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INQUA XV CONGRESS

Sedimentary model of the Staiky loess plateau, Pridniprovs'ka Upland, Ukraine

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There is still a considerable gap between sedimentologic investigations of great geologic intervals and modern sedimentary environments, which especially concerns the continental formations. Elaboration of sedimentogenic models for the small depositional bodies of the Quaternary sequence and spanned in scale from a year to 100,000 years can assist to fill up this gap. A selected study object was a complex of the Staiky Plateau (Pridniprovs'ka Upland, the Ukraine) which has developed after the last glaciation in this area, i.e. 210–250 ka BP. This complex consists mainly of lacustrine, aeolian (loess and sand), slope wash and alluvial deposits. They form regular bodies of suites and groups of suites, defined by a spatial pattern, mode of occurrence, facies composition and lithologic features, which allow correlating. There are three sedimentary zones in the examined region. The first is a proper plateau, with a local lacustrine and then, a stable aeolian (loess) deposition. The second zone is plateau slopes with a sheet and locally, gully erosion, but prevailing aeolian and slope wash deposition. Predomination of down cutting combined with transit intermittent alluvial accumulation is the characteristics of the third zone, i.e. plateau valleys. Clastic material was derived from the areas adjoining the Staiky Plateau and from local sources. The Quaternary and the pre-Quaternary deposits were subjected to erosion, products of which were transported to lower levels of the plateau, and then they were carried out along the plateau valleys to the Dnieper valley.

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INTRODUCTION

Principal problems of sedimentology have been usually worked out conformably to the pre-Quaternary sedimentary rocks or to the modern and actually active environments. In the first case, sedimentologists deal with geologic bodies corresponding to single chronozones, stages and series, geologic duration of which was from a couple to a dozen million of years. In the second case, they consider a momentary (in a geologic scale) manifestation of sedimentation. Advantages and shortcomings of the both approaches are known and according to H. G. Reading (1978, p. 1): "A prime aim of sedimentology is to narrow the gap between modern process and past product...". According to the present author the Quaternary deposits, their elements and complexes (lasting from a few to hundreds of thousand years) are the preferable objects to achieve this aim at a level of the elementary sedimentary bodies. They are noted for the study accessibility, and principles of uniformity can be applied most effectively.

The current investigation, first results of which are stated in the present paper, is turned to create a descriptive detailed spatial-temporal model of the Quaternary continental sedimentation. It envisages the following logical steps: discerning the elementary sedimentary bodies for a definite span and different genesis, analysis of their internal structure, spatial and stratigraphic correlation of the bodies (their complexes), and then reconstruction of a sedimentary environment.

A theoretical base of this approach is tightly connected with concepts about genetic types of continental formations (E. V. Shantser, 1982) and geologic bodies (Y. A. Kosygin, 1983). The Russian geologic term "genetic type of continental formations" is similar to such notions in the other countries as "suite of the lithofacies types" or "genetic facies associations", but it is wider and more certain. It is a complex of sediments, formed due to specific accumulation processes, i.e. alluvial, glacial, aeolian, *etc*. The term "geologic body of deposits" develops the previous one. Firstly applied in studies

Fig.1. Location map

of glacial deposits (A. V. Matoshko, Y. G. Chugunny, 1993), it is regarded to express the elementary rhythm or pulse of sedimentation in a limited geologic space. Therefore, it has quite definite boundaries, i.e. it is strictly discrete in spatial as well as in temporal dimensions. A geologic body of deposits is characterised by form, structure and composition; together, these characteristics determine its genesis. Within such a body, dynamic lithofacies (or their groups) that reflect dynamic phases (conditions) of sedimentation, are distinguished by structural and granulometric features. A group of spatially interrelated geologic bodies that originated within the same sedimentary phase is referred to as a "suite".

LOCATION

The post-Dnieper Glaciation (Middle Pleistocene) strata within the territory of the Middle Dnieper area are selected as the object of the sedimentary model. The selected region of the Staiky Plateau is a typical part for the Pridniprovs'ka loess plateau, located in a glacial zone (Fig. 1). The Pridniprovs'ka loess plateau belongs to the Pridniprovs'ka Upland. From the west and south-west the plateau is bounded by a maximum limit of the Dnieper Glaciation, and from the east by the valley of the Dnieper River. Its surface is located commonly at 170–190 m a.s.l. Close to the Dnieper valley, an escarpment, 90 m high, breaks the plateau. Erosional forms intensively dissect a flat surface of the plateau. Regarding to the main structures, the Staiky Plateau as a whole is related to the northeastern slopes of the Ukrainian Shield and in a regional Quaternary tectonic plan — to the apical part of the local Obukhiv Uplift (A. V. Matoshko, 1996).

Geology of this region has been intensively studied. There are a lot of exposures of the Quaternary deposits and the most complete ones are stretched as the intermittent streak along the plateau escarpment to the Kanivs'ke Reservoir on the Dnieper River. Some of these exposures (Vitachiv, Staiky, Grebeny) were analysed in detail by several field and laboratory methods (M. F. Veklitch, 1958, 1968; N. P. Gerasimenko, 1988), with stress put on the buried soils and a loess stratigraphy. Small exposures are associated with numerous gullies, and there are several tens of the Quaternary boreholes. All these objects and materials as well as the references were taken into consideration.

METHODS

Clastic sedimentology and principles of a field identification of lithofacies (H. G. Reading, 1978; N. Eyles *et al.*, 1983) were the predominant, but general geologic and geomorphologic methods were applied too. There is nothing peculiar in most of them but the most important peculiarity was a general scheme of investigation. In respect to the Middle Dnieper area, it is grounded on the monograph of G. I. Goretsky (1970) who presented significance of consecutive examination of a single sequence in an exposure to a study of their group, then to examination of drill cores and finally, to a mutual correlation in vast key areas and a comparison with key sequences. This approach is applied commonly during geologic mapping but has not been widely developed for a specialised investigation.

Another methodological peculiarity is a dense continuous sampling (by a furrow mode) along a vertical section, with intervals at each 0.2 m for silts and each 1 m for sands. Hitherto, only spot sampling from separate horizons or ran-

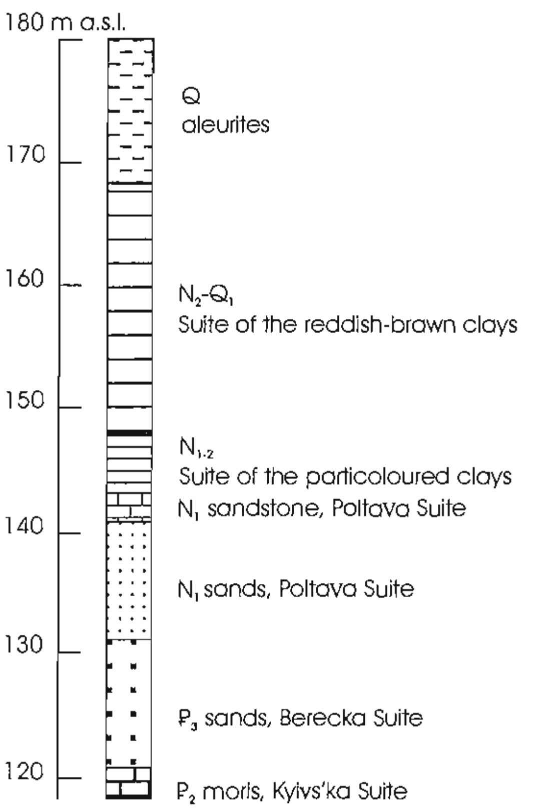

Fig. 2. Typical sequence of the Staiky Plateau (geologic section of the borehole 113)

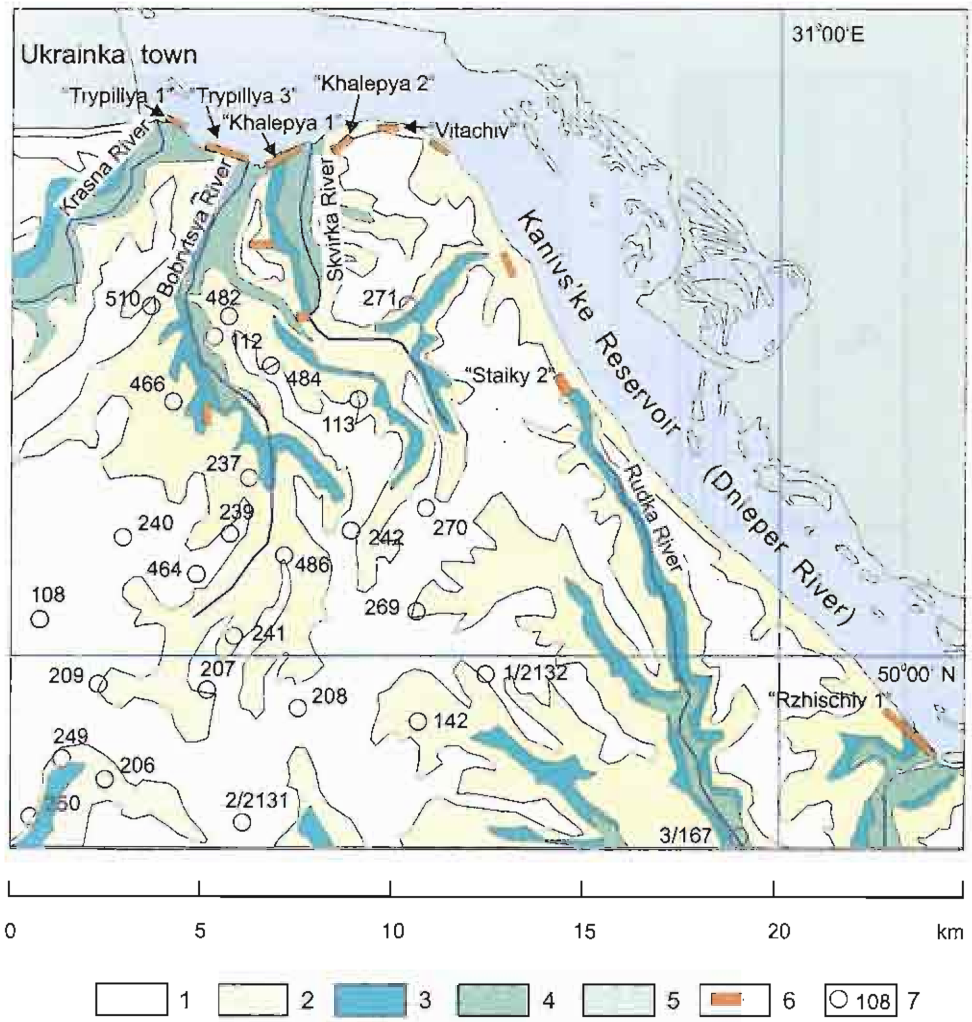

Fig. 3. Map of the Middle to Upper Quaternary non-glacial deposits in the Staiky Plateau

1 — aeolian (loess), 2 — slope wash, 3 — alluvial (periglacial suite) and slope wash, 4 — alluvial (younger suites), 5 — alluvium of the Dnieper valley, 6 — main exposures, 7 — boreholes and their numbers

dom sampling was carried out within the selected region. The original device of the suspension density sounding was used for the separation of the fine-grained deposits.

DATA

GENERAL GEOLOGIC STRUCTURE

A typical sequence of the sandy-clayey Paleogene–Neogene rocks is presented (Fig. 2). They underlie immediately the Quaternary strata and crop out within the Staiky Plateau. Their most complete sequence is known from the watersheds and it truncates towards the river valleys. A complete sequence of the Quaternary consists of three, the most obvious complexes, i.e. preglacial, glacial and postglacial ones, and includes two index horizons. All geologists confidently discern the latter.

The lowest one is the non-stratified horizon of the reddish brown clays, presumably of the Upper Pliocene to the Lower Quaternary age. This horizon is overlain by loess-like silts, 16 m thick, and subdivided into two-three layers by different colour. The origin, both of clays and silts, is under discussion. The second index horizon is the basal till of the Dnieper glacial complex of the Middle Pleistocene. It is a brown or reddish-brown diamictite with a low content of coarse material. The till has a glaciodynamic or glaciotectonic contact with the underlying preglacial deposits or the Neogene rocks. It is 13 m thick and locally, underlain or covered by meltwater deposits. As a whole they have small thiekness, considerably varied along a strike.

In the watersheds a top of the basal till was the original base for a postglacial complex. Its maximum altitude (more than 180 m a.s.l.) is associated with a zone, running from NE to SW in the central part of the region at the interfluve of the

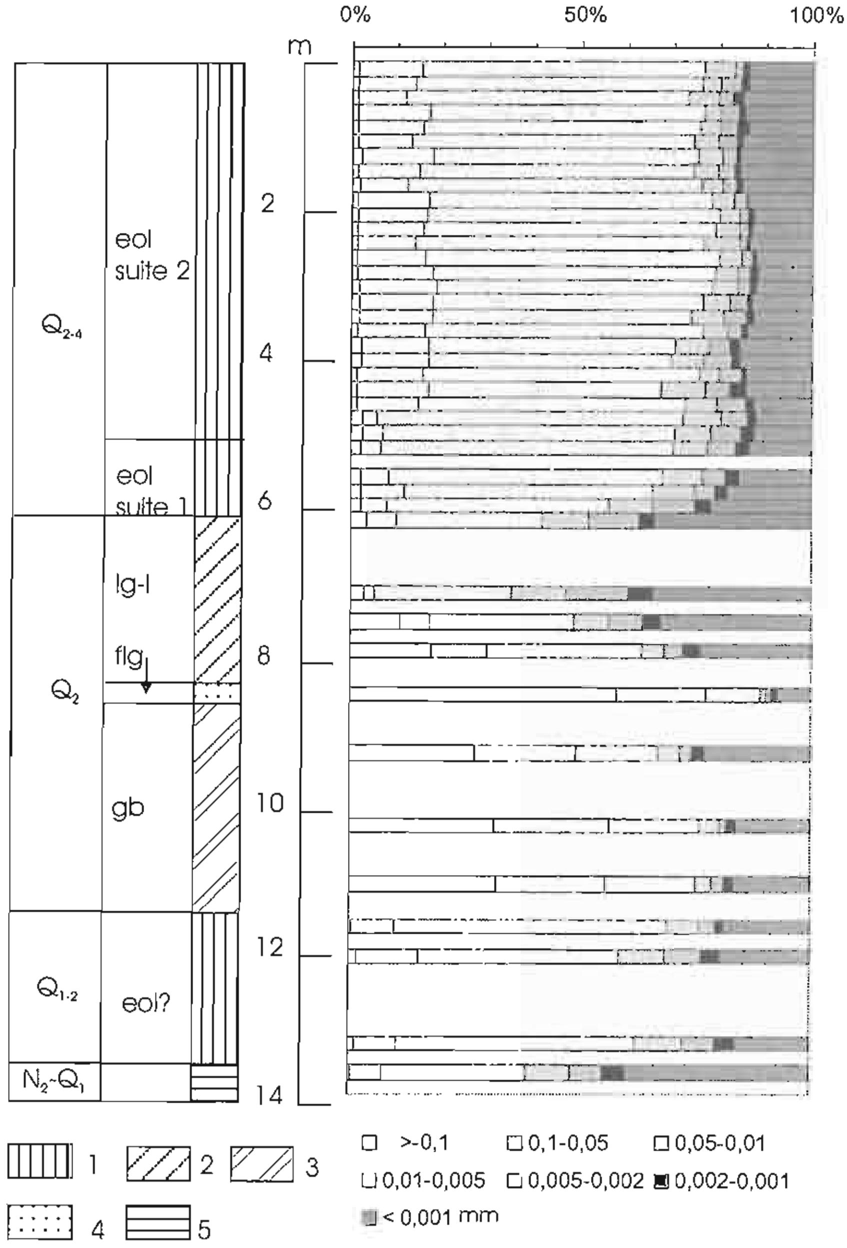

Fig. 4. The exposure Staiky 2: stratigraphy and lithology with granulometric diagram

1 — silts, 2 — clays and silts, 3 — diamictite, 4 — sands, 5 — clays; eol — aeolian (locss), lg–l — glaciolacustrine and lacustrine, flg — glaciofluvial, gb — basal till; N_2–Q_1 — Upper Pliocene to Lower Pleistocene, Q_{1-2} — Lower to Middle Pleistocene, Q_2 — Middle Pleistocene, Q_{2-4} — Middle Pleistocene to Holocene

Bobrytsya and Rudka Rivers (Fig. 3). From this zone, a top of a till gently dips (1–2°) towards the north and the south-east. Its lowest position is about 128–135 m a.s.l. Within the gullies and river valleys, a postglacial complex overlies the preglacial and also the Paleogene–Neogene sediments. In general, deposits of the postglacial complex form continuous covers at watersheds (their slopes included) and patches within river valleys and gullies. In the first case their thickness is very stable (9–11 m), and in the second case it varies from several centimetres to 15–20 m. Postglacial deposits are totally scoured on steep flanks, inclination of which is more than 50–60°.

Field observations of exposures and analysis of borehole descriptions have indicated several typical sequences, which represent a cover at watersheds and plateau slopes, as well as valley deposition.

POSTGLACIAL COMPLEX AT WATERSHEDS

A most complete sequence of the watersheds was studied in the old open pit (exposure Staiky 2), found along a plateau escarpment to the Dnieper valley (Fig. 3; Pl. I, Fig. I). The highest part of the plateau in this very place (primary waters-

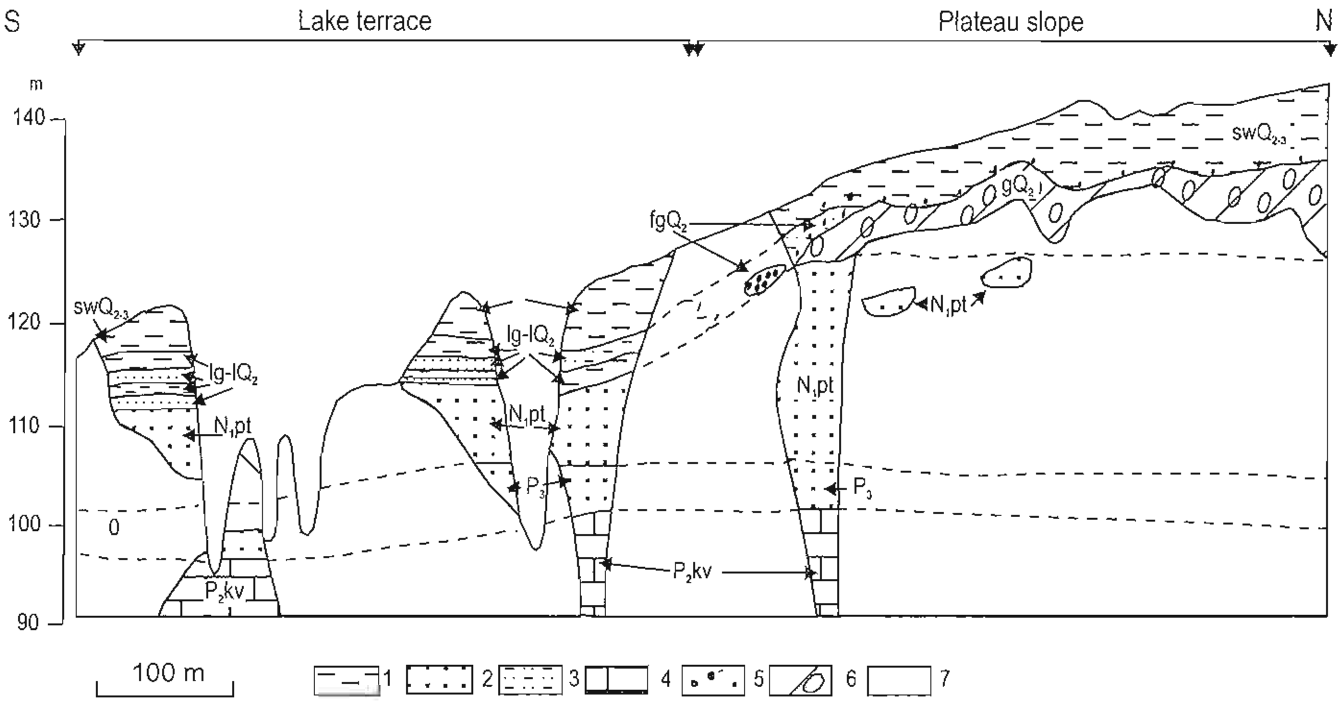

Fig. 5. The exposure Rzhischiv I

1 — silts, 2 — sands, 3 — interbedded sands and silts, 4 — marls, 5 — coarse deposits (gravel, pebbles, boulders), 6 — diamictite, 7 — talus; g — till, fg — glaciofluvial, lg–l — glaciolacustrine and lacustrine, sw — slope wash; P_2 — Eocene, kv — Kyiv Suite, P_3 — Oligocene, N_1 — Miocene, pt — Poltava Suite, Q_2 — Middle Pleistocene, Q_{2-3} — Middle Pleistocene to Upper Pleistocene

hed) has been eroded. The postglacial complex begins there with a transition horizon of light grey horizontally laminated silt, which covers glaciofluvial sand and a till. At the base, there are micro-deformations and it is alternated with fine-grained, poorly sorted sand. The silt becomes more homogenous upwards and a content of clay increases to the middle of the horizon and then gradually decreases (Fig. 4). Thick buried subsoil, from dark grey to black, is located at top of the silts. It occurs in most studied exposures but usually it is thinner (less than 1 m), and the buried soil is not so pronounced or it is absent. According to the author, this silt horizon reflects a transition from a glaciolacustrine deposition to dead ice conditions of a residual lake.

The sequence of a light grey silt grades upwards into a pale yellow carbonate one which continues without breaks right up to the recent surface, i.e. forms a single suite. A bright reddish-brown horizon B (subsoil) of the buried soil and its light yellow horizon C (weathered deposits) are distinguished sharply at a sole of this silt. This soil hides a junction with the previous silt horizon. Three-four feebly marked layers of embryonic buried soils may be observed in the interval 2.5–4.2 m from a recent surface in some parts of the exposure. Their thickness is about 10–15 cm. Small mollusc shells are common, both of superficial and freshwater species, and occur throughout the postglacial complex. However, specific determinations of molluscs (M. F. Veklitch, 1968) do not help to classify a sedimentary environment.

According to the diagram (Fig. 4), the pale yellow silt is different from all the other silt deposits in this region by its granulometric stability along a vertical section. A content of the fraction 0.05–0.1 mm substantially exceeds contents of all other fractions, varying from 40 to 50%. At the same time, a granulometric spectrum of the lower part of the layer has several distinct peculiarities (minimum content of sand and maximum of clay) which are the evidence to discern the separate lower suite.

A lot of exposures repeat a general outline of the cited sequence. The pale yellow silt is a widespread postglacial deposit on the plateau. Its thickness varies in a very short diapason (from 5 to 7 m) and there is no lamination. In some places, this silt rests on thin layers of slope wash or cryogenic deposits, represented by a coarse non-sorted material, or directly on a till. Vertical jointing is manifested on walls of pale yellow silt, especially on southerly or westerly facing exposures.

R. P. Bukatchuk (1992) convincingly argued previously that the mentioned above properties are characteristic for a typical loess sediment of aeolian origin. The latter occur in the Middle Dnieper area on the plateau and the preglacial Dnieper terraces as subhorizontal blankets. He also added that in some cases only detailed granulometric, microstructural and mineralogic analyses of loess allowed to determine its sedimentary and post-sedimentary properties, as well as to distinguish it from similar sediments. Sedimentary properties included: predominance of a silt fraction, stable relationship

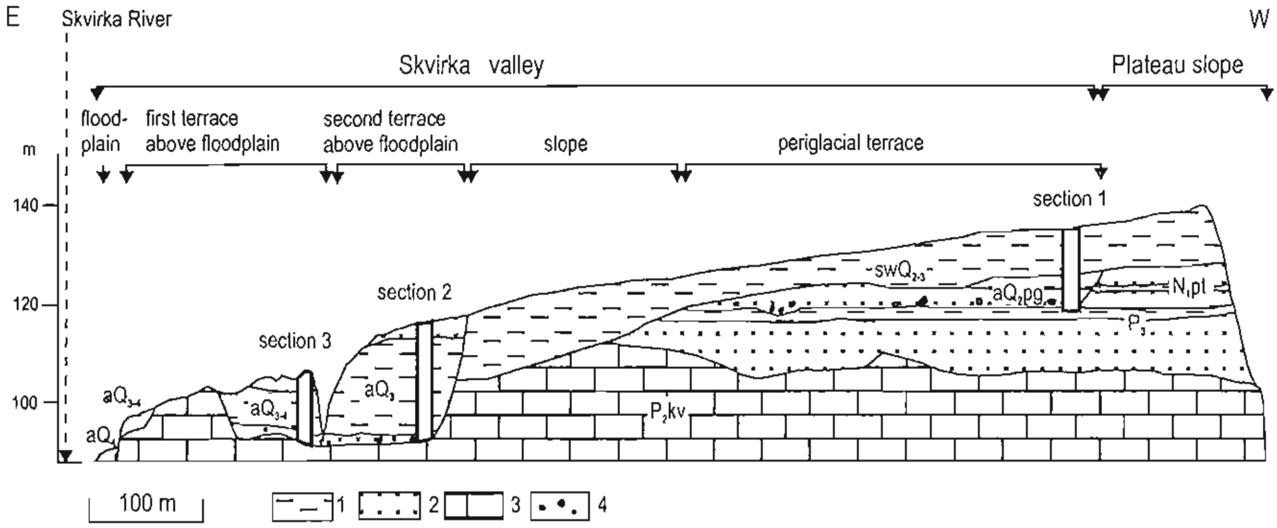

Fig. 6. The exposure Khalepya 1

1 — silts, 2 — sands, 3 – marls, 4 — gravel, pebbles, boulders; a — alluvium, pg — periglacial, sw — slope wash; P_2 — Eocene, kv — Kyiv Suite, P_3 — Oligocene, N_1 — Miocene, Q_2 — Middle Pleistocene, Q_3 — Upper Pleistocene, Q_{3-4} — Upper Pleistocene to Holocene

of sand and silt fractions, as well as minerals in the profile (with the exception of contact zones) and fragmentary microlamination. The post-sedimentary micro-characteristics include a high carbonate content, presence of micro-carbonate concretions and a granular-aggregate microstructure. These properties and yellow colour (different tints are possible), absence of lamination visible with a naked eye, vertical jointing and carbonate formations of different type (they are depicted and classified in detail by Y. G. Chugunny, 1970) are a result of syn- and post-sedimentary diagenesis, mainly a soil formation.

To rely on the results of the present investigation and also on the materials received from the different localities of the Middle Dnieper area (R. P. Bukatchuk, 1992), burried soils only in separate cases coincide with the uncomformities and breaks in the post-glacial complex. Formerly V. G. Bondarchuk (1969) noted that the deposition was continuous throughout soil development. Soil horizons are distinguished above all by their colour, the larger microaggregates, absence of microlamination, significant increase of the clay fraction and decrease of the carbonate content. These properties result from diagegetic (hypergenetic) changes while the remaining lithological features do not differ from htose of the sequence as a whole.

POSTGLACIAL COMPLEX ON THE SLOPES

Another large group of exposures is associated with plateau slopes. Their sequences are more diversified than the previous oncs. A rare case of transition from the loess sequence at a watershed to a slope wash sequence can be observed (Pl. I, Fig. 2). To the left, the till bed truncates and wedges out. In the same place the silt bed divides into two main members, that is underlined by one and then, by two buried soils appearing downslope. The lower member (lacustrine deposits) is light grey and light yellow, and the upper one (slope wash) is dark yellow. In some fragments of the exposure horizontal thin uniform lamination is manifested. It is more visible at the erosional contact between the silt and the till. However, in most of cases, in a slope wash at the upper part of slopes there are no sedimentary structures visible with a naked eye. Therefore, it resembles much the loess at the watersheds. Its top dips at a smaller angle than a sole so as a whole, slope wash blankets fill partially the depressions in a glacial (preglacial) landscape and they are thicker.

The latter is especially represented in the exposure Vitachiv. It is located in the upper part of a wide preglacial balka (local name of a wide ancient gully) slope, which is cut by a scarp of the Dnieper valley native flank (Fig. 3). The postglacial bed consists of two main members similar to the previous ones but thicker (to 9.5 m) and more clayey, especially the lower member. Several buried soils throughout the section are also thicker. Their structure and types, as well as the buried soils of the exposure Staiky 2 are cited in the work of M. F. Veklitch (1968).

In the upper yellow member (slope wash suite), there is a distinct lamination which is underlined by a series of initial buried soils, and dipping till and silt, concordant with a general gentle inclination of a slope. The lower uniform grey lacustrine suite has a thin layer (2–7 cm) of carbonate material (predominantly shell detritus) at its top. The light yellow finely laminated silt layer with single sand and gravel grains at the sole, separates the grey member from a till in the northern part of the exposure. It should be noted that there are no erosional contacts between the silt members. Towards the balka talweg, a thickness of the till and of the postglacial complex is twice smaller, a number of soils increase and the thickest of them splits into two. There are no traces of a noticeable postglacial runoff at the deepest part of this old balka.

A postglacial blanket of the middle and lower part of the plateau slopes is scrutinised in the exposures Rzhischiv 1 and Khalepya 1 (Fig. 3). In the northern part of the exposure Rzhischiv 1 (Fig. 5), a sole of a till occurs approximately at 125 m a.s.l. Further to the south, a till is scoured and boulders rest at a base of meltwater deposits. Below 120 m a.s.l. a complex unit of sands and silts (Pl. I, Fig. 3), enriched in organic matter replaces a glacial complex. This unit is interpreted as a glaciolacustrine-lacustrine sequence, non-stratified in certain genetic types. It is reflected in modern relief as a lake terrace.

In contrast to the previous exposures, a top of glacial deposits is more irregular and with clear traces of erosion. Pale yellow slope wash deposits are separated from a till by a contact layer, 5–30 cm thick, composed of poorly sorted sands, gravel, fine pebble and carbonate concretions. A thin lamination is outlined locally. The slope wash suite is from 3 to 12 m thick and its base occurs at 118–138 m a.s.l. In many places the lamination, dipping parallel to a slope, is pronounced and initial buried soils are rare. At the same time, a distinct layer of thick buried soil at the base of the slope wash unit is observed in the exposure (Fig. 5; Pl. I, Fig. 3). It includes a bright reddish-brown horizon B and a light grey horizon C, penetrating locally into glacial deposits. A double buried soil or a soil suite is at the lower part of the exposure in the same stratigraphic position.

The exposure Khalepya 1 (Fig. 6) presents some important differences from the exposure Rzhischiv 1. There are no glacial deposits at the base of the slope wash suite. The latter forms a single pale yellow or greyish-yellow blanket on the Paleogene–Neogene rocks and on a periglacial alluvium. Its base descends from 128 to 105 m a.s.l. The slope wash suite is 6–14 m thick. The buried soils are absent within a slope wash unit. As a whole, this unit looks very uniform. Coarse bedding is observed in the exposure only occasionally at a large distance. The diagram, compiling materials of the section 1 (Fig. 7, see location in Fig. 6) demonstrates a clear upward trend in the granulometric composition of the slope wash. A decreasing content of sand (except the upper 2 m) and clay, and an increasing content of silt express it. Thus, sorting of the slope wash increases upwards. There are also several peaks of a sand fraction. It is astonishing that despite a striking difference between the diagram patterns of loess (compare with Fig. 4) and slope wash, the average meaning of their granulometric spectrum is almost identical (Fig. 8).

POSTGLACIAL COMPLEX OF THE VALLEYS

A postglacial complex of the valleys combines alluvia and restricted areas of slope wash, aeolian and slump deposits. In comparison with the alluvial history of the Dnieper valley, already explored by several generations of researchers, an alluvial record of a local drainage network has been only scantily studied. And as to the Staiky Plateau, alluvia of the local river valleys have been hitherto unknown. In the most cases their sequences are submerged but after creation of the

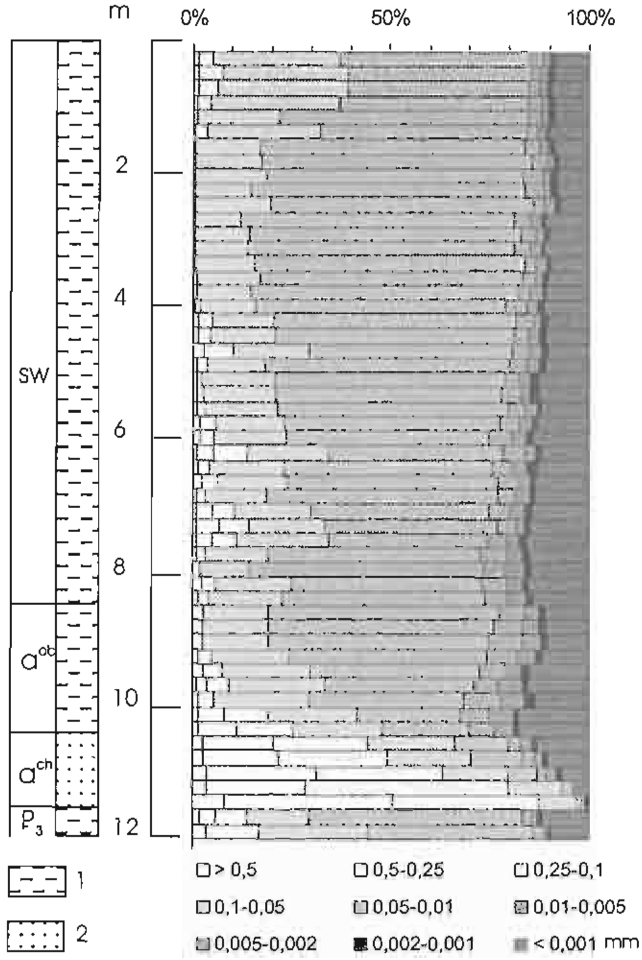

Fig. 7. The exposure Khalepya 1 (section 1): stratigraphy and lithology with granulometric diagram

1 — silts, 2 — sands; P3 — Oligocene; alluvial: a^{ch} — channel facies, a^{ob} — overbank facies; sw — slope wash

Kanivs'ke Reservoir, a series of long alluvial sequences have been exposed along its coast to the south from the town Ukrainka.

Alluvial suites and their groups occur as whole fill-in-fill accumulative bodies at least at four different hypsometric levels, reflected in a modern relief by corresponding terraces. Geomorphologic observation at heads of the gullies, inherited after glacial (preglacial) balkas, has shown that there could be more than four terraces. A probable explanation of this fact is that some of the terraces are of purely erosional origin.

The uppermost level of the postglacial alluvial accumulation is associated with the so-called periglacial suite. For the last time, it was known only in the Dnieper valley and some valleys of its tributaries (G. I. Goretsky, 1970; A. V. Matoshko, Y. G. Chugunny, 1993; A. V. Matoshko, 1996). In the exposure Khalepya 1 (Fig. 6), a periglacial alluvium is incised into the Neogene sands of the Poltava Suite, resting on silts of the Kharkov Suite of the Oligocene (117.5–119 m a.s.l.). It

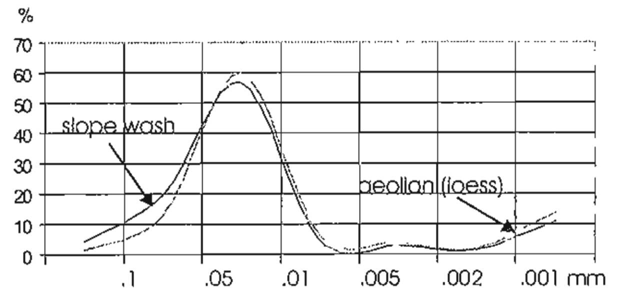

Fig. 8. Mean cumulative curves of granulometric composition of aeolian (loess) and slope wash deposits

is overlapped by the slope wash silts, which cut off the alluvium easterly.

The periglacial suite comprises three members (Figs. 6, 7): a basal layer (5–120 cm thick), channel deposits (2.0–2.5 m thick) and overbank deposits at the top (1.2 m thick). Basal deposits are represented by lenses of coarse and gravel sand, chains of pebbles and boulders, including medium ones. The coarse material is of the erratic glacial origin; its content reaches a maximum among all other alluvial suites in the Middle Dnieper area. Bones of large mammals were discovered in this basal horizon. Some of them were determined as bones of the lower extremities and big cranium fragment of the woolly rhinoceros (*Coelodonta antiquitatis*). The channel alluvium consists of sands with poor cross-lamination. They grade upwards into silts of overbank facies. The overbank deposits are distinguished in the diagram by a high percentage of silt and clay, and also by a striking upward decrease of clay and sand.

Geomorphologic analysis indicated that the periglacial alluvial suite is reflected in the present landscape as a terrace with a gently sloping surface at 135–160 m a.s.l. in the Staiky Plateau (Fig. 3). It turned out that its surface serves commonly as a base level of the erosion for the upper parts of the plateau slopes. Fans of the youngest slope gullies are frequently located in a vicinity of the terrace joint.

A middle level of alluvial accumulation is represented by several sections of the Krasna, Bobrytsya and Skvirka River valleys. Alluvial deposits of these sections possess an erosional contact with the Eocene marls. Their base is at 93–102 m a.s.l. All the alluvial suites of the middle level begin from a basal horizon, represented by poorly sorted coarse-grained sands, mixed in places with fragmented marls, single pebbles and rare small boulders. There are also raddle lenses. The basal horizon is usually 20–60 cm thick reaching occasionally to 2–3 m. Due to water saturation; it is distinguished in some sections by a dark colour if compared with neighbouring layers.

The rest stratum of the alluvial suites of the middle level is predominated by light yellow and greyish-yellow silts. In the granulometric diagram (exposure Khalepya I, sampling section 2) there are two superimposed alluvial suites (Figs. 6, 9), in total about 17 m thick. The lower suite comprises the basal, channel and overbank facies. The channel facies gets finer upwards and grades into the overbank facies, broken at the top with a sharp contact. A thin basal layer of the next suite overlies it. Alluvial deposits above the basal layer indicate unstable granulometric composition and lack of sedimentary structures. Their connection with a definite facies could not be determined.

Two suites create also the alluvial bed in the exposure Trypillya 3 (Bobrytsya River valley). They are both represented predominantly by the horizontally laminated coarse-grained silts and fine-grained sands. The lamina is on the average 5–10 cm thick. The upper suite is divided distinctly into two members: a more sandy lower one and a more silty upper one. A total thickness of the alluvial bed truncates towards a native slope of the valley from 17 to 23 m. The basal horizon in the exposure Trypillya 1 (Krasna River valley) is overlain by a fining-upwards sequence of the monotonous overbank silts, presumably graded to a slope wash.

The alluvial suites of the middle level form the second terraces above a floodplain. Usually they stretch along the valleys as narrow and short segments. Only at the river mouth, their width increases to tens–several hundred metres. In contrast to the periglacial terraces, the second terraces have undulating surfaces, dissected locally by young gullies.

The lower level of the alluvial accumulation is studied in the Skvirka River valley only (exposure Khalepya 1, sampling section 3). General geologic position of this section and its granulometric diagram are presented (Figs. 6, 10). The sequence consists of a single suite with distinct basal and upper overbank facies. The basal horizon occurs at the same level as in the middle level. The maximum thickness (up to 3 m), increased content of clay and silt, and decreased content of coarse material distinguish it among the other alluvial suites. In the upper member there is a coarsening-upwards sequence, unusual for the overbank facies, represented by silts which pass in the uppermost part into fine-grained sands. This suite is reflected in a recent relief by the first terrace above a floodplain (98–104 m a.s.l.). There are peculiarities in its occurrence, similar to the second terrace but it occupies a smaller area.

The Holocene alluvial deposits of the channel and the overbank facies correspond to the present level of accumulation but there are no reliable data on their internal structure and features. They occupy narrow streaks within river valleys, composed of poorly sorted predominantly fine-grained sands and silts, with a thick layer of a hydromorphic soil within a floodplain. In the exposure Khalepya 1, a top of the Holocene alluvial deposits is located 6–13 m beneath a surface of the first terrace.

On the first and the second terraces above a floodplain within the Khalepya 1 exposure, there are yellow aeolian sands (Figs. 6, 9, 10). In the first case they form a sheet, 5 m thick, and in the second case — a pronounced small dune, about 2.0–2.5 m high. The aeolian deposits rest on alluvia without any sharp contact. Within the second terrace, they are represented by medium- to fine-grained sands, and dune sands are predominated by a fine fraction. In both cases the aeolian sands are distinguished by the best sorting and the lowest content of clay among all the sandy deposits in the region. Judging to the results of the geomorphologic analysis, the aeolian sandy deposits are rare in the Staiky Plateau and are located at river mouths where a valley becomes wider.

Young slope wash silts spread locally at the foot of relatively steep flanks of gullies and valleys, usually below 130–150 m a.s.l. They form isolated small accumulative bodies like aprons fans and tongues. These deposits are distinguished from their older analogues by small thickness (less than 1.0–1.5 m), lighter yellow colour, coarser composition, distinct irregular lamination dipping downslope, higher content of humic matter, presence of inclusions and rolls of the underlying sediments, and plant fossils.

Slump deposits occur locally too. Most of them are probably quite recent and they are associated with a plateau scarp of the Kanivs'ke Reservoir. As a rule, the Quaternary strata slides over the surface of the reddish-brown clays. There are two main types of slides, i.e. slumps and flow slides. The slide bodies are usually several metres thick but in some places they form many-tier structure, projecting from a top of the scarp to the water level in the reservoir. An internal structure of the slumps is characterised by a combination of blocks with a primary layer succession, deformed blocks and mixtures of different composition.

Thus, all these sedimentary bodies of different genetic types and age occupy definite spatial positions in the postglacial complex. A mode of occurrence and relation to index horizons, as well as a modern hypsometric location are the main criteria for a correlation of the suites. The suites of different genetic derivation represent a different granulometric profile, in principle even if their composition is similar. The suites of the same genetic types but of different topological position have pronounced individual micro-features. In particular, the alluvial suites are identified by combination and relationship of dynamic lithofacies (basal, channel, overbank), by peculiarities and vertical changes of their granulometric composition.

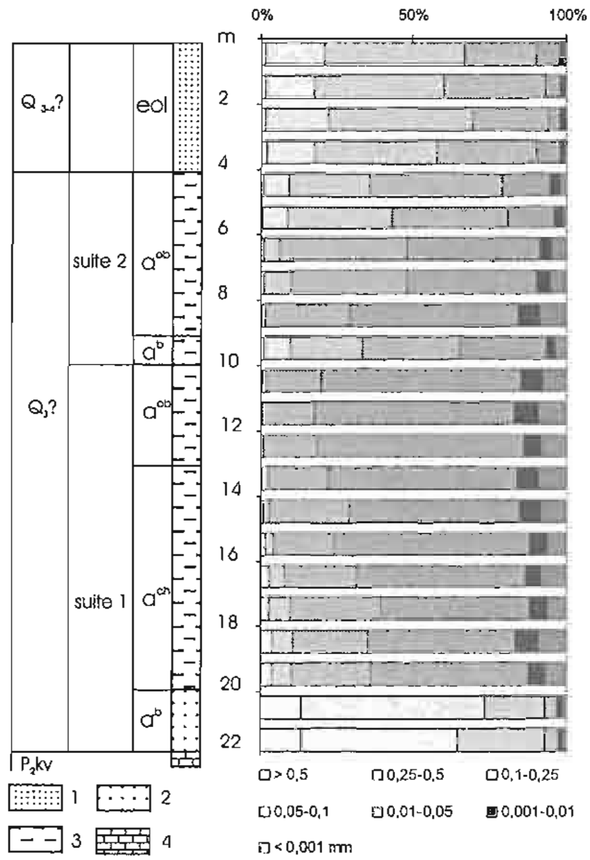

Fig. 9. The exposure Khalepya 1 (section 2): stratigraphy and lithology with granulometric diagram

1 — fine-grained sands, 2 — medium- and fine-grained sands, 3 — silts, 4 — marls; P_2 — Eocene, kv — Kyiv Suite, Q_3 — Upper Pleistocene, Q_{3-4} — Upper Pleistocene to Holocene; alluvial: a^b — basal facies, a^{ch} — channel facies, a^{ob} — overbank facies; eol — aeolian

INTERPRETATION

A reconstruction of a sedimentary environment should present transport and accumulation processes, their mode, direction, velocity, parent area of clastic material, material balance in a region, as well as endogenic and exogenic factors. Results of the cited geologic studies of the Staiky Plateau allow to answer some of these questions and to approach to a rest of them.

TERMINATION OF THE DNIEPER GLACIATION

The second stagnation phase of the Dnieper ice stream was characterised by contemporary glacial and non-glacial sedimentation within a glaciated area (A. V. Matoshko, Y. G. Chugunny, 1993). The most elevated areas, including the territory of the Staiky Plateau, were the first ice-free. At the same time, dead ice blocks were still preserved in the Dnieper valley and in the other main valleys. Numerous shallow lakes occurred on the plateau in local depressions in a till and at contact with dead ice. Stagnant hydrodynamic environment existed in most of them whereas some lakes, especially on plateau slopes, formed the first postglacial runoff system, connected with a real proglacial runoff in ice-contact zones. Existence of lakes was extremely short due to well-developed geomorphologic drainage conditions on the plateau. On the other hand, a till does not form an impermeable layer and the lakes have disappeared after a drop of a groundwater level.

The lakes were filled with lake deposits, typical for their fining-upwards sequences. A clastic material was derived from adjoining areas at the expense of the washout till and meltwater deposits. During a final stage, the lake deposits were enriched in organic matter. Together with a till they form a substrate for the thickest soils in the postglacial strata. A regional break had appeared after the lake deposition. As a whole, a plateau relief at the end of the Dnieper Glaciation was smoothed but its slopes were subjected to erosion.

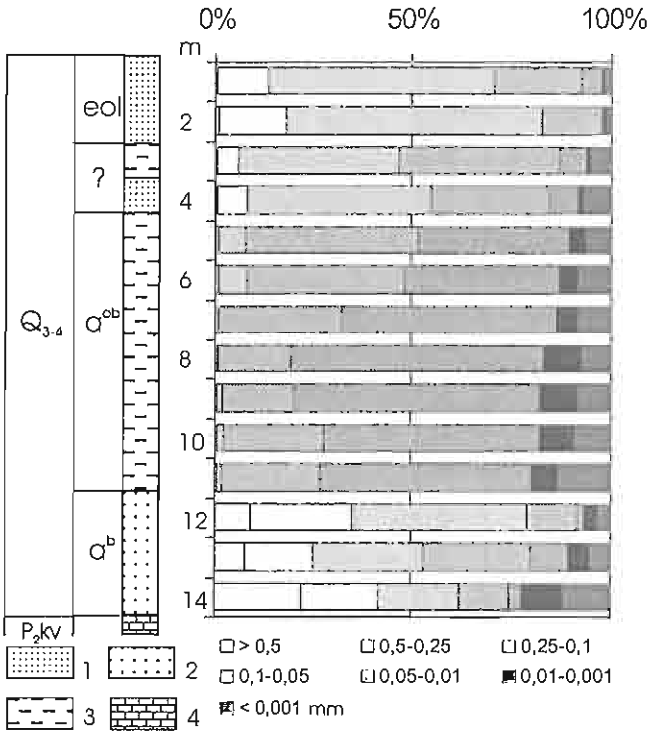

Fig. 10. The exposure Khalepya 1 (section 3): stratigraphy and lithology with granulometric diagram

1 — fine-grained sands, 2 — medium- and fine-grained sands, 3 — silts, 4 — marls; P_2 — Eocene, kv — Kyiv Suite, Q_{3-4} — Upper Pleistocene to Holocene; alluvial: a^b – basal facies, a^{ob} — overbank facies; eol — aeolian

POSTGLACIAL

A lower boundary of the postglacial stage is estimated for 210–260 ka BP (Middle Pleistocene), as generalised by A. V. Matoshko and Y. G. Chugunny (1993). Its beginning is fixed by a sharp change in a sedimentary environment and its differentiation within the plateau itself, plateau slopes and plateau valleys. Features of the loess suite structure indicate that aeolian deposition of silty material continued uninterruptedly during a postglacial time, uniformly during each of the two stages which are recorded by corresponding suites (Fig. 11) until the present. The loess has been deposited very slowly, i.e. in millimetres per year. A progressive aggradation of the plateau is a geomorphologic result of loess deposition.

Derivation and way of transport of the aeolian material are not clear enough. This problem can be partially explained by a mineralogic study. According to the data of V. I. Melnick (1961) and A. V. Matoshko (1995), a till of the Dnieper Glaciation contains transit and far-transported exotic components. In comparison to the preglacial deposits, there is a reduced content of the accessory minerals such as ilmenite-leucoxene, zircon, rutile, and disthene. Amphibole, garnet and pyroxene occur in a till but are absent or rare in the underlying sediments. R. P. Bukatchuk (1992) established a glacial mineral assemblage in the loess above a till, and this conclusion is confirmed by results of the present heavy mineral analysis (exposure Staiky 2), slope wash and alluvium of the periglaeial suite (exposure Khalepya 1). All these deposits contain a glacial mineral assemblage, without any substantial ehange upwards the section. Thus, the aeolian material was locally derived, and the glaciated Middle Dnieper region or at least a part of it, must have been a source area.

According to the authors opinion, the aeolian aecumulation occurred throughout the plateau, including its slopes. However on the latter, erosion was the predominant process. A slope wash has been initiated at the end of the Dnieper Glaciation upslope and then moved downslope, following the incision of gullies and valleys right up to the incision of the second stage (see below). Long (up to several kilometres) tongues developed, being eonfluent in vast apron downslope, and creating the first postglacial slope wash suite (Fig. 3). At first, they filled depressions in a glacial landscape and mantled the periglacial terrace. The slopes assumed a concavo-convex shape and a longitudinal profile was very close to the equilibrium one. In the most cases, however, there was no classical profile of a slope, i.e. erosional in the upper and the middle parts, and the accumulative the lower one. A solid loess cover on watersheds was replaced by a solid slope wash cover on plateau slopes, except for the rare outcrops of the more ancient sediments.

Grain size of a slope wash (Fig. 7) and loess demonstrates very stable conditions during deposition. Therefore they were not directly associated with scour and fill stages in gullies and valleys (Fig. 11). Similar granulometric and mineral composition of the loess and the slope wash indicates that glacial deposits and aeolian silt were derived by sheetflood erosion. But eventually a role of the first source has been slackened off, because of a slope wash recovering the glacial complex and more ancient sediments, including those with a high content of sand and clay. It is expressed by an increased washout of clay, a content of which gradually diminishes

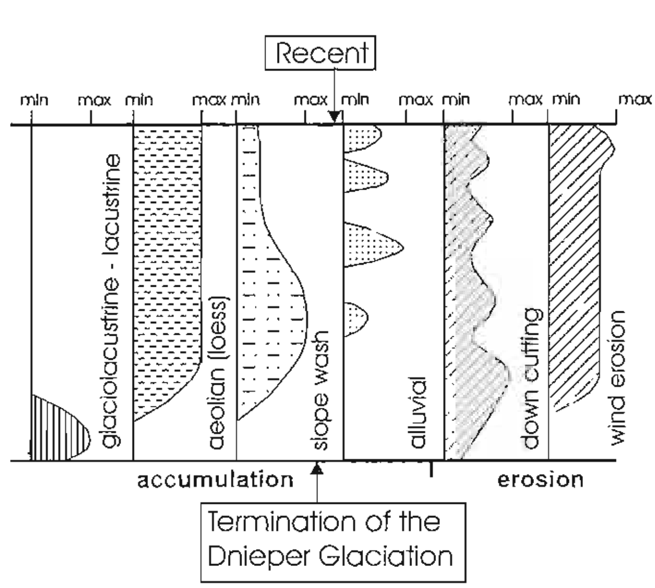

Fig. 11. Intensity of different types of accumulation and erosion after the Dnieper Glaciation

upward (Fig. 7). Flashes of aeolian activity can explain small peaks of sand contents, increasing in the same diagram. These flashes had influenced only a deflation of sand, whereas conditions of silt transport and deposition remained relatively permanent. Probably the first older slope wash suite was two-three times as large as the loess suite.

Evolution of the plateau valley is reflected by scour surfaces (lateral and floor), and by valley deposition. The four-stepped cross-section of the plateau valleys (in some places — more than four) has fixed the main corresponding phases of incision and scour (Fig. 11). There are presumably of different origin. As noted above, a runoff at the end of the Dnieper Glaciation concentrated on plateau slopes around dead ice blocks that occupied the preglacial valleys, and the runoff moved later there. But at that time, a base level of erosion has not been developed. There were numerous local base levels. So as a whole, washout and incision have developed locally downwards in very unstable conditions from the plateau upper slopes. Unfortunately, these traces are extremely rare.

At least when a base level had stabilised, the first postglacial floor surface began to develop. This first incision was not deep but a width of a periglacial valley reached to 700–900 m (Fig. 3). Judging from a coarse grain size composition of the basal and channel facies, and also from a small thickness of the periglacial suite, a river discharge was the largest among the postglacial streams, and a great amount of debris has been washed out. In a rough evaluation, it was more than a half volume of the total postglacial wastage of the Staiky Plateau.

After the periglacial stage, a substantial incision up to 25 m took place. For the first time after the Dnieper Glaciation, head erosion has begun to distribute over the plateau valleys. A down cutting was accompanied by formation of a new young slope wash suite on steep slopes of corresponding valleys and gullies. The valleys became highly narrower (100–300 m). This second stage of valley deposition was represented by progressive deposition of two superimposed alluvial suites and it was the maximum for the postglacial time. A floodplain deposition predominated whereas channel erosion played an insignificant role.

The third stage of valley development had the same depth of incision but a much smaller volume of the deposits. During this time, a valley became still narrower. There is, however, an incomplete information about the fourth stage, nevertheless if compared with the Dnieper River (G. I. Goretsky, 1970), its incision could be 17–19 m deep and the deposits 4–7 m thick. To interpret the evolution of a valley deposition, it should be taken into account that, owing to a lateral shift of the watercourse, the sequence of the basal and channel alluvium, no more than 3–5 m wide, could have been deposited during a single year only. At the same time, a progressive accretion of the overbank strata was possible only if a base level of erosion was uplifted. Thus, remained fragments of the alluvial suites are the momentary and casual prints of a fluvial record, and they could have lasted from several hundred to several thousand years.

During the fourth stage an intensified wind activity, accompanied by other favourable climatic conditions, stimulated the aeolian deposition on the first and the second terraces above a floodplain. The aeolian deposition of sands could have changed from several to 10–20 cm a year. A development of plateau valleys resulted in a stepped alluvial plane with four main terraces and two systems of erosional features, associated with base levels of the periglacial terrace and of the Dnieper River. They have been presumably caused by intermittent tectonic uplifting of the Middle Dnieper region since the end of the Middle Pleistocene (A. V. Matoshko, 1996).

Aeolian and fluvial processes were the basic ones during the postglacial sedimentogenesis. Therefore, climatic factors stimulated these processes and a sedimentary environment itself. There were three principle sedimentary zones with gradual transition between them (Fig. 3). The first zone is the proper plateau with stable aeolian loess deposition. The second zone are the plateau slopes, developed first due to sheet and local gully erosion, second due to prevailing accumulation (aeolian, slope wash). Predomination of down cutting, together with transit intermittent alluvial accumulation is typical for the third zone, i.e. plateau valleys. Clastic material was derived from the adjoining areas as well as from the Staiky Plateau. The Quaternary and pre-Quaternary sediments were subjected to erosion, products of which were transported to lower levels of the plateau and then, carried out along the plateau valleys to the Dnieper valley.

Many questions associated with a sedimentary environment of the Staiky Plateau are still disputable, and others have remained insufficiently examined. The most disputable question concerns dating of sediments and a detailed stratigraphic correlation of the sequences. The author foresees possible objections from stratigraphers and palaeogeographers in connection with a lack of any stratigraphic subdivision after the Dnieper Glaciation. It is a special task for a separate investigation. In any case, the presented sedimentologic model for different geomorphologic, tectonic and climatic conditions approaches us to understanding the main regularities of a continental sedimentogenesis during the Quaternary for the small geologic bodies and the small spans of a geologic time.

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OSADY PLEJSTOCEŃSKIE WYSOCZYZNY STAJKOWSKIEJ (WYŻYNA NADDNIEPRZAŃSKA, UKRAINA)

Streszczenie

Między badaniami sedymentologicznymi dużych plejstoceńskich okresów geologicznych oraz współczesnych środowisk sedymentacyjnych zaznacza się istotna rozbieżność, w szczególności dotycząca sekwencji kontynentalnych. Wypełnienie tej luki może ułatwić opracowanie modeli sedymentacji niewielkich czwartorzędowych ciał akumulacyjnych, o skali czasowej od 1 roku do 100 tysięcy lat.

Przedmiotem badań była Wysoczyzna Stajkowska, wchodząca w skład Wyżyny Naddnieprzańskiej na Ukrainie (fig. 1). Jej kształtowanie rozpoczęło się 210–250 ka BP i jest ona zbudowana głównie z osadów jeziornych, eolicznych (lessy i piaski), stokowych i aluwialnych (fig. 2–10; tabl. I). Tworzą one regularne kompleksy, złożone z sekwencji i zespołów sekwencji o określonej strukturze przestrzennej, stylu występowania, facjach i litologii, co umożliwia ich wzajemną korelację.

Stwierdzono trzy obszary różniące się charakterem osadów. Pierwszy z nich to właściwa wysoczyzna z lokalnymi nagromadzeniami osadów jeziornych oraz stabilnej akumulacji lessowej. Druga strefa obejmuje zbocza wysoczyzny, ukształtowane przez spływ powierzchniowy, a lokalnie — wąwozowy, oraz przewagę erozji (eolicznej i stokowej). Dominacja wcinania w połączeniu z niestałą akumulacją aluwialną to cechy charakterystyczne dla trzeciej strefy, w skład której wchodzą doliny w obrębie wysoczyzny. Materiał mineralny pochodził z samej Wysoczyzny Stajkowskiej oraz z obszarów sąsiednich. Osady czwartorzędu i jego podłoża podlegały erozji (fig. 11), a jej produkty były przenoszone na niżej położone obszary wysoczyzny i następnie transportowane dolinami do doliny Dniepru.

EXPLANATIONS OF PLATES

PLATE I

Fig. 1. The exposure Staiky 2: loess section underlain by glaciolacustrine-lacustrine deposits; buried soil suite with bright reddish-brown horizon B and several horizons C stands out against a background of the latter

Fig. 2. Khalepya 2. Quaternary sequence downwards: 1 — pale yellow loess grading into slope wash to the left (Q_{2-4}), 2 — light yellow and light grey lake deposits (Q_2), 3 — brown basal till truncating to the left (Q_2); reddish-brown clays (Upper Pliocene–Lower Pleistocene) are at the bottom

Fig. 3. Fragment of the exposure Rzhischiv 1. Pale yellow slope wash silts, 5–6 m thick (Q_{2-4}), underlain by the glaciolacustrine-lacustrine deposits (Q_2), up to 7.5 m thick, composed of yellow sands with coarse material at the lower boundary and dark grey horizontally laminated silts with high content of organic matter. Contact between slope wash and lake deposits is underlined by the buried soil with bright reddish brown horizon B and light grey horizon C

1

2

3

Andrei V. MATOSHKO — Sedimentary model of the Straiky loess plateau, Pridniprovs'ka Upland, Ukraine