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Correlation between the Quaternary continental sediments in North-eastern Bulgarra with the marine sediments in the Black Sea Shelf

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В. Шопов, Й. Евлогиев, Н. Попов — Корреляция между четвертичными континентальными отложениями Северо-Восточной Болгарии и морскими отложениями Черноморского шельфа. Северо-Весточная Болгария была экстрагляциальной областью в течение четвертичното периода. Активная эрозия и абразия эдесь считается связанной с плювиальными фазами ледниковывых эпох. Аллювиальные отложения террас T_0—T_6, накопившиеся при соответствующих гляциальных и стадиальных циклах, были первоисточником лёссового мелкозёма. Лёссовый аккумулят, образовавшийся при данном цикле, залегает на более древних терарсах и ступенях, которые были открыты для эоловой седиментации. Активную эоловую деятельность нужно связать с фазами дегляциации ледников. В Черноморской области отмечены эффекты пяти больших оледенений, соответствующих регрессиям моря, с начала четвертичного периода: дунавия, гюнца, минделя, риса и вюрма. Аллювиальная почва над седьмым лёссом свидетельствует, что в это время произошел перерыв в седиментации — регрессия гюнца-2. Аллювий над шестым лёссом соответствует минделской регресии, над пятым лёссом — регрессии риса-1, а над четвертым лёссом, может быть, соответвует регрессии риса-2. Аллювий над третьим лёссом (соответствующим оледенению W_1) соответствует посткарангатской регрессии, над вторым лёссом (W_2 — перерыву, с которым связано образование континентальных отложений нижнего новоэвксинского подъяруса, а аллювий над первым лёссом (W_3) — регрессии между верхнеплейстоценовыми и голоценовыми отложениями. Перерыв, при котором образовалась современная почва, вероятно, соответствует Фанагорийскоа регрессии.

Abstract. North-eastern Bulgaria was an extraglacial region during the Quaternary. The active erosion and abrasion in this region is connected with the pluvial facies of the glaciation epoch. The alluvial sediments in the terraces — To-T6, accumulated during the relevant glacial and stacial cycles were sources of fine grained loess. The loess accumulate from a given cycle lies over the older terraces and levels then denuded for eolian sedmentation. The active eolian activity has to be connected with the deglaciation phases of the glaciers. From the beginning of the Quaternary the effects of five big glaciations corresponding to the regressions of the sea are marked in the Black Sea region. These are: Dunavium, Günz, Mindel, Riss and Würm. The alluvial soil on the seventh loess reveals that there has been a break in sedimentation — the regression of Cünz 2. The alluvium of sixth loess — the Mindel regression, that of fifth loess — the regression of Riss 1 and the alluvium of fourth loess — maybe the regression of Riss 2. The alluvium of third loess (corresponding to the glaciation (W1) — the Post-Karangatian regresssion, this of second loess (W2) — the break which caused the deposition of continental sediments over the Lower New Euxinian Substage and this on first loess (W3) — the regression between the Upper Pleistocene and Holocene sediments. The break, in recent soil time, probably corresponds to the Fanagorian regression.

Introduation

The Quaternary comprises the youngest geohistorical events in the evolution of our planet. It is significantly shorter than the preceding periods but is nevertheless rich on various geological events and processes.

The proposed by Никифорова et al. (1984) chronostratigraphic scale of the Quaternary, based on a comparison of the radiation curve for latitude 65° in both hemispheres with the isotope-oxygen curves of Shackleton, Opdyk (1973, 1976, 1977) reveals good coincidence within the boundaries of Pleistocene. According to the recommendations of the 27th International Geological Congress in Moscow and under the assumption that the boundary Neogene-Quaternary is in the base of the Calabrian and its stratigraphical analogies, the chronostratigraphical subdivision of Pleistocene has the following form: Early Pleistocene including also Eopleistocene (1.64-0.37 million years), which includes Dunavium, Dunavium-Günz and Günz; Middle Pleistocene (0.37-0.13 million years), including Günz-Mindel, Mindel, Mindel-Riss and Riss; and Late Pleistocene (0.13-0.10 million years) to which Riss-Würm and Würm belong (fig. 3).

Correlations

The active erosion in North-eastern Bulgaria is connected with the pluvial phases of the glaciation epochs characteristic with high water rivers and falling level of the Black Sea due to blocking of water masses in the glaciers. The land in the whole territory was lifted as result of the glacial isostasy.

The alluvial and eolian sedimentation was widely developed in the extraglacial zones. During the Quaternary the Danube lowland represented an extraglacial region where according to the changes in climate strictly consequent processes took place — erosion (terrace formation), alluvial sedimentation, active eolian activity, soil formation. As result of all these processes a spectrum of river terraces and abrasion levels was formed in North-eastern Bulgaria. The latter are of stratigraphical importance for the Quaternary and represent stages of evolution of the Danube lowland (fig. 2).

In the end of Pliocene and the beginning of Pleistocene (1.64 million years) the existing glacial covers in the polar regions started to grow gradually as result of the lowering of temperature and coming of the Dunavium. Up to the Günz the glaciers occupied only the high parts of the mountains and the polar regions were out of the range of the contemporary continents. The scientists nominate this period as "non-glacial" due to the absence of glacier cover on the continents in the beginning of Pleistocene (1.64-0.88 million years). The cyclic changes in climate during the "glacial" Pleistocene (0.88-0,10 million years) have a clearly expressed rhythmic character.

The following erosion surfaces are of stratigraphical importance in North-eastern Bulgaria — erosion surface formed by the Biber (2.5 million years), erosion surface of the Günz (0.87 million years), which lies below the loess complex on the Quaternary abrasion-accumulation level (QAAL), erosion levels which form the footing of the river terraces and correspond to the glaciations of Günz 2 to Würm 3. Each erosion level marks the beginning of alluvial sedimentation. Lithostratigraphically significant are the denudation and erosion levels, the alluvial and eolian sediments and the soils. Based on paleomagmatical investigations and paleontological occurrences a stratigraphical scheme of the Quaternary system in North-eastern Bulgaria was developed (Дончев et al., 1985) (fig. 3).

By determination of the position of the boundary Neogene-Quaternary in North-eastern Bulgaria one has to consider the paleomorphological form he is currently standing on. According to the recommendations of the 27th International Geological Con-

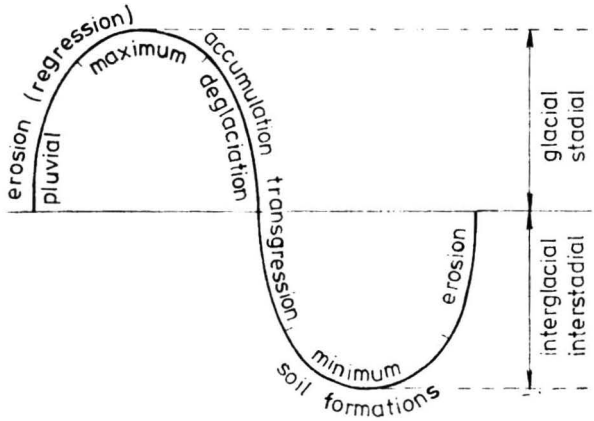

Fig. 1. Curve of the erosion and accumulative processes

gress the boundary Neogene-Quaternary on a Pliocene denudation level (PDL) has to be observed in the red clays under the loes (terra rosa) which were formed during the whole Vilifranchian. For the moment we do not dispose of any stratigraphical information to distinguish the Upper from the Lower Vilifranchian. The position of the boundary Neogene-Quaternary on the Quaternary abrasionaccumulation level (QAAL) has to be observed below the covering gravel-clayey complex (=Bjala Slatina Formation according to Коюмджиева, Попов, 1988) and more specific — in the upper (final) part of the basic gravel-sandy complex of St. Boncev. In the eastern regions, where this level is an abrasion one the boundary Neogene-Quaternary has to be observed in the polyfacial washing surface, developed on Middle Romanian and Sarmatian sediments.

In order to clarify the stratigraphy paleomagmatical investigations with sampling of sandstones and red clays from the gravel-clayey complex were carried out. The latter are of negative magnetic properties, characteristic for the magnetic epoch Matuyama (2.47-0.73 million years). Considering also the established fauna this interval is limited to the range 0.87-0.73 milion years. This pertinence together with the lithological characteristics of sediments allows us to refer them to the Günz glacial. The seventh loess horizon and the underlying red clays over QAAL are with negative magnetic polarity (Butchvarova, Evlogiev, 1994) and we connect its formation with the stacial Günz 2, while fs6, formed over it – with the interglacial Günz-Mindel. The boundary Bruness-Matuyama in the loess complex is situated between 17 and fs6.

The boundary Neogene-Quaternary within the range of terrace T6 is observed below the alluvium which lies over Dacian sandstones. In the other terraces — T5, T4, T3, T2, T1, T01, T0, the position of the boundary Neogene-Quaternary is determined by the erosion surface which has modelled their plinth in the Lower Cretaceous sediments and over which the alluvial sediments of these terraces occur.

The alluvial sediments of the terraces — To, To1, T1, T2, T3, T4, T5 and T6, accumulated during the relevant glacial and stacial cycles are initial source of fine grained loess at the time of their deposition. The loess accumulate originating from a given cycle of alluvial sedimentation lies over the older terraces and levels which were then denuded for eolian sedimentation (fig. 3).

The active eolian activity should be connected with the phases of regression (deglaciation) of glaciers, i. e. with the formation of the flood-plain bench alluvium of the terraces, which bears a large quantity of fine grained material suitable for eolian sedimentation (fig. 3).

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terraces, which bears a large quantity of fine grained material suirable for eolian blow off in the dry and windy seasons of the year. The forming of soils corresponds to the end of the active phase of alluvial sedimentation, i. e. to the phase of final retreat of the glacier. Over the alluvium alluvial soil was formed, which is not so well expressed by the soil of the relevant loess accumulate from the older relief forms. The relation between the erosion and accumulation processes and the climatic curve is as follows (fig. 1).

The number of regressions in the Black Sea and their depth depend on the number and extent of the Pleistocene glaciations. In this way the Black Sea determined the erosion basis of the Danube river and its affluents during the Quaternary.

From the beginning of the Quaternary the effects of five big glaciations corresponding to five regressions of the sea are marked in the Black Sea region. These are Dunavium, Günz, Mindel, Riss and Würm. The regressions of the Global Ocean and of the Mediterranean Sea (which starting from the Pliocene was connected with the Global Ocean) were in synchrony with the glaciations.

A little more complex in the question with the fluctuations of the Black Sea level. In the course of its Quaternary history five stages are marked. Their sediments and fauna reveal that the sea was then isolated from the Mediterranean Sea and was connected with the Caspian Sea. This connection lasted during the Eopleistocene, the whole Early, the beginning of the Middle and the end of the Late Pleistocene subepoch when Caspian influence on the Black Sea is observed. Vice versa, a significant Mediterranean influence is observed during the phases of transgression of the latter — i. e. in the second halfth of the Middle and the first halfth of the Late Pleistocene as well as in the Holocene epoch.

A number of local stratigraphical units based on brackish molluscs and ostracods were established in the Black Sea region on the basis of combined evolution-ecological principle. Some of them, especially those, separated by regression facies of the isolated marine basins have the character of regional stages.

The regional stages of the Quaternary System in the Black Sea region comprise the sediments formed during the long periods of geohistorical development of the region in the Quaternary. Due to the periodically broken connections of the Black Sea Basin with the adjacent basins at that time the stages differ in their haline water regime and in the deposition environment for their sediments. The changes in the complexes of molluscan fauna pertaining to the salinity of water together with the regional breaks (regressions) due to climatic events, delineate the boundaries of the stages. The regional stages of the Quaternary in the Black Sea region have no (and could not have) global isochronical boundaries.

The fact that during the Quaternary a periodical alteration of two types of basins — Caspian and Mediterranean took place in the Black Sea makes the subdivision of these sediments significantly easier and the alteration of two entirely different molluscan faunas — Caspian semisaline (brackish) and Mediterranean halophyllic molluscs presents an objective precondition the Black Sea regional stages to be characterized through specific biostratigraphical differences.

The Eopleistocene includes the sediments of the Ashperone Regional Stage and its stratigraphical correlations. The Ashperon is compared to the Calabrian Regional Stage in Italy and to the Upper Vilifranchian in Western Europe. The stratigraphical analogies of Ashperon in the Black Sea are the sediments of the Gurian Regional Stage. In other words, the Eopleistocene Series in the Ponto-Caspian region comprise the sediments from the lower most part of the Quaternary System, between the Dunavium and the Günz glaciations, i. e. between the internationally recommended by the 27th International Geological Congress and officially approved in the former Soviet Union lower boundary of the Quaternary System (Шопов, 1993) (fig. 3).

Sediments of the Gurian Regional Stage are not established with certainty in the Bulgarian Black Sea Shelf (Shopov, 1993; Шопов, 1993) although data of some Russian authors are available (Куприн et al., 1984; Григорьев et al., 1985).

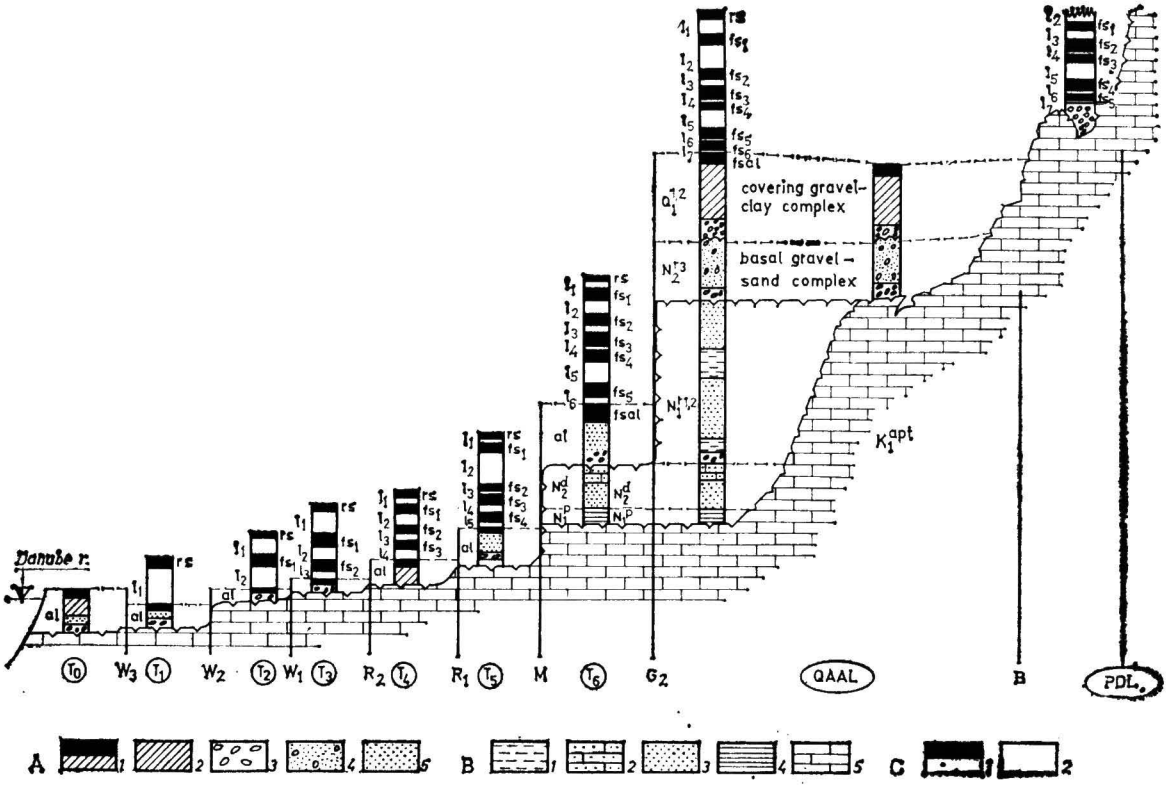

Fig. 2. General lithostratigraphical section of the paleogeomorphological forms in Danube-adjacent North-eastern Bulgaria (according to unpublished data of E v l o g i e v)
A — *marine and lake-river deposits:* *1* — fossil soil over alluvium (fsal); *2* — clays; *3* — gravels; *4* — pebble sands; *5* — sands. *B* — *marine and river deposits:* *1* — clays; *2* — sandstones; *3* — sands; *4* — sandy clays; *5* — limestones. C — *eolian deposits:* *1* — recent (rs) and fossil (fs) soil; loess horizons (l); TO-T5 — river terraces; QAAL — old Quaternary abrasion-accumulation level; PDL — Pliocene denudation level
Other designations: W — Würm; R — Riss; M — Mindel; G — Günz; Q_1^{1-2} — nonglacial Pleistocene (Dunavium, Dunavium-Günz) and part of the glacial Pleistocene (Günz 1, Günz 1 — Günz 2); Bi — Biber; N_1r^3 — Upper Romanian; N_1r^1, 2-Lower and Middle Romanian; N_2d — Dacian; N_2p — Pontian; K_1apt — Aptian

The mentioned authors found remnants of microfauna with Miocene age and also of Lower Pleistocene vegetation in sterile, what concerns the molluscan fauna, dark green clays and sands, lying below the shelly accumulations of the Upper Chaudinian Substage. The existing oblique and rather undetermined data on the age as well as the absence of molluscan fauna in the clays under no circumstances could be considered as proof for sediments of Gurian (Eopleistocene) Age in the Bulgarian shelf. As consequence the lower boundary of the Quaternary System in the Bulgarian Black Sea Shelf is considered to coincide with the situation of the officially approved in the former Soviet Union lower boundary, i, e. below the deposits of the Bakinian-Chaudinian Regional Stage.

According to literature data the sediments of the Gurian Regional Stage occur with a gradual transition below these of the Chaudinian. The erosion surface of T6 and the seventh loess horizon reveal that there has been a break in sedimentation at that time. We presume this is the still not proven regression (corresponding to Günz 2), which divides the Gurian from the Chaudinian deposits. Traces of such a regression,

which according to the regional scheme of Федоров (1978) has to separate with a washing the sediments of the Gurian from these of the Chaudinian Substage is not established in the Bulgarian shelf. Probably, due to this regression the sediments of the lower Chaudinian Substage were not deposited (Shopov, 1993; Шопов, 1993) (fig. 3).

The Pleistocene Series is divided into three subseries. The lower subseries comprises the sediments formed in the Günz-Mindel interglaciation time. In the Black Sea these are the sediments of the Chaudinian Regional Stage. In both closed basins (Caspian and Chernomorian) the sedimentation has been broken by the Mindel glaciation which caused a regression of the lake-marine basins. To the latter regression corresponds the Romanian (Mindel) regression of the Mediterranean Sea.

The Middle Pleistocene subseries comprises sediments formed during the Mindel-Riss inerglaciation time. The sediments of the Old Euxinian Regional Stage were deposited then in the Black Sea. During the short increasing of temperature (interstadial) between the first and second phase of the Riss glaciation in the Black Sea the sediments of the Uzunlarian Regional Stage were deposited. The second Riss stadial causes an overall regression in the Mediterranean Sea basin and in the Ponto-Caspian region during which the base of the Bosphorian Strait is deepened to 100 m.

Only the presence of the Upper Euxinian-Uzunlarian "subhorizon" of Федоров (1978) is established in the Bulgarian shelf. Probably the effects of the two regressions caused by the Mindel and the first phase of the Riss glaciation have imposed over each other and therefore the relevant stratigraphical hiatus should coincide with the early Euxinian-Uzunlarian Subage.

For that reason we consider that the alluvium of terrace T5 from which sixth loess horizon is formed corresponds to the Mindel regression, this of T4 and fifth loess — to the regression of Riss-1 and the alluvium of terrace T3 and fourth loess — maybe to the regression of Riss-2 (fig. 3).

The Upper Pleistocene comprises sediments formed during the Riss-Würm interglaciation time when the sediments of the Karangatian Regional Stage were deposited in the Black Sea. The Würm glaciation marked the end of Pleistocene and caused a worldwide regression. It is known as Grimaldian for the Mediterranean region and as Post-Karangatian for the Black Sea region. The beginning of this regression in the Black Sea is marked with the deposition of continental deposits over the Lower New Euxinian Substage, replaced later (in the second halfth of the age) with the sediments of the Upper New Euxinian Substage containing brackish molluscan fauna, due to the slight lake transgression of Caspian waters.

The range of the global regression in the Mediterranean Sea and in the Global Ocean is estimated to be up to minus 10-120 m and this values for the Black Sea basin are respectively up to minus 80-100 m.

In the Burgas gulf, the only place where the sediments of the Karangatian Regional Stage are established, no washing between its sediments and the sediments of the underlying Uzunlarian Stage exists and the transition between them is gradual (Христчев, Шопов, 1979). This fact brings in question the thesis of Федоров (1978), according to which between these two horizons exists a regression, comparable to the one of the second Riss glaciation.

In our opinion, the alluvium of terrace T2 and the third loess horizon (corresponding to the glaciation (W1) formed from it correspond to the Post-Karangatian regression, this of terrace T1 and second loess (W2) — to the break, which caused the deposition of continental sediments in the time of the lower New Euxinian Stage and the alluvium of terrace T01 and first loess (W3) — to the regression between the Upper Pleistocene and Holocene sediments.

The Holocene comprise sediments formed in post glaciation time or during the recent increase of temperature which lasts for more than 10 000 years. The increase of temperature causes a global transgression of the Global Ocean named Flandrian.

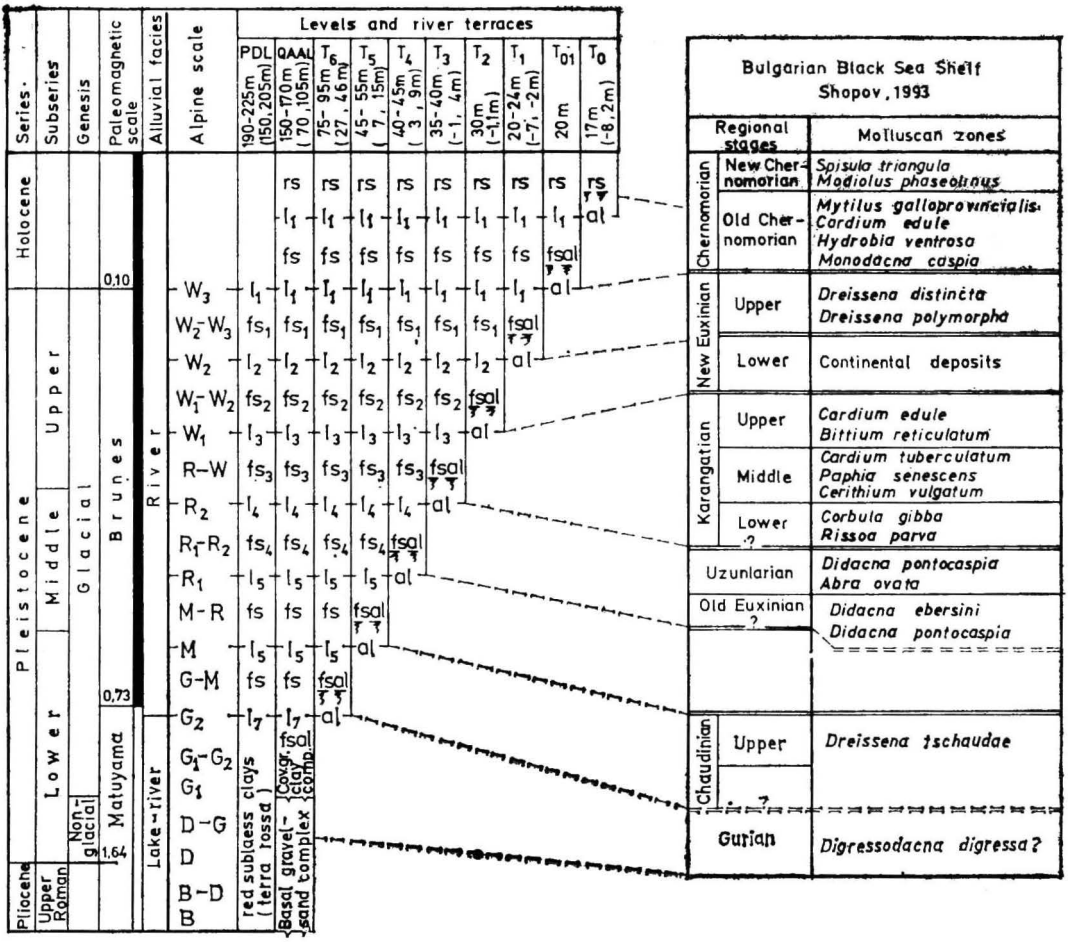

Fig. 3. Correlation between the stratigraphical schemes of the Quaternary in North-eastern Bulgaria and in the Black Sea shelf (according to Evlogiev unpublished data; Shopov, 1993)
B — Biber; B-D — Biber-Dunavium; D — Dunavium; D-G — Dunavium-Günz; G1 — Günz 1; G1-G2 — Günz 1 — Günz 2; G2 — Günz 2; G-M — Günz-Mindel; M — Mindel; M-R — Mindel-Riss; R1 — Riss 1; R1-R2 — Riss 1 — Riss 2; R-W — Riss-Würm; W1 — Würm; W1-W2 — Würm 1 — Würm 2; W2 — Würm 2; W2-W3 — Würm 2 — Würm 3; W3 — Würm 3; 1 — loess horizon; fs — fossil soil over loess; fsal — fossil soil over alluvium; rs — recent soil

In the Black Sea sediments of the Black Sea Regional Stage are deposited. The break which caused forming of the recent soil probably corresponds to the Fanagorian regression, which according to the scheme of Федоров (1978) occurred about 3.5 thousands of years ago decreased the sea level with 2-3 m.

Conclusions

The erosion surface of terrace T6 and seventh loess horizon reveal that there has been break in sedimentation at that time. This is the regression (corresponding to Günz 2), separating the Gurian from the Chaudinian sediments. The alluvium of terrace T5 and the formed from it sixth loess horizon correspond to the Mindel regression, this of terrace T4 and fifth loess — to the regression of Riss-1, and the alluvium of terrace

T3 and fourth loess — maybe to the regression of Riss-2. The alluvium of terrace T2 and third loess horizon (corresponding to the glaciation (W1) correspond to the Post-Karangatian regression, this of terrace T1 and second loess (W2) — to the break which caused the deposition of continental sediments during the Lower New Euxinian Substage and the alluvium of terrace T01 and the formed from it first loess horizon (W3) — to the regression between the Upper Pleistocene and Holocene sediments. The break which caused the formation of recent soil probably corresponds to the Fanagorian regression.

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