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

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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 microaggregation 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 Vytaichiv 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, Vytaichiv, 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 predominant in the modern soils of the territory of Ukraine. Assertainment 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 evolutionary 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

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Анотація. Виявлено основні мікроморфологічні особливості викопних плейстоценових ґрунтів території Середнього Побужжя. Для ґрунтів раннього неоплейстоцену (широкинських, мартоносних, лубенських) і середньоплейстоценових завадівських, ґрунтів характерні яскраві буруваті, червонуваті та коричневі 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, манганинових та карбонатних новоутворень. У ґрунтах раннього оптиму 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-
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. Yarinova (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 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. Mrosche; 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. Chalyshevch, 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 and 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
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 Vinnytsia 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 expeditiously 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 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 (Khmelnitsky 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), Ozerevo, 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
Pobuzhzhya is represented by light gray, gray and dark gray podzolized, chernozems degraded, 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 4a-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; IGPG – light-grau podzolized gleyed; dGP – dark-grau podzolized; 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; BF – brown forest with sign of steppe; dB – dark-brown; dBC – dark-brown cinnamonish; BC – brown cinnamonish; CB – cinnamonish-brown; IB – light-brown; IBC – light-brown cinnamonish; ICB – 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 brownzern-liked; ChC – chernozem cinnamonish
# Table 1. Micromorphological diagnostics of soil formation processes in fossil Pleistocene soils of the Middle Pobuzhzhya (Doroshkevych, 2018)

<table>
<thead>
<tr>
<th>Elements of microstructure</th>
<th>Micromorphological signs and traces of ancient soil formation</th>
<th>Conditions, processes of formation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Microstructure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compact, dense, merged, with rounded clutches of organo-clay substances</td>
<td>Soil formation took place under favorable climatic conditions, where there was a sufficient amount of moisture and heat. Properties for the Lower Pleistocene soils</td>
<td></td>
</tr>
<tr>
<td>Cubs, loose, soft, grains of the skeleton are proportional to each other</td>
<td>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</td>
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<tr>
<td><strong>Aggregation</strong></td>
<td></td>
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<tr>
<td>Aggregates</td>
<td>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</td>
<td></td>
</tr>
<tr>
<td>Complex grainy microaggregates of II-IV order, black or almost black, separated by a grid of vorticular pores</td>
<td>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, k_d, k_b of soils</td>
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<tr>
<td>Simple and complex (to the third order) microaggregates of dark color</td>
<td>Actual for gray forest soils</td>
<td></td>
</tr>
<tr>
<td>Fuzzy micro aggregates of dark or brownish color</td>
<td>Intrinsic to podzolic soils, in the eluvial horizon often acquire puff formation</td>
<td></td>
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<tr>
<td>Oval, simple and complex (to the third order) micro aggregates</td>
<td>This is mainly facails of mites fauna. Own chestnut soils. It is characterized by zonal southern soils of Dofinivka and Pryluky time</td>
<td></td>
</tr>
<tr>
<td>Tightly packed structural isolations of the 1st-2nd order</td>
<td>Actual brown soils</td>
<td></td>
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<tr>
<td><strong>Porosity</strong></td>
<td></td>
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<tr>
<td>Cleave blocks</td>
<td>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</td>
<td></td>
</tr>
<tr>
<td>Branched net of pores</td>
<td>Active livelihoods of soil biota and favorable conditions for soil aeration. Properties for forests and soils of chernozem type</td>
<td></td>
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<tr>
<td>Pores-cracks</td>
<td>They are formed for successive swelling of clay mass under humid conditions, and then compression due to the drying of the soil mass. Intronically enriched soils</td>
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<td><strong>Optical orientation</strong></td>
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<tr>
<td>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</td>
<td>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</td>
<td></td>
</tr>
<tr>
<td>Transparent and bright streaks</td>
<td>The processes of podzolizations. These traits for characteristic of podzolic and turf-podzolic soils</td>
<td></td>
</tr>
<tr>
<td>Influxes are enriched on finely dispersed humus and clay particles</td>
<td>The process of podzolization and lessive. Signs are characteristic for gray forest soils</td>
<td></td>
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<tr>
<td>Influxes of red color, not transparent, much ferruginous, occur throughout the profile</td>
<td>Processes of lessive (illimerizations). Actual for brown forest soils</td>
<td></td>
</tr>
<tr>
<td>Impoverished on mullers and humus (swashed) microplots</td>
<td>The course of eluvial processes of moving organo-clay substances down the profile. Manifested in eluvial horizons</td>
<td></td>
</tr>
<tr>
<td>Clay substance that is not oriented or oriented in the form of rings located near individual minerals or aggregates</td>
<td>Complicated conditions for the course of illuvial processes and leaching</td>
<td></td>
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<tr>
<td>There is not expressed optical orientation of clay substances</td>
<td>Formation of soils under constantly dry conditions (grayzems, typical loesses, southern zone of the Dofinivka soil formation</td>
<td></td>
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<tr>
<td><strong>Organic matter</strong></td>
<td></td>
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</tr>
<tr>
<td>Dispersed brown humus, which is closely combined with clay</td>
<td>Characteristic for soils of forest genesis, of Early Pleistocene</td>
<td></td>
</tr>
<tr>
<td>The organic substance is coagulated in the form of clots and lumps, which are combined into complex microaggregates</td>
<td>Intense biogenic and accumulative processes. Particularly good expressed in the chernozems-liked soils, gray forest of Middle and Late Pleistocene soils</td>
<td></td>
</tr>
<tr>
<td>Brown humus in the form of cinnamon or light clots</td>
<td>Displays the effect of relatively arid climate, closed to dry-steppe</td>
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</tbody>
</table>
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 removal 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 gypses 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

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<th>Micromorphological signs and traces of ancient soil formation</th>
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<tr>
<td>Needled calcite-hablinit</td>
<td>Characteristic for soils with intensive seasonal migration of carbonates</td>
<td></td>
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<tr>
<td>Micro-calcite, concentrated on the walls of pores</td>
<td>Relatively fast, intense evaporation and high concentration of carbonates in the soil solution</td>
<td></td>
</tr>
<tr>
<td>Fine-grained calcite, concentrated on the walls of pores</td>
<td>Gradual evaporation and slight migration of carbonates</td>
<td></td>
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<tr>
<td>Increased carbonate content</td>
<td>Dryer conditions characteristic of steppe type soils</td>
<td></td>
</tr>
<tr>
<td>Insignificant carbonate content</td>
<td>More wet conditions of soil formation, which are characteristic for forest types of soils</td>
<td></td>
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<th>New formation of easily destroyed salts</th>
<th>Presence of ferruginous and manganese new formations</th>
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</tr>
<tr>
<td>Compact microfiber with clear edges</td>
<td>Seasonal changes in the humidity conditions</td>
<td></td>
</tr>
<tr>
<td>Friable microfibers with fuzzy, blurred edges</td>
<td>Formed in ungleyed or deeply gleyed sod-podzolic soils</td>
<td></td>
</tr>
<tr>
<td>Ferruginations of walls pores</td>
<td>Increasing gleying in the illuvial horizon</td>
<td></td>
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<tr>
<th>Iron and manganese neoplasms</th>
<th>Carbonate-clayey loess particles are commensurate with the seeds of primary minerals, wrapped with transparent films and membranes, separated by a developed pore net</th>
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<th>Other</th>
<th>The accumulation of sand-aleurite particles, micro-polygons in the form of rings, sorting of sand and large alyurite particles</th>
<th>The course of cryogenic processes, the existence of freezing-thawing out conditions</th>
</tr>
</thead>
</table>
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:
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 microscope 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, which are tightly packed in cleave blocks in brown forest soils (vt b2; Raihorod) /magn. 100/; t) the nodule of the ferruginous-clay substance from the middle part of the brown soil (vt b2; Magn. 40/; s) the ferruginous-clay substance is segregated into nodular formations, which are tightly packed in cleave blocks in brown and flakes of hydroxides of iron and manganese in reddish-cinnamonish brown soils (mrb2; Raihorod) /magn. 100/; p) dense glandular-micromorphological analysis, through the study of the natural peculiarities of certain primary soil 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
The Shyrokyne deposits are investigated in the section of Raihorod, where the thickness of sediments is relatively conditionally divided into three soil 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).

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

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 (Bolikhovskaja, 1995), Rzhaksyno soil (Velychko et al, 1997), Illyinsk time (Hlushankova, 2008; Rekovez, 1994), Tegelensk interglacial (Veklych, 1968), Mindel 1-2 (Veklych, 1990). It is widespread in the subaerial 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 substages \( m_{rb1} \) and reddish-brownish-brown of substages \( m_{rb2} \); in the section Pankratove – it is a reddish brown meadow of early optimum (\( m_{rb1} \)) and reddish-cinnamonish-brown meadow soil of late optimum (\( m_{rb2} \)). The soils are monolithic, clay-sandy, dense, gleyed and ferrugenous, with fine silicious-carbonate concretions, the number of which grows in the lower soil.
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, microcrusts, diffuse rings) indicate the processes of gleying, enrichment on hydroxides of iron and meadow process development (Figure 6).

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 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 lb1 substage and brownish-cinnamon substage lb2 are represented; in the sections of the Korobchyne-quarry, this is a cinnamonish-brown forest soil of early optimum (lb1), dark-cinnamonish meadow weakly saltish soil of late optimum (lb2).

The Lubny horizon is correlated with 15-13 isotopic-oxygen stages (Matviishyna et al., 2010; Lindner et al., 2004), Muchkap interglacial (Bolihovskaja, 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-cinnamon dry-steppe soil of the final stage (lb); in the section Pankratove it is a meadow-cinnamonic soil of the floodplain facies of the early optimum (lb1) and meadow-cinnamonic chernozem-like soil of late optimum (lb2). The soils are monolithic, dense, enriched on clays, 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).

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: \( z_v \) is the soil of the initial stage, \( z_{v1b} \) is the early soil of the optimal stage, \( z_{v1b2} \) is the late soil of the optimal stage, \( z_{v2} \) is the loess layers (Oril) and \( z_{v3} \) 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, cinnamomin-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, cinnamomin-brown soil of late optimum, loess-liked 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 (redish-brown alluvial) and Pankratove-1 (brown forest cinnamonish).

Zavadivka soils are dense, clayed and enriched on iron hydroxides, 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, microorstein (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
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 Dniepro 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), brown 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. 8. Microstructure of Zavadivka soils: a) incrustation of pores with hydroxides of iron in the zv, soil of the section Raihorod /magn. 100/; b) compact microstructure with a dense packing of grains of the mineral skeleton in a plasma of zv1b soil section Raihorod /magn. 100/; c) dense blocks are separated by a system of twisted pore-cracks in the zv1b soil section Raihorod /magn. 40/; d) scaly ferruginous-clayey outflow of polynite in the zv1b soil, section Raihorod /magn. 100/ (nic. II)](Matviishyna Zh.M., Doroshkevych S.P. Journ. Geol. Geograph. Geocology, 28(2), 327–347.)
of the genetic types of soils in time. In the initial stage (kd\textsubscript{a}), turf and turf podzolic soils were formed, under the age of the early climatic optimum (kd\textsubscript{b1}) – the soils of forest and forest-steppe genesis (turf podzolic, brown forest, brown forest gleyed, podzolic and pseudopodzolic, light gray, gray podzolic and their gleyed varieties, dark gray podzolic, chernozems podzolized), in the late optimum (kd\textsubscript{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 Tyasyn 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 – Vyatachiv soils. In the sections the horizon is often represented by soil suits or separate soils. In the subaquaie 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, Strzyzhavka, Yakushynts, Sabariv, Korobchyn-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, Strzyzhavka, Yakushynts, Pervomaisk), brown forest with signs of steppe (Sabariv) and near to the chernozem ordinary (Korobchyn-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 microaggregation 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, Strzyzhavka, Yakushynts), chernozem-like soils (Trebukhivtsi, Sabariv) and chernozem-like, brownish soils (Pervomaisk, Korobchyn-quarry). For these soils, there are signs that indicate...
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 microaggregation. 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$_{b3}$), 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,

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**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$_{b1}$, 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. ||)
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, Korobchyn, Korobchyn-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 Pobuzzhya (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 Pobuzzhya – 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 forms, 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 of the Upper Pleistocene in the non-glacial zone of Ukraine. Stratigraphically, it correlates with Moloho-Sheksmysky, and Paudorf interstadials, Mazurezyk interstadial of the Vistulian glacial, the second interstadiale of the Wurm glacial (Veklych, 1968), the Trubchevsky horizons of the Valdai glaciation

![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. ||)](image)

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-Sheksmysky, and Paudorf interstadials, Mazurezyk interstadial of the Vistulian glacial, the second interstadiale of the Wurm glacial (Veklych, 1968), the Trubchevsky horizons of the Valdai glaciation.
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 confirms 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 microaggregates 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.

The obtained data are good correlated with the results of palinological and paleopedological researches by near Pobuzhzhya disposed territory of Ukraine (Sireenko, Turlo, 1986; Gerasimenko, 2004; Sireenko, 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 in 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, half-destroyed 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 (cryptocrystal-, 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 of iron and manganese hydroxides concentration), meadow 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 microaggregation of the mass, a branched net of twisted pores, a coagulated 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 evolutionary soil changes and, accordingly, natural conditions in time and space. From the Early Pleistocene to the Dniipro glaciation, during the Shyrokyne, Martonosh, 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 Dniipro 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 regularities in the development of nature.

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

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 Dniipro 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 Martonosh times) or expressed weakly (Lubny, Zavadivka times). Brighter zonal differences appeared in the post-Dniipro 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


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