Journal of Critical Reviews

ISSN- 2394-5125 Vol 7, Issue 4, 2020

Review Article

MORPHOLOGICAL FEATURES OF BURIED SOILS OF LOESS FORMATIONS OF THE PRYTASHKENT REGION OF UZBEKISTAN

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Received: 04.12.2019 *Revised: 02.01.2020* *Accepted: 09.02.2020*

Abstract
When solving the issues of paleogeography, soil science and chronostratigraphy of loess deposits, paleosoil horizons become objects of detailed study since they reflect the geological history of the Quaternary sedimentation. Loess deposits are widespread on the globe including in Uzbekistan. In the piedmont and mountainous regions of Uzbekistan there are quite powerful strata (more than 100 meters) of loess deposits. The objects of our research were selected sections of loess deposits of the Prytashkent region in which Quaternary buried soil horizons are fairly well traced. The morphological description of the loess-soil deposits of the study area revealed specific features for the paleosoils of the Eopleistocene, Pleistocene and Holocene. Paleogeographic changes (climatic and tectonic) during the Quaternary period "imprinted" on the horizons of soils and loess formations. The carbonate nodules in loess deposits also reflect the variety of physiographic conditions of the Quaternary period. Comparison with the carbonate nodules of other regions makes it possible to distinguish them in the form of visual regional criteria for the dismemberment and correlation of loess strata.

Key words: buried soil, loess, stratigraphy, Quaternary period, Prytashkent region, Charvak depression.

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INTRODUCTION

The buried soil horizons are a kind of "archive" of the geological history of the Quaternary [7, 9, 13, 17, 18]. Studying them, we establish data on the processes and conditions of loess sedimentation, climatic and tectonic changes in the studied territories. Sequential alternation of loess and soil horizons makes it possible to establish a chronology of the formation of the soil sequence and to correlate spatially remote deposits of the Quaternary period [1, 8, 9, 11, 16].

The development of the soil-forming process is most directly affected by the natural conditions in which it proceeds, its features and the direction in which this process will develop depend on one or another combination of them. The most important of these natural conditions, called the factors of soil formation, are the following: mother (soil-forming) rocks, vegetation, wildlife and microorganisms, climate, topography, the effects of water (soil and ground) and the age of soils. The biological factor is always of leading importance, while the remaining factors represent only the background on which the development of soils in nature occurs, but they have a great influence on the nature and direction of the soil formation process. The amplitude of these changes in soils in separate parts of the earth's surface can be limited by one type of soil formation or several, as if sequentially overlapping one another. In the latter case, polygenetic soils arise, preserving to some extent the features of the previous ones and acquiring the features of new soils, overlapping soil formation types. Sometimes the most ancient paleosoils serve as the mother rock for newly emerging soils.

The duration of soil changes can be of different scales, including until the change of soil from the era of the previous natural zone to the soil of a new era. Such soils, for example, may reflect the processes of greening or afforestation of the territory. In the first case, carbonate content increases in them, in the second, leaching manifests itself in the form of podzolization or leaching, etc.

The organic matter of soils undergoes large changes as a result of humification processes, which are manifold manifold with changes in thermal and air-water conditions. During wet periods, leaching of carbonates and weathering of the rocks occurs with the release of iron, causing the reddish, sometimes brightly red color of the soil (the phenomenon of rubification). In a medium saturated with bases, red soils appear, and in acidic - brown soils. Rubification is associated with the dehydration of iron oxides upon drying of the soil. The iron bound to the clay in the form of $Fe(OH)_2$ gives it an ocher color. The anisotropy of soils and parent rocks determines their variegation and sporadicity of newly emerging morphological features.

In poorly aerated horizons of malting soils, liberated iron accumulates in the form of nodules and rust spots that remain in a fossil state. The appearance of solonetzic soils is relatively stable, but they lose the essence of solonetzic soil formation even before overlapping by sediment. Such changes in soils during the period of terrestrial existence are extremely diverse.

As is known paleosoils can be buried, relict and exhumed [12, 18]. In all cases, these soils developed in landscapes in the past. The buried (fossil) soil was formed on the surface of the earth and subsequently buried. Estimated ranges of required depth range from a few centimeters below the surface to a depth below biological activity. Relict soil is soil that has formed on the surface of the earth and has never been buried. Distinctive signs indicate its formation in another pedological environment. Identification of relict signs can be subjective, since it is difficult to finally recognize pedogenic signs that developed in different environmental conditions. This is especially true when soils have undergone a long pedological evolution [4, 5, 10, 15, 16]. Soils that were buried and in later periods were again exposed on the surface as a result of erosion are defined as exhumed or open. Depending on the degree of erosion, the exhumed soil may be fully preserved or only part of the horizon remains.

Once in a buried state, the morphological features of soils are smoothed out, and some even disappear, such as numerous neoplasms, distinct transitions of genetic horizons, color tones and shades, structure, structure, etc. But much remains in the form of relics, sometimes in a greatly altered form. The recognition of fossil soils is therefore very difficult and has to be done by interpolation and extrapolation on the basis of ground pedogenesis data. First of all, it is necessary to establish the type of soil formation, which is being restored according to direct and indirect signs and traces, such as molehills, humus spots and streaks, streaks, pseudofibers, nodules, secretions, primary or secondary coloring, secondary minerals and other formations that are stored for a long time in the fossil condition [17, 19].

The aim of our research is to compare the morphology of buried soils of the Quaternary period and carbonate inclusions of loess deposits of the Pristashkent region of Uzbekistan. The study also examined the change in the mineral and chemical parts of the soil horizons leading to their growth, the dependence of the thickness of the soil cover on the magnitude of the period with respect to the relatively stable paleogeographic conditions of soil development.

MATERIALS AND METHODS

The study area is the Prtashkent region which according to the scheme of physical and geographical zoning is located in the north-eastern part of the Republic of Uzbekistan. The geomorphologically this region is characterized by a combination of mountain-foothill and lowland territory (fig. 1).

Figure 1. Physico-geographical position of the Prytashkent region in space imagery.

The objects of study are confined to natural outcrops along the Chirchik and Akhangaran river valleys, including artificial ones created by walls in loess strata within the Gazalkent-Parkent canal, the Tashkent-Angren road, etc. The large thickness and length of the artificial outcrops of loess sections (tens of kilometers) made it possible to fix fossil soils in them depending on the main landforms (watershed, slope, terrace, river floodplain) and describe the transitions of automorphic soils to hydromorphic ones. Here loess-like formations have alluvial, proluvial, deluvial and eluvial genesis, including loess rock in the form of stone loess [1].

The alluvial loess-like rocks of the Late Pleistocene and Holocene cover the surfaces of the alluvial terraces of Syr Darya, Chirchik and Akhangaran, characterized by low thickness, often up to 10 m, the presence of lenses and interlayers of sand and gravel.

The proluvial loess is developed on the irrigated plain parts of the Chirchik and Akhangaran valleys as well as the hungry steppe and has the greatest thickness up to 40 m and more compared to other genetic types. Characteristic for it is the uniformity of the thickness and a decrease in power when approaching the mountains. Proluvial loesslike rocks compose the foothills of the ranges of Turkestan, Kuraminsky and Karzhantau. They are characterized by interlayers and lenses of coarse-grained material, increasing near the mountains.

Deluvial loess-like rocks are developed on the slopes and at the foot of the mountains, their thickness is measured from a few centimeters to several meters (rarely tens of meters), the presence of neokatannye fragments of bedrock of various sizes is characteristic in them.

Eluvial loesslike rocks are found on flat watershed areas of mountainous terrain, where there are no conditions for their washing off, their thickness is usually from several to tens of centimeters; with depth, a gradual increase in the content and size of bedrock fragments is observed.

Stone loess of the Early Pleistocene usually lies at the base of terrace deposits under loess rocks or conglomerates, has a significant thickness (tens of meters), differs from loess rocks in hardness, resembling rocky rock [20].

In the study area depending on the geomorphological position of loess sediments, there is a clear differentiation of modern and buried soils from floodplains to ancient terraces (fig. 2). Often buried soils wedge out mosaic to the day surface within the slopes, terraces and plateaus. As a result, these soils are sometimes difficult to distinguish from modern soils.

Figure 2. The nature of the buried soils of the loess strata of the Prytashkent region.

The soils of young terraces and slopes of the southern and eastern exposures of the study area have a slightly differentiated profile with crushed stone and pebbles and a small thickness (30-50 cm), high carbonate content from a depth of 4-40 cm (4-6% CO_2) and a humus content of up to 2% Brown soils with a developed profile are usually found on the higher terraces of the river valleys of the foothills, as well as on the flat secondary watersheds. They have a clearly defined two-membered profile: the upper 60-120 cm are dark-colored, structural (nut-grained), carbonate-free loams in a clear straight line turn into carbonate pale-gray loess rocks.

Sometimes carbonate inclusions are found in loess formations, the formation and depth of which are associated with the degree of their leaching from the upper horizons by atmospheric precipitation. According to this criterion, soils are divided into weak, medium (typical) and deep carbonate (or alkaline) types. However, in most cases, the upper carbonate-free stratum is not genetically related to the underlying one, which represents the outcrops of ancient loesses. For this reason, the boundary between the carbonate-free and carbonate strata is straight, clear, i.e. upon careful examination, it turns out to be a denudation line.

On mountain slopes, modern soil lies with little contact on relatively young (Holocene) carbonate layers, which gives the impression of a genetically homogeneous body. Sometimes, fossil soils can be located close to the day surface, preserving their brown color and nutty structure for millennia, which leads to erroneous conclusions about their modern genesis.

In the course of paleo-soil studies and descriptions of soils, we used standard terminology [5, 20]. Among the field methods, the leading ones were comparative-morphological and comparative-geomorphological. The comparative morphological method made it possible to obtain a number of morphotypic characteristics (structure and thickness of the profile, color and structure of soils, types of neoplasms) and to establish the direction of development of soil-forming processes. The comparative geomorphological method made it possible to trace the conservation and distribution of fossil soils according to ancient relief elements, and in combination with the comparative morphological one, to restore the structure of the ancient soil cover [5, 9, 10, 15].

DISCUSSION

Throughout fossil soil of the Quaternary period as a complex physical, geochemical, biological formation, evolves, secondary changes develop in it. One example is the precipitation of iron, manganese or calcium carbonate, and the organic material may be oxidized. Nevertheless, soils buried by sediments of different genesis retain a number of features of their original nature, by which it is possible to reconstruct the natural (bioclimatic and paleogeographic) environment [2, 3, 9, 11, 14]. If the environment changes, usually as a result of climate change, the soil also changes, although the change can be slow. In relict soil, physical, chemical, or morphological features that determine the characteristics of a pre-existing environment can be identified. The main morphological features are the structure of the soil profile, the thickness of the soil and its horizons, color, mechanical composition, neoplasms and inclusions.

The review of literature data shows that for the first time on the genesis and conditions of the formation of fossil soils in loessial deposits of the region are reflected in the works of Yu.A.Skvortsova (1957). He associated the formation of paleosols with pebbles and conglomerates lying beneath them, denying the possibility of their independent, non-alluvial path of development. This led to the abandonment of the possibility of using buried soils for stratigraphy of loesses in Uzbekistan. Later, from the mid 60-ies of the XX century in the works of N.I. Krieger, G.A. Mavlyanova, A.M. Khudaiberdyeva, M.Sh. Shermatova, V.I. Eliseeva A.A. Lazarenko and other researchers described a series of different in properties buried soils of the Quaternary period of Uzbekistan [20].

In the 70-80 years of the XX century in the works of I.N. Stepanova, U.K. Abdunazarova, V.N. Kolpakova, M.Sh. Shermatova, E. Kadyrova, H.A. Toichieva and others for Quaternary paleosoils described vertical and horizontal zonality, morphological features of the formation, engineering-geological, physico-chemical, tectonic, climatic and paleomagnetic properties. Moreover, in stratigraphic diagrams of the Quaternary period of Uzbekistan different-aged paleosoils were associated with one of the four interglacial periods and attributed to one of the four stages of geomorphological formation of terraces - the Nanai (Q_I), Tashkent (Q_{II}), Holodnostep (Q_{III}) and Syrdarya (Q_{VI}) complexes (fig. 3; fig. 4).

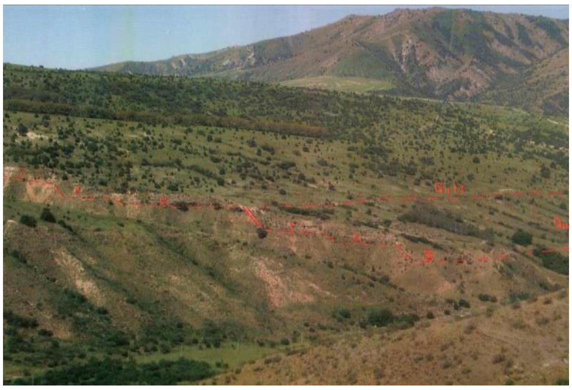

Figure. 3. Tashkent (Q_{II}) and Holodnostep (Q_{III}) complexes depending on the hypsometric position of the relief within the Prytashkent region.

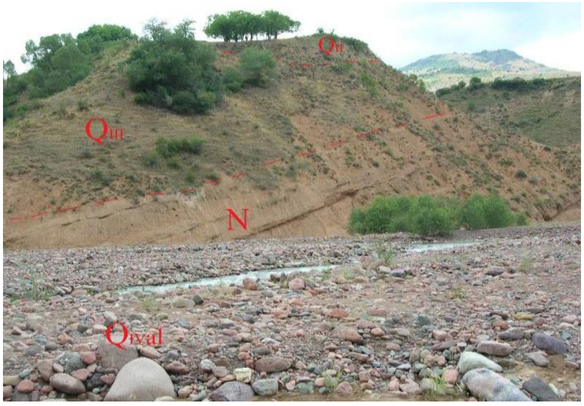

Figure 4. Syrdarya (Q_{VI}), Tashkent (Q_{II}) and Holodnostep (Q_{III}) complexes depending on the hypsometric position of the relief within the Prytashkent region.

However, such stratification did not correspond to reality, since up to several soil formation phases were established in the loess sections of Uzbekistan during one interglacial period [20, 21].Currently, research by paleopedologists is aimed at detailing the morphological features, systematics and stratigraphic binding of soil series of the eopleistocene, pleistocene and holocene [1, 8, 14].

Morphological features of fossil soils. When considering paleosoil horizons in the Pristashkent region, we recorded transition zones of loess deposits from the watershed to the valleys, i.e. the alternation of horizons of typical loesses and soils with interbeds of loesslike loams was traced [15, 20].

Modern “A” soils are brownish or gray in color, depending on location, heavy loamy, lumpy, soddy from the surface, often carbonates appear from a depth of 30-90 cm.

Loessial loam “A” lies under modern soil “A”, is not expressed everywhere and is often replaced by buried soil “B”. Loam “a” was likely to be washed away in many places. This is confirmed by the fact that between the soils “A” and “B” there is a clear erosion line and a thin (5-10 cm) horizontally layered, schoko-like layer.

The color of loam “a” varies from grayish-brownish in the wet state to fawn-gray in the dry state, the mechanical composition is medium to heavy. Loam is coarse, medium density, less dense than soil “a”, many pores with a diameter of 0.2-0.3 mm (up to 25 in 1 cm^2) and promiscuous tubules with a diameter of up to 3 mm. Carbonates are present in the form of powdery pseudomycelia (when polishing the pit walls with a knife, isolated filamentary white spots appear), pore walls are inlaid with carbonates, randomly located along the profile. In the gravelly soils on the underside of the gravel, carbonate inlets are formed. The content of total humus is about 0.3%, carbonates (CO_2) up to 8%, sludge 8-15%.

Buried soil “B” is the uppermost and youngest of the buried soils, often located directly beneath the soil “A”, separated from the last 5-10 cm by a layer of schoch. Layer shokh - dense horizontally layered pale-gray rock with buffy spots. The buried soil “B” is grayish-brown in the wet state and fawn-gray in the dry state, in terms of its mechanical composition it is heavy loam, a nut-powder structure, dense, when polishing the pit wall with a knife, a web-like pattern appears (light gray carbonate grid) around structural lumps). Structural "nuts" are a zoogenic formation 1-3 cm long, up to 1.5 cm in diameter, they are of medium strength, crushed by hand. On an area of 1 cm2, large (up to 17-20 pieces of diameter up to 0.5 mm), medium (up to 30 pieces of diameter up to 0.2 mm) and small (up to 50 pieces of diameter less than 0.2) pores can be distinguished. There are no nodules here. The thickness of soil “B” ranges from 0.3 to 2 m. The carbonate content (CO_2) is 19%, total humus is 0.3%, and sludge is 10-15%. The transition to the underlying loam is usually gradual. The preliminary age of soil “B” is the average Holocene.

Loess loam “b” is a rock of lighter mechanical composition than the overlying layer. Loam of brownish, light brownish color in the wet state and fawn gray in the dry state, dense, lumpy-powdery, the presence of nodules is typical for this layer. Loam has many pores, mainly with a diameter of 0.5 mm (in 1 cm2 up to 30-35 pieces) and tubules with a diameter of 2 3 mm, the inner walls of which are inlaid with fine-grained calcite. The content of carbonates (CO_2) is 12%, total humus is 0.4%, and sludge is 10 16%. The transition to the underlying layer is usually noticeable. The thickness of layer “b” is from 2 to 4 m. Loess loam “b” by age is tentatively assigned to the lower part of the Holocene and the upper part of the Late Pleistocene. Numerous archaeological finds on young terraces also testify to the Holocene age of the studied paleosoils.

Buried soil “C” differs from other buried soils in a more pronounced structure, high thickness and heavy loamy composition. The color is taupe and brown when wet and pale gray when dry. The soil is dense, with a nutty structure, nuts up to 2 cm in diameter, they are tightly pressed one to one, they are hardly crushed by hand, there is carbonate mold around the structural lumps. Monoliths are difficult to take, as the soil easily crumbles into walnut-like areas. Nodules are absent. The content of carbonates (CO_2) is 15%, total humus is 0.4%, and sludge is 10-15%. Thickness is 1-2 m. In the lower layers of the slopes (on ancient extension cones), loam "c" is underlain by coarse clastic material, and at higher levels by soil "D". The transition to the underlying horizon is noticeable. The approximate age of soil "C" and loam "C" is the top of the Late Pleistocene.

The buried soil "D" has a heavy loamy composition and differs from other soils in a darker, brownish color, has a dense composition, lumpy-nutty structure. In this case, the "nuts" are rounded, with a diameter of up to 2 cm, around them there is a thin mold of light gray carbonates; on the faces of structural units in the wet state, darkish spots are usual. The lumps are dense, they are hardly crushed by hand, when taking a monolith, the entire horizon easily breaks up into "nuts". The soil is nodose, pores are scarce, nodules are absent. The carbonate (CO_2) content is 7-8%, total humus is 0.2-0.4%, and sludge is 13-14%. The thickness of the layer is 1-2 m, the transition to the underlying layer is gradual.

Loess loam "d" is a medium to heavy loam of grayish-brown color in the wet state and fawn gray in the dry state, medium density, lumpy-powdery, sometimes there are inclusions of semi-solid structural lumps, which are probably traces of the relic soil-forming process . The degree of porosity does not differ from other loessial loamy layers. Loessial loam "d" carbonates are represented by separate powdery whitish spots and nodules in the form of "tubes". The content of carbonates (CO_2) is up to 15%, total humus is 0.3%, and sludge is 10-17%. Thickness is 1-3 m, in some places in the lower parts of the slopes there are crushed stone inclusions. Very often, the horizon is underlain by a thin (10-20 cm) schoko-like layer. The complexes "Cc" and "Dd" are tentatively assigned to the lower Pleistocene.

The buried soil "E" differs from other soils by a lighter color in the wet state and a pale gray color in the dry state, as well as by the presence of nodules in the form of large dendroids. The mechanical composition is heavy loam of a lumpy-nutty structure, dense, slightly porous. Carbonate "mold" around the "nuts" is less pronounced than in other overlying soils. The content of carbonates (CO2) is 6-7%, total humus is 0.3%, and sludge is 17-25%. Thickness is 1-3 m, the transition to the loam "e" layer is gradual.

Loess loam "e" is a heavy loam of brown color in the wet state and fawn gray in the dry state, medium density, powdery, stains hands, lumpy and powdery. Nodules in the form of "rattled". Loam is macroporous (1 cm2 accounts for 20-25 pores with a diameter of up to 0.5 mm). The content of carbonates (CO_2) is 10-12%, total humus is 0.2%, and sludge is 9-11%. Power 1-2 m.

When littering with uncut loams, the transition is gradual, when moving to soil "F" the transition is noticeable. The approximate age of soil "E" and loam "e" is the upper Middle Pleistocene.

Buried soil "F" is found on high watershed and water-divider parts of the slopes of the study area. Heavy loam of brown color, dense, lumps angular with a diameter of 1.5-2 cm, dark spots are visible on their faces, carbonates are not expressed. The content of carbonates (CO_2) is 6%, total humus is 0.3%, and sludge is 15-20%. Power up to 1 m, marked transition.

Loess loam "f" is greyish brown in the wet state and light gray in the dry state, medium to heavy loam, dense, pore less than in the overlying loamy layers, oblong-round nodules occur in some places. The content of carbonates (CO_2) is up to 8-10%, total humus is 0.1-0.2%, sludge is 15-20%. Usually underlays by a shokhovy horizon.

Soils and loams "Ff", "F_1f_1", "F_2f_2", etc. we assigned to the Middle and Lower Pleistocene. The loesses of the Lower Pleistocene are an alternation of brown-brown buried soils, underlain by a shokheobrazny horizon, with a thickness of about 20-40 cm and loesslike loams separating them.

The fine-grained deposits of the Eopleistocene within the Prytashkent region are very fragmented and can be found within the low- and mid-mountain parts of the river valleys, where they have the appearance of a thick red-brown monoclinic bed. The layers of this stratum are formed by the alternation of powdery grayish-brown loams, lumpy-nutty, reddish-brown paleosols designated by us as "Gg", "G_1g_1", etc., consisting of soil-loess complexes and fawn carbonate "schoch" horizons, often called "stone loess".

As can be seen from the above review, buried soils and loams have specific morphological features, which allows us to divide the studied loess layer into a number of age complexes.

A comparative study of the micromorphology of modern soil and samples of buried soils showed that they are all microaggregated. In modern soil, aggregates of the second order dominate, the structure is loose. In fossil soils, aggregates of the first order, the composition is dense. There are flocculent humus, charred organic residues, as well as the remains of shells of small organisms. Sometimes these signs are also noted in the horizons of loesslike loams, but in much smaller quantities. Only soil horizons are characterized by a scaly clay structure (claying). There are no signs of clay moving. Clay matter is represented by hydromica, mixed-layer mica-montmorilotite components, and kaolinite.

The presence of brown spots (iron oxide) in the profile of fossil soils indicates a former hydromorphism - increased surface moisture. The glandular neoplasms noted in the paleosoils in the form of spots and diffuse rings, including intense black-brown pigmentation along the pores, indicate the movement of soluble iron and manganese compounds. The presence of manganese films confirms the assumption of a former hydromorphic process. All this shows that paleosoils are not just gray earths of modern times, but polygenetic soils that have passed a difficult evolutionary path.

Paleosoil nodules are a special group of neoplasms. Their distinctive features are morphological severity, density (regardless of soil moisture), concentrically layered or parallel-layered composition and a clear separation from the host sediment in chemical and mineral composition. Their uniqueness lies in the fact that each type of paleosol is characterized by its special set and ratio of nodules, their specific position in the profile, and confinement to certain genetic horizons [20].

The first systematics of macroforms of soil neoplasms was given by S.A. Zakharov (1930), dividing them into two large groups: chemical and biological origin [8]. To the first group, they included plaques, discolourations, smears, stains, crusts, veins, tubules, nodules, contractions, interlayers consisting of readily soluble salts, gypsum, calcium carbonate, sesquioxides, iron (II) compounds, silica, humic substances. He assigned wormholes, coprolites, dendrites, molehills, and rootstones to the second group.

A very complete morphological system of soil neoplasms, including microforms, was proposed by R. Brewer (1964). He identified the following species [18]:

- cutans - changes in texture or composition on natural surfaces in soil material due to the concentration of any soil components or in situ plasma modification; on the surfaces on which they are formed, they are divided into cutans of grains, aggregates, channels, surfaces of aggregates and pores.
- pedotubules - neoplasms consisting of soil material and having a tubular external shape in the form of simple or

branching tubes with relatively sharp external boundaries; among them granotubules, agrotubules, isotubules, striotubules and pedotubules stand out;
- gobules - rounded neoplasms that differ in the concentration of some material and structure from the containing material and are separated by clear boundaries; are undifferentiated, concentric, layered, oriented and porous;
- crystallaria - single crystals or clusters of crystals outside the soil matrix, comparable in shape to those pores in which they are formed; divided into crystalline tubes, crystalline chambers, crystalline interlayers and incorporated crystals;
- subcutaneous neoplasms - distinguishable by texture, structure and addition from the matrix of formation, having a material connection with the host material and formed near the surfaces of aggregates, but not directly on the surfaces, unlike cutans; divided into neo-cutans, quasicutans;
- fecal tablets - excrement of soil fauna, coprolyte, single or complex (in heaps).

The confinement of nodules of various shapes and sizes to loesses of different ages was noted in China, Tajikistan, Ukraine, Russia and other countries. So, V.A. Obruchev (1951) notes that in China young loesses rarely contain small nodules, their size increases with depth and in the oldest red loess nodules grow into irregularly branched bodies ranging from a nut to a fist.

A.S. Kies (1969) indicates that in China, Pliocene loesses contain large nodules with a diameter of up to 20 cm, in young loesses (Middle Pleistocene) their sizes do not exceed 5-7 cm, and in Holocene loesses 1-3 cm. According to V.N. Pavlinov (1959), about ten layers of nodules in China's loess, is evidence of temporary interruptions in aeolian dust deposits: a dark-colored horizon, probably fossilized soil, is almost always noted above the nodule layer [20].

In the south of Tajikistan, where the loess stratum is more ancient, the number of nodule layers reaches ten, as in China.

In the loesses of Ukraine K.A. Baranov (1953) described calcareous nodules located on the floors - cranes at a depth of 3-4 m, directly under modern soil (their length is 17 mm), "dutiks" at a depth of 5-6 m, spherical, hollow inside (diameter 14-22 mm): "Pupae" at a depth of 7 m, cylindrical, inside the nodules, radial cracks (length 70-100 mm): "rattled" at a depth of 8 m, irregularly spherical in shape with a diameter of 36-44 mm, sometimes flattened and elongated to 100 mm. The inner part of the nodules is dissected by cracks, they separate pieces of nuclear material that, when shaken, the nodules make noise.

Nodules of the same age strata retain their size, shape and composition in the vast expanses of Central Asia and beyond. Despite the large distances between the reference sections (Western Tien-Shan, southern Tajikistan, Kopet-Dag), where they were described, nodules retained the same shapes and sizes and belonged exactly to the horizon to which they belonged in the Pristashkent region. This indicates that during the formation of a particular nodule layer, bioclimatic conditions were close in large spaces. So, for example, nodules have almost the same size, shape and composition both in the Pristashkent region and in loesses of Ukraine, China and Western Europe [6, 12, 14, 15, 16, 2, 11, 20]. Therefore, nodules can be considered as the most important marking feature of layers of different ages in loesses.

The mass description and collecting of nodules from the loess-soil strata of different ages in the Pristashkent region made it possible to form a definite idea about them [20]. In an idealized 20-30 meter thick loess composed of soils and loams of the Holocene, upper and middle Pleistocene, the following floors of carbonate nodules alternate from top to bottom, mainly confined to loamy layers, and not to soils: "cranes", "tubules", "dendroids large","rattled","core". Since nodules are of great importance in the stratification of loess, an attempt is made below to determine their relative age.

Modern soil and subsoil do not contain nodules, carbonates in them are represented at a depth of 0.5-1.5 m in the form of "mycelium", "cobwebs", sagging on the lower surface of crushed stone. The first from the surface are the so-called "cranes" (fig. 5).

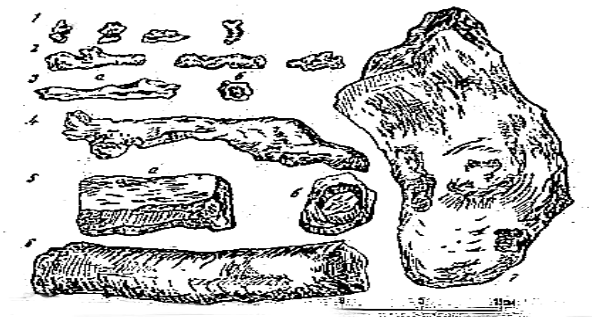

Fig. 5. Carbonate nodules - diagnostic indicators of different ages of loams and soils in the loess-like strata of the Prystashkent region [20].

1 - loamy cranes; 2 - loam pupae; loam tubes d: a - general view; b - transverse section; 3 - tubes of loam "s"; 4 - large dendroids from soil E; 5 - rattles of loam e: a - general view, b - transverse section; 6, 7 - nodules from loams at the contact of the lower Quaternary and Pliocene deposits.

Cranes usually lie at a depth of 2-5.5 m under the ancient buried soil "B", i.e. in loam "b". The length of the nodules is 30 mm, and the diameter is 10 mm. In shape, they resemble Ukrainian "cranes", differing from them in larger sizes. Similar nodules in loesses of the Hungry Steppe of Uzbekistan are described by G.A. Mavlyanov (1958) at a depth of 1.3-2.1 m (their size is 4-10 mm, sometimes on an area of 1 cm2 there are 1-2 cranes), as well as V.B. Gussak et al. (1961) within Charvak of Uzbekistan at a depth of 70-100 cm.

Pupae occur at a depth of 8–10 m and are confined to loam "C", which lays well structurally powerful buried soils "C" ("Victor's soil"). Nodules have a slightly smoothed roundish-oblong to spherical shape; their diameter is 15-20 mm, length is 50-70 mm. The core is darker in color and in the cross section from it to the periphery radial thin drying cracks (syneresis cracks) diverge. In the section under the binocular, in a cross-section, microgranular calcite predominates.

Tubules are found at a depth of 12-14 m in loam "d", underlying the brown structural soil "D". Irregular nodules are sometimes reminiscent of light yellow roots with a smooth surface. The length of the nodules is 40-60 mm, and the diameter is up to 20 mm. In the center of nodules there is a thin, branched cavity with a diameter of 1-2 mm, with sharp edges - a drying crack; in some cases, the tubules do not have a cavity, but then their central part is darker than the periphery. Nodules occur unevenly throughout the "d" layer, although they become larger in its upper part at the contact with the "D" soil; in such cases, there are 1-2 nodules on an area of 10 cm^2. All of them are very hard, do not break by hand. In the total mass of nodules, fine-grained calcite predominates.

Large dendroids occur at a depth of 15-16 m in the buried soil "E", usually found in loamy layers separating buried soils. In this case, nodules are located in the structural brown soil "E" and are confined to its lower and middle parts. They have a flattened shape and resemble the roots of shrubs. The length of the nodules reaches 150 mm, a diameter of 20-50 mm; the surface is rough, the color of the central and peripheral parts is almost the same. In some places, small drying cracks in the form of specks are observed in the center of nodule.

The rattles occur at a depth of 16-18 m and are confined to loam "e", the shape is elongated and rounded, length 60-100 mm, diameter 40-50 mm. The surface of these nodules is flat, smooth. The nodules themselves are dense, as if petrified; inside there is a cavity in which the core is placed in a relatively free state. Nodules are very similar to the "rattles" of Ukraine, but they do not always make a sound when shaken. Therefore, the name of these nodules is conditional.

The cores are large carbonate-clayey, very dense, petrified rounded nodules, but can be elongated-rounded, up to 200 mm long, with a diameter of 50-80 mm or more. Nodules are massive, their weight reaches several kilograms. They are confined in the contact zone of gray or grayish-brown loessial loams of the Lower Pleistocene with brownish deposits of the Pliocene.

The chemical composition of nodules is predominantly carbonate of loess often carbonate-clay. Micromorphological analysis of their transverse sections showed that they are composed mainly of microcalcite. According to the results of gross analyzes, in addition to calcium, nodules contain silica. The chemical composition of nodules from different ages of the region is different. So, in loam "c", the total content of silicon oxide in the cores is 24-36%, and in their peripheral part almost twice as much up to 60%; in loam nodules "d", the amount of SiO_2 is 5-7%, in soil nodule kernels "E" up to 16%, and in margins 30-60%, i.e. the closer to the periphery, the more.

The content of calcium and silicon oxides in nodules of different ages is different. In loam "b" they are relatively enriched with these oxides, which indicates a slight change in minerals by hypergenesis, i.e. nodule is in an early stage of diagenesis. Nodules of loam "d" with a low content of silicon oxide and a high content of calcium oxide, on the contrary, are subject to longer transformations (mineral grains are dissolved and substantially leached). All this confirms the relatively young age of the described loam "b" and older, located below the loam [20].

RESULTS

In the process of the extinction of the soil, its organic part is preserved only in the event of a catastrophic burial of the ancient day surface. In situations where the biological and physicochemical processes that contributed to the burial cease without catastrophic burials, the entire organic part, devoid of renewal, burns out and erodes, and only its mineral part remains in place. The most characteristic feature of such soils, deprived of the organic part, is the presence of soil zonality. It differs only in the nature of the mineral part of the fossil soil. Moreover, the maximum amount of newly formed minerals is located at the top of the soil section, a gradual transition to the lower underlying stratum is observed. As a mineralogical characteristic of the loess-soil stratum of the Prystashkent region, we consider the Kishlaksay profile, where soil and loess are varied in genesis, composition, and age (table 1).

Table 1. Distribution of light fraction minerals in % (density less than 2.9) in buried soils and loams of the Kishlaksay profile separating them (fraction size 0.1-0.05 mm) [20]

Location and pit number	Loam and soil index	Depth, m	Quartz	Feldspars	Rock debris	Clay. wreckage	muscovite	biotite	Quartz, feldspars
Buried part of the slope, 46	red flowers	2,0	44	25	8	2	12	9	1,8
	also	2,3	45	28	7	3	5	2	2,0
Upper part of the slope, 42	D	7,0	46	26	3	3	7	16	1,8
	E	9,0	15	5	1	78	1	0,5	3,0
	e	13,0	42	24	4	4	12	14	1,8
	e	15,0	45	26	12	4	10	3	1,7
	red flowers	17,2	37	32	5	22	0,5	4	1,2
The middle part of the slope, 44a	B	1,0	47	31	17	-	0,8	3	1,5
	B	1,4	46	28	18	-	2	4	1,6
	b	3,6	40	31	22	-	2	4	1,3
	b	4,0	44	26	26	-	1	3	1,7
	C	4,6	41	31	22	-	1	4	1,3
	C	5,3	45	31	19	-	2	2	1,4
	c	5,6	50	27	16	-	1	5	1,8
	c	6,2	40	32	15	-	3	8	1,2

	B	6,6	51	31	14	-	1	3	1,6
	E	8,2	44	32	18	-	2	3	1,4
44	Shoh	9,0	46	28	8	4	9	5	1,6
	E	12,0	47	25	3	3	8	14	1,9
	E	14,0	42	37	7	6	3	6	1,1
	red flowers	19,5	43	30	4	2	13	7	1,5
Lower slope ,41	C	5,0	54	28	6	3	6	2	1,9
	C	8,0	38	26	12	22	1	0,4	1,5
Lower slope, 39	A	0.7	40	23	16	18	1	2	1,7
	A/B	1.0	45	26	19	2	3	5	1,7
	B	1.0	45	23	14	11	2	4	2,0
	B	1.5	39	26	18	10	2	5	1,5
	B	1.7	32	20	7	29	4	9	1,6
	B	1.9	44	24	17	9	1	4	1,8
	b	2.5	43	27	11	14	2	3	1,6
	b	3.0	41	22	18	12	1	3	1,9
	b	3.4	31	20	8	35	0.5	5	1,6
	b	4.0	39	27	14	13	3	3	1,5
	C	4.5	41	24	10	14	3	8	1,7
	C	4.9	43	26	12	15	1	3	1,6
	C	5.5	41	23	15	14	2	3	1,8
	c	9.2	42	25	9	16	1	7	1,7

Mineralogical research was based on the principle of a phased study of soil horizons from the highest levels of the watershed to the foot of the slope. So, in ancient soils and loams within the watershed, the quartz is slightly larger (43-45%) than at the foot of the slope (40-42%). Feldspars are greater in loesses of the upper part of the slope (28-31%) than in the lower (24%); the loesses of the watersheds also contain more biotite and chlorite.

This indicates that during the development of horizons of ancient soils and loams on different elements of the relief there were heterogeneous bioclimatic conditions that determined the geochemical differentiation of substances. Although morphologically the horizons of ancient soils are represented by an externally homogeneous mass (the same structure, color, nature of nodules), their position, depending on the geomorphological level, left a certain imprint.

It should be noted that the difference in the material composition of soils and loams in the vertical section is more significant than in the relief elements; the change in the nature of the layers was due to larger landscape changes [3].

Redflowers are noticeably depleted in quartz and feldspars compared to ancient soils and loams, since in the process of loess accumulation, probably, the initial stage occupied a large place - the weathering of red blossoms, in which quartz and feldspars accumulated and mica was intensively decomposed. Transportation of material down the slope either gave a slight decrease in quartz and feldspars, or retained them in equal amounts.

A study of the mineralogical composition on the example of the Kishlaksay profile of the Pristashkent region shows a noticeable decrease from the upper parts of the slopes to the lower weathering minerals: zircon, tourmaline, rutile, garnet, epidote and an increase in other less stable minerals: hornblende, biotite. This phenomenon is explained by the fact that minerals that are least resistant to weathering are more quickly released during the destruction of the crystal lattice, and are carried out by a deluvial drain to the foot of the slope, where they accumulate. In this case, the difference in the content of both stable and less stable minerals between the upper (initial) part of the relief and the lower (accumulation band) is large: two minerals are more than others, twice. This is an indirect indicator of the intensity of denudation and transfer of weathered fine earth.

Comparison of minerals of different age soils of loesses of the Prytashkent region (on the example of the Charvak basin) revealed the following differences in the composition and degree of their weathering (table 2).

Table 2. Arithmetic average of the content of light fraction minerals in% (density less than 2.9) in buried soils and loams of the Charvak depression (particle size 0.1-0.005 mm) [20]

Loam and soil indices	Number of Definitions	Quartz	Feldspars	Rock debris	Aggregated Grains	muscovite	biotite	chlorite	Carbon particles	Quartz, feldspars
A	1	40	23	16	18	1	1,5	-	-	1,7
B	2	42	22	8	16	5	7	-	-	2,0
b	3	39	23	7	13	7	10	0,1	-	1,8
C	11	41	27	9	14	4	5	-	one	1,5
c	9	41	30	8	9	4	7	one	-	1,4
D	6	38	27	7	21	3	4	also	-	1,4
d	7	39	28	12	11	3	6	-	-	1,4
E	10	45	27	8	12	3	4	one	-	1,8
e	7	39	29	6	14	5	7	-	-	1,3
F	3	37	27	8	22	2	4	-	-	1,3
f	3	40	24	6	3	11	16	-	-	1,4
red flowers	5	37	22	5	22	6	7	-	-	1,5
average		40	26	9	14	4	7	one	one	1,5

Modern soils contain angular fragments of quartz and feldspars in amounts that differ little from those of more ancient soils. Here, as in other underlying soils, hematite and limonite are always greater in large fractions, and magnetite and ilmenite predominate (almost twice) in small fractions; granite is clean, colorless.

Soil “C” already has signs of stronger weathering of mineral particles. So, granite, although it remains angular, but its color acquires a bright yellow hue. Pyrite grains instead of angular become round, fine-grained; the latter occurs with hematite.

Soil “D” undergoes even more significant changes, probably due to the high moisture content of that time. This is evidenced by the films of iron hydroxides that appeared on the fragments of rocks and quartz, many pomegranate grains from angular shapes were transformed into semi-rounded ones, their surface relief became more pronounced, bumpy. Druze of rutile appeared, and at zircon - the verge of growth; pyrite became angular.

The signs of sulfate salinization observed in some pits can be explained as a cycle of soil aridization. This is especially clearly observed in the soil "E".

Soil “E” is the most weathered of the buried soils. This is evidenced by the predominance of clay and mica in the minerals, impregnated with organic matter and iron hydroxides. Hematite and magnetite for the first time get rounded outlines. However, in loam “d” located above soil “E”, as well as in places and in soil “E”, we find increased salinization (up to 0.9% of the solid residue) by calcium sulfates, which does not correspond to a high degree of climate moisture during formation these layers. Nevertheless, the findings of spores and pollen of woody vegetation, indicating a wide development of forests, suggest that the soil "E" has survived several phases of soil formation - from moist to arid. This made the soil profile polygenetic, complex.

When comparing soils and loams separating them, it is found that the minerals of the latter are always angular in shape, their edges are serrated, the color is clear. This also indicates a significant transformation of minerals in the loamy layers, but these changes are not soil, but are associated with the movement of their water and air flows.

In loesses of the Charvak depression, a clay fraction consisting of particles less than 0.001 mm in size, not more than 30%. Spectral analysis revealed 29 chemical elements in them. On the other hand, the data of electron microscopy and X-ray diffraction analysis of samples of ancient soils and loams of the Kishlaksay profile showed that loesses are divided into two unequal parts: the upper, young with soils A, B, mainly of hydromica composition, and the older stratum, starting from loam and b flesh to soil E - predominantly montmorillonite. Across the section, kaolinite is present, which could have formed during the wetter and hotter climatic epochs of the Early and Middle Pleistocene, and later reassigned as a relic. Kaolinite characterizes humid conditions under a quiet tectonic regime, and montmorillonite or hydromica – arid [20].

A clear division of loesses in the Charvak basin into montmorillonite (ancient) and hydromica (young) indicates that hydromicusal montmorillonite has occurred in the upper young loesses in recent millennia [20].

CONCLUSION

The degree of preservation and thickness of the profiles of buried soils in the loess sediments of the Pristashkent region are dependent on the geomorphological structure and geological structure. Here, the main factors that influenced the differences in the formation of soil horizons were tectonic processes and a change in the humid conditions of sedimentation to arid ones in the Quaternary period.

Macro- and micromorphological studies have shown that the studied loess stratum is a numerous formation. Paleo-soils occur at various depths, which are separated by horizons of loess-like deposits. The latter are represented by clusters of finely clastic, predominantly silty yellow-yellow material, characterized by macroporosity, the formation of columnar prismatic separations, subsidence, and variability of texture from massive to layered, feldspar-quartz in the mineralogical composition, and carbonates are noted in them. In turn, the paleosols are morphologically well defined, have a darker color from brown to bright bluish, are well-structured into lumps and grains with traces of the activity of earth moving and numerous remains of former vegetation in the form of charred thin horses and their prints. Contacts with higher and lower lying loesslike loams are clearly pronounced.

Unlike modern soils, buried soils become more structural, clayey and brownish with increasing age, carbonate nodules appear in the underlying loam, the size of which increases with increasing age of the layer, and the shape of their nodules changes with age. All these features make it possible to distinguish fossil soils by age in a vertical profile.

A comparison of the age of nodules with the age of modern and buried soils shows that they are a relict sign of previous eras of pedogenesis. In all cases, the age of nodules corresponds to the age of the sediment enclosing them, which allows us to consider them as a significant chronological indicator. The study of nodules of paleosols in the study area made it possible to obtain information on the dynamics of paleoclimatic conditions in narrow time intervals, which is especially important for predicting changes in the environment and climate in the near future.

The analyzed mineralogical data on the loess-soil deposits of the region revealed that in the paleosols and loess loams within the quartz watershed there are slightly more (43-45%) than at the foot of the slope (40-42%). Feldspars are greater in loesses of the upper part of the slope (28-31%) than in the lower (24%); the loesses of the watersheds also contain more biotite and chlorite. This indicates that during the development of paleo-soil horizons and loessial loams on different elements of the relief there were heterogeneous bioclimatic conditions that caused the geochemical differentiation of substances. Although the morphologically paleo-soil horizons are represented by an externally homogeneous mass (the same structure, color, nature of nodules), however, their position, depending on the geomorphological level, left a certain imprint.

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