenne, Medzhybizh, Trebukhivtsi, Stryzhavka, Yakushyntsi, Vyss, Ozerove, Andriivka 4, Korobchyne, Korobchyne-quarry, Pervomaisk. The thickness of the horizon ranges from 0.4 m to 1.0 m. The Vytachiv soils are most densely clayed and enriched on iron oxides among the Upper Pleistocene,

have more heavily granulometric (medium-heavy-grained) composition compared to the lower Pryluky and Kaydaky soils, often with sands.

In the investigated sections of the Pleistocene deposits, the Vytachiv horizon represented by 1-3 soils of the suit (Medzhybizh, Stryzhavka, Yakushyntsi, Vyss, Ozerove, Korobchyne, Korobchyne-quarry) or one brownzem-like soil (Bezimenne, Trebukhivtsi, Andriivka 4). The suits mainly consist of dark brown soil of early optimum and brown and light-brown soils of the late. In the south of the Middle Pobuzhzhya (Pervomaisk) the soils get brownish shades. For Vytachiv soils is characteristic enriching on iron oxides and claying of the material, which are largest in the middle part of the profile, high position of carbonate illuvium, insignificant thickness of the soil profile (0.4-0.6 m), significant deformation by the frost-free cracks and solifluctural processes associated with Bug time cryogenic processes, in the south of Pobuzhzhya – the features of saltiness and gypsums.

The micromorphological analysis of 17 thin sections with undisturbed structure allowed to trace the individual diagnostic features of the Vytachiv sediments, which also allows to use micromorphological data for stratigraphic purposes. Thus, the specific feature of their microstructure is the presence of concentric formations of the organo-clay substance in the form of nodules and ooids, as well as ferruginous cells of loess particles that diagnose the periodic segregation of substances and indicate the formation of the soils of the Vytachiv time in contrasting variable-humid-arid conditions (Fig. 11).

type of soil formation; insignificant thickness of the soil profile – for a relatively short time soil formation; carbonatisation (primary), the presence of mole hollows – the steppe type of soil formation; strong deformity of the upper part of the Vytachiv horizon – on intensive post Vytachiv cryogenic processes; the presence of segregating nodular and ooid forms of organo-clay substances in the microstructure – on contrasting variable-moisture-dry conditions, during which the clay substance could swell in conditions of sufficient moisture, and subsequently, during periods of drought, to segregate in rounded iron-clayey ooid structures. The above features indicate the specific physic-geographical conditions of the Vytachiv soil formation, when periods of good moisture alternated with arid ones. At this time, during wet periods, soil formation could go in the direction of brownzem formation (processes of enrichment on iron oxides, leaching, lessive, podzolization, gleying), and in arid – steppe soil formation (humus formation, migration of calcium carbonates, segregation of iron solutions, etc.). The noticeable cleying and iron enriching of Vytachiv soils indicate a fairly warm climate of the time of their formation. The small thickness of soil profiles, significant capacity carbonates, partial salinity in the south indicate a dryer than the current climate. Such a combination of natural factors is possible only under conditions of a specific climate, rather contrasting, variable-humid to the north and sufficiently arid in the south.

The Dofinivka horizon is of first warm stages after Bug glaciation, which is the marking horizon

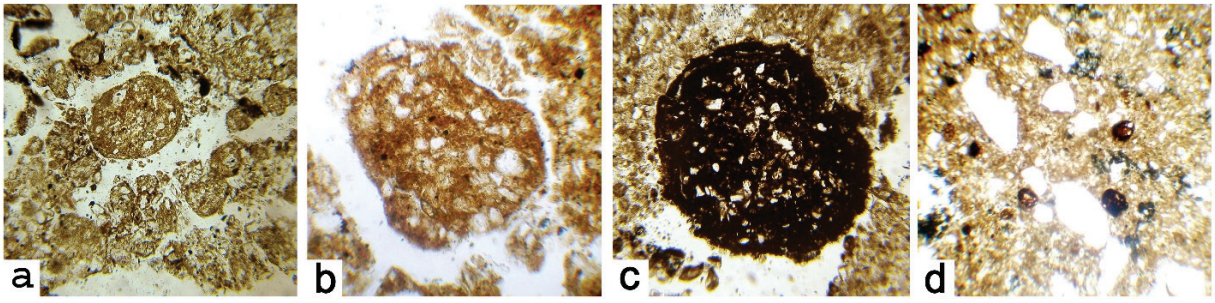

Fig. 11. Microstructure of Vytachiv soils: a) concentric nodules of the ferruginous-clay substance in the humus horizon of the vt_{b1} soil Yakushyntsi /magn. 100/; b) a nodule in the middle of the cinnamonish-brown field, section Ozerove /magn. 140/; c) iron-manganese microorstein of a concentric structure in the soil of vt_{b1}, section Yakushyntsi /magn. 100/; d) small glandular microorsteins in the fused ferruginous-carbonate-clay plasma of the brown-like soil, section Bezimenne /magn. 70/ (nic. ||)

Paleopedological data, such as the gleying and enrichment on iron oxides of soil mass, weathered seeds of primary minerals (feldspars) indicate the formation of Vytachiv soils under favorable conditions for the course of weathering processes; leaching of carbonates rare occurrence of colomorphic clays – on the forest

of the Upper Pleistocene in the non-glacial zone of Ukraine. Stratigraphically, it correlates with Moloho-Sheksnynsky, and Paudorf interstadials, Mazurezky interstadial of the Vistulian glacial, the second interstadiale of the Wurm glacial (Veklych, 1968), the Trubchevsky horizons of the Valdai glaciation

(Velychko et al, 1997), the Rivne soil (Shelkoplias et al, 1986), the middle of the 2nd isotope-acid stage (Matviishyna et al, 2010). It is common in the subaerial strata of the Upper Pleistocene deposits starting from the second floodplain terrace, which is represented by eluvial-deluvial deposits – fossil soils, which lie on Bug loesses and loess-like loams. The stratigraphic equivalent of fossil soils in the subaqual facies is the lower stratum of alluvium of the first flood plain.

The horizon is investigated in sections of the Pleistocene deposits Bezimenne, Uman and Pervomaisk. The horizon's thickness ranges from a few centimeters to more than 1 m. The granulometric composition is mainly light and medium loam. In the north of the Middle Pobuzhzhya, as a separate stratigraphic horizon, it is rather rare, as often it is a relic of modern soil cover or destroyed or transformed by processes of further paleogeographical stages. In the south and south-east – it appears more often and often overlaps with the Prychernomorya loess horizon.

According to paleopedological data, the Dofinivka soils are represented by suits consisting of two soils: the optimum and final stage, or the soil of one of the specified stages. The suits of the soils were discovered and investigated in sections of the Pleistocene deposits near the town of Uman and Pervomaisk. In both cases, the soils of the optimal stage are represented by chernozem soils, and the final one is brown steppe. In the section Bezimenne it is studied one chernozem-like (sod?) soil of optimum. For the investigated soils, the light-medium-grained granulometric composition, carbonate, loose structure and high degree of sorting of the material inherited from the underlying Bug loesses, which are soil-forming rocks, are characteristic. The soils of the final stage were formed directly on the soil of the climatic optimum. The chernozem type of soil formation of optimum confirmes the grayish color of the upper part of the profile, gradual transitions between the genetic horizons, a large number of mole and worm holes, carbonate of mass with new formations which are particularly clearly manifested in the Pk horizon in the form of carbonate mycelium.

According to the micromorphological analysis, for Dofinivka soils, complex microagregates is presented in the form of fuzzy microaggregates of the I-III order, the concentration of humus type mull in clotting and thickening, cementation of plasma by microcrystalline calcite and filling by it of pores, absence of signs of redistribution of humus-clay substance by profile (Fig. 12).

Natural conditions during the Dofinivka stage evolved in the direction of increasing the climate irregularity. The genetic types of drought-bearing fossil soils point to a more continental, colder and dryer climate, especially in the final stage, as compared to modern ones. At this time there is a dominance in the soil cover of carbonate short-profile soils of the steppe, and in the south - dry-steppe and semi-desert genesis.

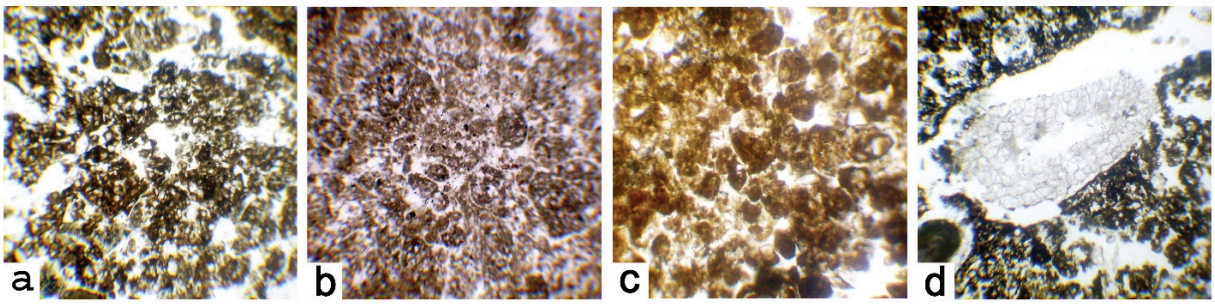

Fig. 12. Microstructure of Dofinivka soils: a) simple and complex microaggregates are separated by a net of twisted pores in the Hk horizon of the chernozem-like soil of optimum, section Uman /magn. 70/; b) simple and complex humus carbonate-clay round microaggregates are separated by a net of twisted pores in the humus horizon of the soil df_b section Pervomaisk /magn. 70/; c) rounded micro aggregates of I-II order are separated by pores, loose microstructure of soil df_c, section Uman /magn. 140/; d) the nodule of fine crystalline calcite in the pore of Hk horizon of chernozem-like (optimum), section Uman /magn. 70/ (nic. ||)

The obtained dat are good correlated with the results of palinological and paleopedological researches by near Pobuzhzhya disposed territory of Ukraine (Sirenko, Turlo, 1986; Gerasimenko, 2004; Sirenko, 2017; et al).

Conclusions. In the Pleistocene soils of the Middle Pobuzhzhya, on the basis of micromorphological research, diagnostic features of soil formation processes were revealed. These features are systematized in groups (biogenic-accumulative, eluvial, illuvial-accumulative, hydrogen-accumulative and metamorphic), which made it possible to find out the issues of the genesis and identification of fossil soil formations, to identify individual micromorphological

features of soils of separate stratigraphic horizons, to establish the laws of evolutionary changes soil and perform paleogeographic reconstruction on the basis of paleopedological data.

1. It was found that in unsorted structures of fossil soils *biogenic and accumulative processes* are characterized by dark, dark brown or brown humus-clay plasma, structural formations as simple and complex microaggregates, well-defined inter- and intra-aggregate cavity space, developed pore net, the presence of coagulated or dispersed humus, coprolites, microbial mass, plant tissue residues or animals of varying degrees of decomposition or other organo-mineral compounds. The characteristic features of the *eluvial processes* are the predominance of the skeletal particle over the plasma, halfdestroyed microaggregates in the eluvial horizons of the soils, the «washed» seeds of primary minerals without films, fussy amorphous plasma. *Illuvial-accumulative processes* are diagnosed on the basis of the displacement of organo-clay substance numerous separations of calomorphic clays in form of influxes, stream, films around the grains of the mineral skeleton.

Among the *hydrogene-accumulative processes* in fossil soils, it is possible to diagnose the signs of gypsum enrichment (micro, fine, medium grained, rhombus, lens and other forms of gyps), carbonatization (cryptocristal-, micro- and small-grained calcite concentrations, lublinitis, etc.), salinization (forms of the separation of light-dissolving salts), ore creations processes (spots, flakes, films, diffuse rings, microorsteins, incrustation and other forms iron and manganese hydroxides concentration), meadow processes (high content of mull humus, in the lower part of the profile gray-blue of manifestations of ferrous forms of iron, ferruginous microorsteins, signs of redistribution of clay, carbonates and other salts.

In the thin section under the microscope, especially from the soil of the Early and Middle Pleistocene, there are signs of *metamorphic processes* «in situ» can see, such as iron enrichment (reddish-cinnamonish, yellowish-brown tints of the plasma), claying (reduced proportion of grains of the mineral skeleton – an increased proportion of plasma mass, dense microstructure in the form of cleave blocks, mass compactness, sharp edges of pore-cracks walls), cleaving (dense block microstructure, segregation of organo-clay substances into nodular formations in the middle of cleave blocks), rubbification (brown color of plasma, films and stains of iron oxides, grains of goethite and hematite), intrinsic soil weathering (corrosive grains of the mineral skeleton), etc.

2. It has been established that certain groups of soil forming processes are characteristic for fossil soils of separete paleogeographical stages. In the soils formed prior to the Dnipro glaciation (Shyrokyne, Martonosha, Lubny and Zavadivka), signs of processes of enrichment, rubbification, ferralization, cleaving, weakly expressed humus formation, carbonization, and sometimes enrichment on gyps were diagnosed. For the soils formed after the maximum glaciation (Kaydaky, Pryluky, Vytachiv, Dofinivka), signs of the same processes (humus formation, podzolization, illimerization, leaching, meadow, carbonate migration, etc.), which are characteristic for modern soils of the territory of Ukraine are established.

It is proved that the *individual features* of the microstructure of the Pleistocene soil horizons of the Middle Pobuzhzhya can be used for stratigraphic purposes. The micromorphological features of the Shyrokyne, Martonosha, Lubny and Zavadivka soils are with bright brownish, reddish and brownish shades of plasma color, have compact massing with structural separations in the form of cleave blocks with densely packed nodular formations of ferruginous-clay matter, a considerable amount of ferruginous, manganese and carbonate new formations. In the soil of the early optimum of the Kaydaky and Pryluky stages signs of eluvial-illuvial processes are recorded (depleted on the mulle and humus area with the «washed» grains of the mineral skeleton, the microaggregates in the eluvial horizons are destroyed, but din the illuvial – the impregnation of the plasma by calomorphic clays in the form of streaks, films, streams). In the soils of late optimum of these times, there is a well-expressed microagregation of the mass, a branched net of twisted pores, a cougulated humus in the humus and humus transition horizons, various forms of carbonate evidences as impregnation and cementation of plasma by microcrystalline calcite, grouping of crystals, concentration of crypto-, micro- and fine crystalline calcite. Specific individual characteristics of the Vytachiv soils are block microstructure, numerous nodular concentrations of organ-ferruginous-clay substances, the presence of microorsteins. Dofinivka soils are characterized by a loose microstructure, fuzzy rounded simple micro aggregates, a developed system of twisted pores, and carbonaceous mass.

3. Complex paleopedological studies with wide application of micromorphological data allowed to *identify genetic types of fossil soils* and reconstruct the soil cover of the Middle Pobuzhzhya for eight warm stages of the Pleistocene. Shyrokyne horizon in the study area are represented by the reddish-brown, reddish-dark-brown semi-hydromorphic soils and their meadow species. In the early optimum of Martonosha time, reddish-brown forest, semi-hydromorphic and meadow soils, while in the late optimum – reddish-

cinnamonish-brown semi-hydromorphic and meadow species were formed. Lubny soils are represented by brown forest, light cinnamonish-brown forest (early optimism) and brownish-cinnamonish, meadow-cinnamonish chernozem-like and sod-chernozem (late optimum). Zavadivka stage is characterized by a variety of soil cover. In particular, yellow-brown and brown forest soils formed in the initial stage; in the early optimum – brown forest, yellowish-brown forest (in the north-west), brown forest reddish, cinnamonish soils (in the south-east); in late optimum – brown forest cinnamonish, reddish-brown forest, cinnamonish-brown, leached, brownish-cinnamonish, brownzem-like, meadow; in the final stage – yellowish-brown, reddish-brown and meadow. In the suits of the Kaydaky horizon, the following types of soils were studied: turf and turf-podzolic (in the initial stage); turf-podzolic, brown forest, including gleyed, podzolized and pseudo-podzolized, light gray, gray podzolized, in the south – dark gray podzolized, chernozems podzolized (in the early optimum); turf, chernozems leached and podzolized, meadow chernozem (in late optimum). Within the limits of the Pryluky horizon on the territory of the Middle Pobuzhzhya are found: brown, gray forest, chernozems leached (early optimum); chernozem brownzem-like, leached, meadow, typical, cinnamonish (late optimum); turf, grayish-brown chernozem-like, chernozems brownzem-like (final stage). During Vytachiv time, specific dark-brown soils of early optimum brown and light-brown soils of late optimum were formed. In the north-west of the territory, the Vytachiv soils are often gleyed, close to the grasslands meadow, and in the south and south-east - they get cinnamonish shades, there are solonets species. In the optimum of the Dofinivka time, turf, turf-carbonate and near to chernozem soils formed on the vast territory of the Middle Pobuzhzhya.

4. Identified genetic types of Pleistocene fossil soils and reconstructed soil coverages of the Middle Pobuzhzhya reflect the *dynamic of evolutional soil changes* and, accordingly, *natural conditions* in time and space. From the Early Pleistocene to the Dnipro glaciation, during the Shyrokyne, Martonosha, Lubny, and Zavadivka periods full profiled reddish-cinnamonish, reddish-brown, cinnamonish-brown and brown varieties of soil-pedosediments were formed in weathering favorable to conditions of a moderate, humid, close to subtropical climate.

After the Dnipro glaciation, the genetic types of soils, which are close to modern, close to the modern soil zoning, began to be formed on the territory of the Middle Pobuzhzhya. All types of fossil Kaidaksky soil (soddy-podzolic, brown forest, gray podzolized, meadow-chernozem, chernozem leached, podzolized) indicate that they are formed in slightly more humid conditions of temperate climate compared with modern ones. The genetic types of soils of the Pryluky time reflect the changes in soil conditions from the forest, forest-steppe and meadow-forest-steppe regimes in the early optimum (meadow chernozem, brown forest, gray podzolized, chernozems leached, etc.), in the direction of meadow, meadow-steppe and steppe regimes of soil formation (chernozems, brownzem-like, leached, meadow, micellar-carbonate, cinnamonish) in the late optimum. The soils of Pryluky time were formed in a warmer and evenly humid environment for the modern climate. Specific brown and dark brown soils, analogues which are not present in the modern soil cover of Ukraine, were formed in Vytachiv time in conditions of fairly warm, contrast, change-humidity-arid climate. The Dofinivka soils, which are close to the chernozems, reflect the conditions of a more continental, arid and cooler climate.

5. Changes in *paleogeographic conditions* in the Pleistocene recorded in the soil sediments on the territory of the Middle Pobuzhzhya are subordinated to the basic legularities in the development of nature.

Alternating in subaerial layers of soils (formation of warm stages) with loesses (deposition of cold stages) reflect *rhythmeness*.

The development of natural conditions during the Pleistocene in the direction of aridization and coldness indicate *direction in the development*.

The structure of the most complete soil suits clearly confirms the stage of development stadials – in the initial stage of soil formation, the climate is relatively cold and humid, in the optimum stage – warm and humid, in the final – warm and dry.

Zonal changes in the soil cover of the Pleistocene are manifested both in time and in space (*regionality*). In the early Pleistocene, genetic types of soils, close to subtropical ones, were formed. After the Dnipro glaciation, changes in the natural conditions that occurred in the formation of soils of the subboreal and boreal zones occurred. Spatial zonal changes in the soil of the early Pleistocene were almost non-existent (in the Shyrokyne and Martonosha times) or expressed weakly (Lubny, Zavadivka times). Brighter zonal differences appeared in the post-Dnipro warmer stages. The most suitable for the modern soil zoning was formed in Kaydaky and Pryluky times. The boundaries of natural zones compared with modern ones were displaced to the south in the early optimum of the Kaydaky time, and to the north – in the late optimum of Pryluky. In the Vytachiv and Dofinivka times, the zone was evidenced.

References

Bolihovskaia N.S., 1995. Evoliutsiia lessovo-pochvennoi formazyi Severnoi Evrazii [The evolution of the loess-soil formation of Northern Eurasia]. Moscow, MSU Publishing House. (In Russian).

Denysyk H.I., Korinniy V.I., Volovyk V.M., Pivoshenko I.M., Diedov O.V., Vdovychenko S.M., Stiefankov L.I., Gudzevych A.V., Panasenko B.D., Mudrak O.V., Konieva S.I., Tkach L.O., Husak O.M., Chyzh O.P., Yazentiuk J.V., Babchynska O.I., Haiezkyi H.S., Parashchuk N.V., Valchuk O.M., 2002. Serednie Pobuzhia [Middle Pobuzhya]. Winnyza, Hipanis. (in Ukrainian).

Doroshkevych S.P., 2018. Pryroda Serednioho Pobuzhia u pleistotseni za danymy vyvchennia vykopnykh gruntiv. [The nature of the Middle Pobuzhya in Pleistocene according to the study of fossil soils]. Kyiv, Naukova Dumka. (in Ukrainian).

Doroshkevych S.P., Matviishyna Zh.M., 2012 a. Diahnostyka gruntoutvoriuvalnykh procesiv u wykopnykh pleistotsenowykh gruntakh za danymy mikromorfolohichnoho analizu. [Diagnosis of soil-forming processes in the Pleistocene fossil soils according chrono-biological analysis]. Science, Bulletin of Chernivtsi University, Biology (Biological systems), Vol. 4(2). (In Ukrainian).

Doroshkevych S.P., Matviishyna Zh.M., 2012 b. Zminy pryrodnykh umov u pleistotseni na terytirii Serednioho Pobuzhia za danymy vyvchennia vykopnykh gruntiv. [Changes in natural conditions in the Pleistocene on the territory of the Middle Pobuzhya according to the data of the study of fossil soils]. Ukrainian Geographic Magazine. No. 4 (In Ukrainian).

Gerasimenko N.P. (2004). Zminy polozhennia landshaftnykh zon na terytorii Ukrainy. [Changes in the position of the landscape zones on the territory of Ukraine in the Pleistocene and the Holocene]. Ukrainian Geographic Magazine. No. 3. (In Ukrainian).

Hlushankova N.I., 2008. Paleopedohenez i prirodnaia sreda Vostochnoi Evropy v pleistotsene. [Paleopedogenesis and the natural environment of Eastern Europe in the Pleistocene]. Smolensk-Moscow, Magenta. (In Russian).

Karmazynenko S.P., 2010. Mikromorfolohichni doslidzhennia vykopnykh i suchasnykh gruntiv Ukrainy. [Micromorphological study of fossil and modern soils of Ukraine]. Kyiv, Naukova dumka. (In Ukrainian).

Kubiena W.L., 1938. Micropedology. Jowa: Collegiate Press.

Kubiena W.L., 1970. Micromarphological features of soil geographi. New Brunswish: N.J. Rutgers universities press.

Lanczont M., Madeyska T., Holub B., Boguzky A., Hodorovsky J., Klimovich Z., Mroshek P., Laska B., Fedorovich S., Navrozky J., Frankovsky Z., Standzikovsky K., Zogola B., Komar M., Kraicarz M., Troian A., Grafka O., Gola M., Aleksandrovich V., Nadahovsky A., Ridush B., Volde-Novak P., Sytnik O., Stefaniak K., Wojtal P., Zarzeska-Szubinska K., 2015. Paleolityczna ekumena strefy pery- i metakarpackiej [Paleolithic ecumena of the peri and metacarpathian zone]. Lublin, Publisher of the Maria Curie-Sklodowska University. (in Polish).

Lindner L., Gozhyk P., Marciniak B., Marks L., Yelovicheva Y. Main climatic changes in the Quaternary of Poland, Belarus and Ukraine // Quaternary International. – 2004. – 248. – P. 97-114.

Matviishyna Zh.M., 1982. Mikromorfolohia pleistocenowykh pochv Ukrainy. [Micromorphology of Pleistocene soils of Ukraine]. Kiev: Naukova dumka. (In Russian).

Matviishyna Zh.M., Gerasymenko N.P., Perederii V.I., Brahin A.M., Ivchenko A.S., Karmazynenko S.P., Nahirnyi V.M., Parkhomenko O.H., 2010. Prostorovo-chasova koreliaziia paleoheohrafichnykh umov chetvertynnoho periodu na terytoriyi Ukrainy. [Spatial and time correlation of paleogeographical conditions of Quaternary in Ukraine]. Kyiv, Naukova dumka. (In Ukrainian).

Matviishyna Zh.M., Doroshkevych S.P., 2011. Rezultaty paleopedolohichnoho doslidzhennia piznopaleolitychnykh pamiatok u baseini Welykoyi Wysi. [The results of the paleopedologic study of the late paleolitic artifacts in the Great Visa basin]. Ukraine's Stone Age: Coll. Sci. articles. iss. 14. Kyiv, Shliah. (In Ukrainian).

Matviishyna Zh.M., Karmazynenko S.P., Doroshkevych S.P., Mazibora O.V., Kushnir A.S., Perederiy V.I., 2017. Paleoheohrafichni peredumovy ta chynnyky zmin umov prozhyvannia liudyny na terytorii Ukrainy. [Paleogeographical preconditions and factors of the changes of human's living environment on territory of Ukraine in pleistocene and holocene]. Ukrainian Geographic Magazine. No. 4 (In Ukrainian).

Matviishyna Zh.M., Karmazynenko S.P., Stepanchuk W.M., 2009. Dribna rytmika lesovo-gruntovykh vidkladiv Pobuzhia na osnovi vyvchennia arheolohichnykh pamiatok. [Minor rhythm of forest-soil deposits of Pobuzhya on the basis of the study of archaeological sites]. Kyiv, Physical geography and geomorphology, Horizons. (In Ukrainian).

Matviishyna Zh.M., Parhomenko O.G., 2008. Grunty davnoi stoianky Wyss nepodalik s. Shmydove na Kirowohradshchyni yak indykator pryrodnykh umov mynulogo. [The ancient fortresses of the Vise near the village. Shmidov in Kirovograd region as an indicator of the natural conditions of the past]. Ukraine's Stone Age: Coll. Sci. articles. iss. 11. Kyiv: Shliah. (In Ukrainian).

Morozova T.D., 1981. Razvitie pochvennoho pokrova Evropy v pozdnem pleistotsene. [The development of the European soil cover in the late Pleistocene]. Moscow, Science. (In Russian).

National Atlas of Ukraine. Sci. editor L.H. Rudenko, 2007. Natsionalnyi atlas Ukrainy. [National Atlas of Ukraine]. Kyiv, SSPE Cartography. (In Ukrainian).

Parfenova O.I. and Yarilova K.A., 1962. Mineralohicheskie issledovaniia v pochvovedenii. [Mineralogical studies in soil science]. Moscow, Publishing House of the Academy of Sciences of the USSR. (In Russian)

Parfenova O.I. and Yarilova K.A., 1977. Rukovodstvo k mikromorfolohicheskim issledovaniiam v pochvovedenii. [Guide to micromorphological studies in soil science]. Moscow, Science. (In Russian).

Rekovez L.I., 1994. Melkie mlekopitaiushchie antropohena yuha Vostochnoi Evropy. [Small anthropogenic mammals of southern Eastern Europe]. Kyiv, Naukova dumka. (In Russian).

Rozanov B.G., 2004. Morfolohia pochv: uchebnik dlia vysshei shkoly. [Soil morphology: Textbook for higher education. Moscow: Academic Project]. Moscow, Academic Project. (In Russian).

Stratigraphic Code of Ukraine. 2 nd ed. Resp. ed. P.F. Gozhik. Kyiv, 2012. (in Ukrainian).

Shelkoplias V.M., Gozhyk P.F., Hrystoforova T.W., Mazuy V., Shevchenko V., Morozov H., Lysenko O., Chuhunnyi Y., Palatnaia M., Bohuzky A., Demedyuk M., 1986. Antropohenovye otlozhenia Ukrainy. [Anthropogenic deposits of Ukraine]. Kyiv, Naukova dumka. (In Russian).

Sirenko N.O., Turlo S.I., (1986). Razvitie pochv i rastitelnosti Ukrainy v pliozene i pleistozene. [Development of Ukraine's soils and vegetation in Pliocene and Pleistocene]. Kyiv, Naukova dumka. (In Russian).

Sirenko E.A., (2017). Palinostratigrafia kontinentalnykh verhnepliozenovykh – nizneneopleistocenovykh otlozheniy yuzhnoi chasti Vostochno-Evropeiskoy platformy. [Palynostratigraphy of continental Upper Pliocene – Lower Neopleistocene deposits of southern part of the East European platform]. Kyiv, Naukova dumka. (In Russian).

Veklych M.F., 1968. Stratigrafiia liossovoy formazyi Ukrainy i sosednikh stran. [Stratigraphy of the loess formation of Ukraine and neighboring countries]. Kyiv, Naukova Dumka. (In Russian).

Veklych M.F., 1990. Osnovy paleolandchaftovedenia. [Basics of paleolandscape science]. Kyiv, Naukova Dumka. (In Russian).

Veklych M.F., Matviishyna Zh.M., Medvedev V.V., Sirenko N.A., Fedorov K.N., 1979. Metodika paleopedologicheskikh issledovaniy. [The methods of paleopedological research]. Kiev, Naukova dumka. (In Russian).

Veklych M.F., Sirenko N.O., Matviishyna Zh.M., Adamenko O.M., Artiushenko A.T., Kunitsa N.A., Tretiak A.N., Shelkoplias V.M., Bachynski H.A., Bohuzki A.B., Gozhyk P.F., Demediuk N.S., Dubniak V.A., Melnychuk I.V., Pasechni H.V., Perederii V.I., Turlo S.I., Shevchenko A.I., Arbuzova L.S., Veklych V.M., Gerasimenko N.P., Vozhrin B.D., Harytonov V.P., 1993. Stratihraficheskaia shema chetvertichnykh otlozheniy Ukrainy. [The stratigraphic scheme of the Quaternary deposits of Ukraine. Phanerozoic and Precambrian Ukraine stratigraphic schemes]. Kiev: State Committee of Geology of Ukraine. (In Russian).

Velychko A.A., Gribchenko J.N., Hubonina Z.P., Drenova A.N., Zelikson E.M., Markova A.K., Morozova T.D., Nechaev V.P., Oreshkin D.B., Pevzner M.A., Svetlitskaia T.V., Sychova S.A., Timireva S.N., Udarzev V.P., Halcheva T.A., Zazkin A.I., Chepalyha A.N., Chikolini N., Chichahova O.A., 1997. Lessovo-pochvennaia formazyia Vostochno-Evropeiskoi ravniny: Paleoheohrafiia i stratihrafiia. [Loess-soil formation of the East European Plain: Paleogeography and stratigraphy]. Moscow, Institute of Geography RAS. (In Russian).

Zalizniak L.L., Stepanchuk V.M., Kuharchuk J.V., Tovkailo M.T., Matviishyna Zh.M., Manko V.O., Vetrov D.O., Belenko M.M., Ozerov P.I., Hoptynets I.M., Nezdolii O.I., Doroshkevych S.P., Sorokun A.A., Shevchenko T.O., 2013. Kamiana doba Ukrainy: Naidavnishe mynule Novomyrhorodshchyny. [Ukraine Stone Age. The oldest past of Novomyrhorodschyna. Ed L.L.Zalizniak. Is.15]. Kyiv: Shliakh. (In Ukrainian).