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QUATERNARY GEOLOGY, GEOMORPHOLOGY AND TECTONICS IN THE OGOSTA RIVER VALLEY SYSTEM, THE DANUBIAN PLAIN (BULGARIA)

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ABSTRACT

The Quaternary in the Ogosta River valley system (the Danubian plain) is represented by various genetic types of continental Quaternary sediments (eolian, alluvial, deluvial, proluvial). They lie on a diverse pre-Quaternary base. It is uneven and with various denudation. The accepted correlation schemes are based on local data in which the tectonic factor and duration of deformation have not been accounted for. The present work considers the complex results obtained during the investigation of the Quaternary sediments and formations.

The filling consists of clayey-sandy or calcareous-sandy materials, coloured in rusty nuances by iron hydroxides. Their age has been determined on the basis of the found fauna: *Elephas meridionalis Nesti*, *Anancus arvernensis Cr. et Gob* (Bakalov, Nikolov, 1962).

KEY WORDS: Quaternary geology, geomorphology, tectonics, lithology

1. INTRODUCTION

The Quaternary in the Ogosta River watershed is represented by various genetic types of Quaternary sediments (Fig. 1). They overlie either a diverse pre-Quaternary base, which is uneven and with various denudation, or a differing in age weathered crust. The thickness of the Quaternary sediments varies from several m to 110 m. They have been the topic of investigation of many authors (Filipov et al., 1989 and others). Most of the reference literature considers the loess and the loess complex. Regardless of the significant number of works on the Quaternary, the problems concerning its range, genesis, age and correlations are still debatable. The eolian theory about loess origin is accepted in Bulgaria. The present work shows a part of the complex investigations and results obtained during the study of the Quaternary in the Ogosta River watershed in the Danubian plain (Fig. 2), in which the author has taken part too.

2. QUATERNARY GEOLOGY AND GEOMORPHOLOGY

The Quaternary is represented by different lithological varieties, building different morphological bodies and complexes (Fig. 1). They are grouped as follows: Covering Gravel Formation, Red Clay Formation, Group of Eolian Sediments and Formations (loess complex), Group of Alluvial Sediments (terrace complexes), eluvium, deluvium, gravitational formations.

Covering Gravel Formation. The polygenic gravel with sandy-clayey filler, covering the ridges between the valleys is included in this formation. It is observed at the surface in the form of single spots or strips of different shape (Fig. 1). The gravel is widely distributed and has a considerable thickness from 10-15 m in the southern parts of the investigated region to 1 m in the vicinity of the Danube River. The thickness is variable in west-east direction too. This is due to the intensity of the neotectonic movements and to the specific features in the development of the river-ravine network (Vaptsarov et al., 1993, Angelova et al., 2000). They overlie the Neogene sediments with abrupt, uneven and eroded contact. The gravel is not cemented, unsorted, with various piece sizes and diverse composition and processing of the material.

According to their origin these are alluvial-proluvial and alluvial deposits, building two morphological levels at a height of 90-100 m and 130-150 m above the contemporary riverbeds.

Red Clay Formation. It is observed at the surface as narrow strips (Fig. 1)in the right valley slopes. The red calcareous-sandy aleurite clays refer to this formation. In most of the cases they are situated between the coarse-clastic sediments of the Covering Gravel Formation and the loess complex.

They are uniformly distributed and have been formed under conditions of warm and humid climate. The clays are dense, thick, heavy, unstructured, with massive outlook without expressed stratification. Their bulk

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Fig. 1. Geological map of the Quaternary sediments in the watershed of the Ogosta River in the Danubian Plain (according to the Geological Map of Bulgaria in Scale 1:100000, map sheets Kozloduy and Byala Slatina, authors: Filipov et al., 1989 and 1993, with amendments): 1-4 - Holocene: 1 - alluvium; 2 - proluvium; 3 - gravitation formations and sediments; 4 - deluvium; 5-9 Pleistocene: 5 - alluvium covered by loess; 6 - sandy loess; 7 - typical loess; 8 - clayey loess; 9 - loess-like clay; 10-11 - Plio-Pleistocene: 10 - Red Clay Formation; 11 - Gravel Cover Formation; 12 - pre-Quaternary rock complexes. The circular diagrams show the clay:aleurite:sand ratio (%) in the loess varieties.

density varies from 1.74 to 2.27 g/cm^3, the porosity reaches up to 20-30 % and the magnetic susceptibility - from 0 to 200 x 10^{-6} SI. They have high carbonate content - within the range of 10 to 50 % of the total rock mass. The thickness of the red clays is not constant and changes from 1-2 m in the southern parts of the region to 21 m to the north. The ratio between the building components is simultaneously changed from "clay : aleurite : sand" = 40-50:10-20:5-25 % in the northern parts to 50-70: 10-15:2-5 % - n the southern parts. The age, as well as the origin of the red clays in Bulgaria are debatable problems (Fig. 3). The author has accepted the eolian-alluvial-proluvial origin as the most suitable one for the investigated territory. This has been confirmed by the pollens found in a borehole at a depth of 24 to 31 m, that refer to the W_2 interstadial.

The polens have been determined by M. Dyakova (unpublished data, National Geofund, Sofia), who established in them the predomination of AP = 88.4-94.4 % (*Pinus*, *Picea*, *Abies*) under the herbaceous (NAP = 5.6-11.4 %) species with *Gramineae*. The investigated materials are the result of secondary redeposition of the existing at that time paleo-river network.

The red clays were formed under conditions of warm and humid climate on various relief forms (denudation levels, structural steps, river terraces) between 3.3-0.87 Ma (Evlogiev et al., 1995). The redeposition proceeded in connection with the changes in the slopes of the topographic surface to the NE as a result of the neotectonic movements (Angelova et al., 2000).

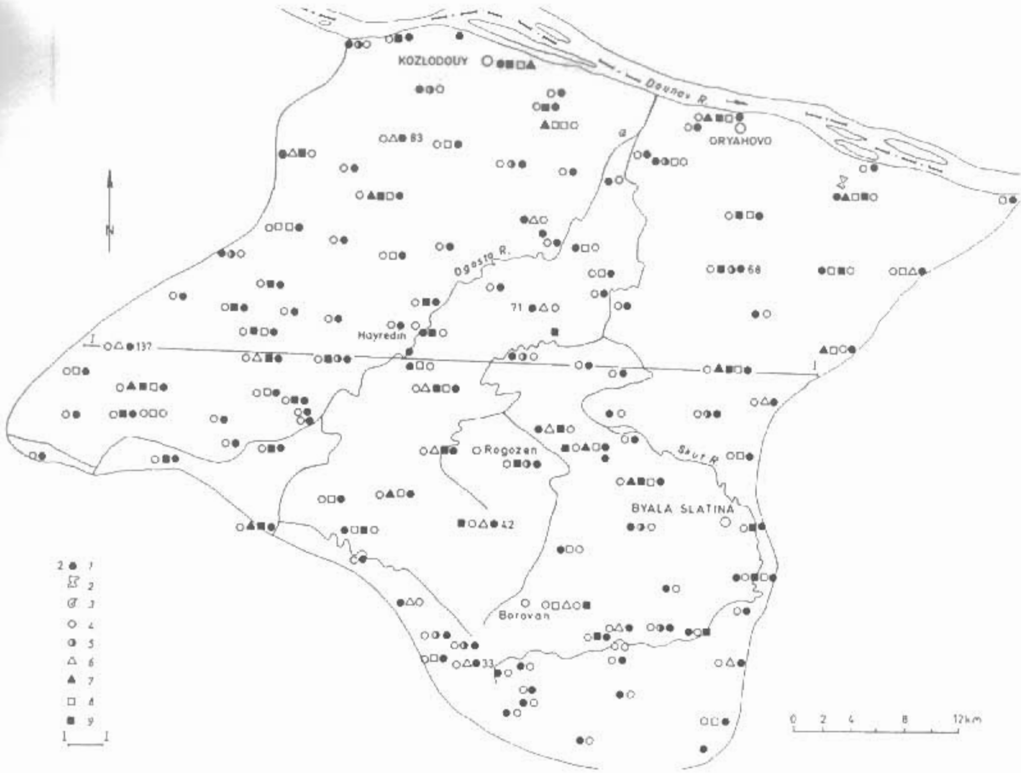

Fig. 2. A map of the actual material: 1 - borehole; 2 - sample with vertebral fauna; 3 - sample with invertebral fauna; 4 - sample with microfauna; 5 - sample for spore-pollen analysis; 6 - sample for physical properties; 7 - sample for mineralogical analysis; 8 - sample for granulometric analysis; 9 - sample for sediment-petrographic analysis; 10 - profile line (I -I).

The Group of the Eolian Sediments and Formations includes the loess horizons with the buried soils in them. They have a considerable thickness and are widely distributed in the studied region. Their thickness varies from 1-2 to 110 m. It changes in the same directions as the red clays, which in single cases is also an indication for secondary redeposition of the existing in these times paleoriver network. It has been established from the performed investigations that there are no complete stratigraphic sections. This shows that the correlations made are relative in their essence. There are 5 loess horizons and several secondary redeposited ones in the investigated area. The ratios between clay, aleurite and sand are different and they determine the loess division into: sandy (10-20:40-50:15-20 %), typical and clayey (50-70:20-30:1-2 %) and loess-like clay (40-60:10-30:5-10 %). The calcium carbonate content is high (20-40 %) and calcareous concretions have been formed in the loess.

The loess density varies from 1.69 to 2.16 g/cm^3, the magnetic susceptibility is from 4 to 929 x 10^{-6} SI for the clayey loess and from 0 to 186 x 10^{-6} SI for the loess-like clays. Teeth and bones of *Castor* sp. were found in the loess-like clays near the Boukovets village. There about 1 to 5 buried soil horizons in the loess (Fig. 4). Almost all researchers of the region have used them for stratigraphic purposes. According to the author it is difficult to use them for stratigraphic purposes at this stage without additional studies, since it cannot be determined what are the soil horizons of regional importance with spatial homogeneity and established age. Moreover, they are wedge-like and interrupted in immediate proximity in one and the same morphological bodies. The buried soils are calcareous-aleuritic to strongly aleuritic clays and only some of them are very rich in humus. Their density is 1.74-2.22 g/cm^3 and their magnetic susceptibility - from 25 to 250 x 10^{-6} SI. The distribution of the minerals in them is not uniform. The age of the loess complex as a whole is not proved. Bearing fauna and flora specimens are found in it but there only the Wurmean (W_2 and W_3) and Holocene age.

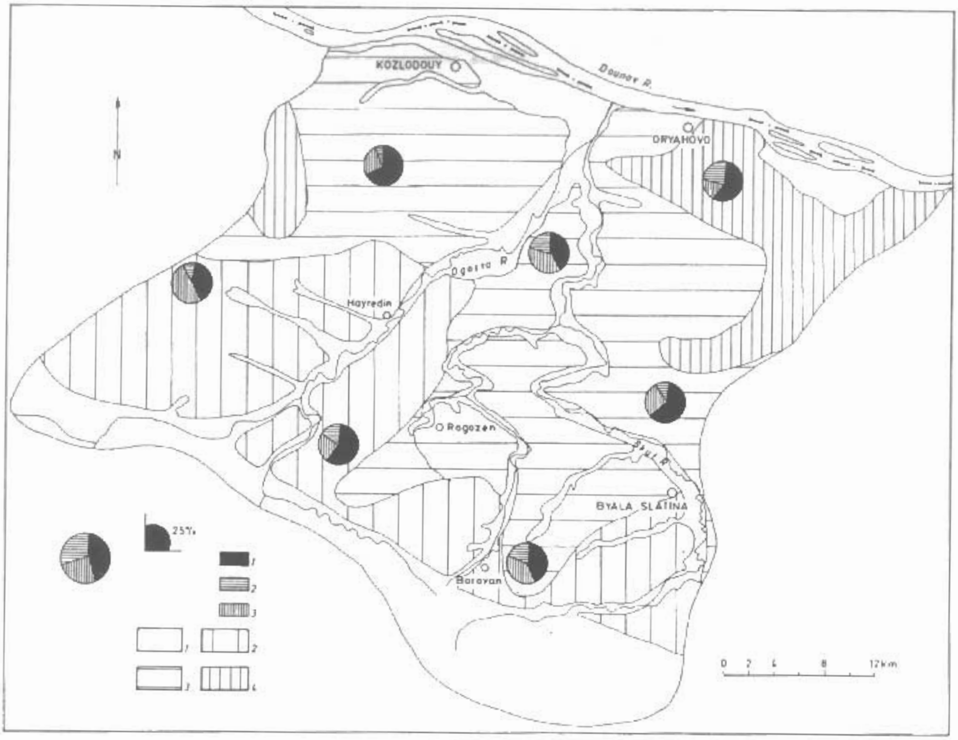

Fig. 3. Map of the distribution and thickness of the red clays: 1 - sections with no red clays; sections with red clay thickness: 2 - 0-5 m, 3 5-10 m, 4 - 10-15 m. The circular diagrams show the clay:aleurite:sand ratio (%).

The Group of the Alluvial Sediments contains the sediments building the accumulative superstructures of the high, middle high and low flood terraces belonging to the Pleistocene and of the flood Holocene river terraces. The high terraces are very often on different levels and are of relict character. The fifth overflood terrace along the Ogosta River for example is observed at the level of 75-85 m, 60-70 m and 50-60 m. The average high river terraces have medium relative heights: 40-50 m (for the fourth one), 30-35 m (for the third one), 18-25 m and 8-12 m above the contemporary riverbeds (for the low overflood terraces). The alluvial sediments are from the riverbed facies and have a thickness from several centimetres to 25-30 m. The gravel has mainly middle- and small-size pieces and is well processed, with different composition and sand filler. The age of the first overflood terrace is proved by the found fauna: *Unio pictorum platyrhynshus Rossm*, *Coretus cerneus* L. and *Planorbis planorbis* L.

The alluvial sediments of the Holocene flood terrace complex comprise the sediments of the riverbed and flood facies building the low and high flood terraces. The alluvium thickness is very variable - from 1 to 40 m. The age is determined according to the found fauna: *Theodoxus transversales Pfeif*, *Lithoglyphus Pfeif*, *Amphimelania holandri Ferr*, *Fagita acicularis Ferr*. (Kojumdgieva, unpublished data, National geofund).

The eluvial, gravitational and proluvial sediments have the greatest distribution compared to the other genetic types (Fig. 1). Their formation had started before the Holocene and was enhanced during the Holocene and the contemporary stage. The different sub-types of the chernozem soils as well as the coarse mechanogenic eluvium filling the karst forms, are the most widely distributed eluvial sediments. According to their origin they were the result of the mechanical, chemical and biogenic weathering. The eluvium thickness varies between 10-20 cm and 10 m. It is very thin. The proluvial sediments have a more restricted distribution and their thickness does not exceed 10 m. The gravitation formations are observed mainly along the right river valley slopes. They are of different origin but their composition depends on the rocks building the slopes. These are coarse unsorted materials. Their thickness is usually small (1-6 m) for the erosion provoked ones and much greater - for the tectonically formed ones. The deluvial deposits in the loess terrains are fine, clayey-sandy ones.

The formation of the contemporary relief in the considered territory is related to the closing and filling with sediments of the Fore-Carpathian basin and the following post-collision extension. Tectonically predetermined

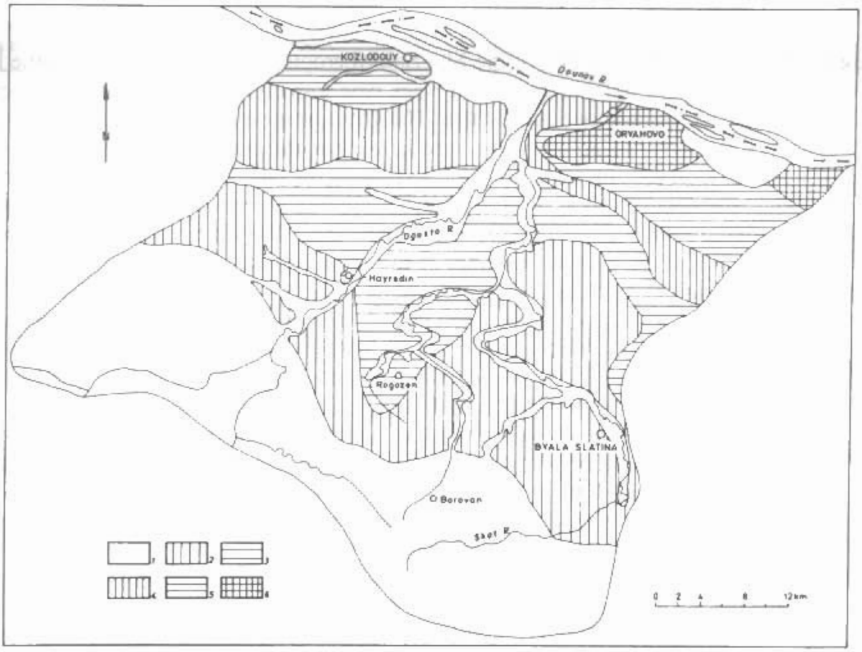

Fig. 4. Map of the distribution and number of the fossil soil horizons in the loess complex: 1 - 0; 2 - 1; 3 - 2; 4 - 3; 5 - 4; 6 - 5.

relief is observed: local fold-block forms, gravitation steps, negative structural-denudation lowerings filled and buried by younger sediments, a number of faults predetermining the main directions of the river-valley network. The most pronounced display of the action of the endogenic and exogenic processes is observed in the morphology of the river valleys and the connected with them terrace complexes as well as of the karst forms. The karst is either covered by the loess complex or is observed at the surface. The underground karst is also well presented. The process of young karst formation is connected with the Late Pliocene - Early Quaternary development of the relief. The stages in its development are closely related with the formation and evolution of the river-ravine network. The karstification is an incomplete process and the development of karst forms continues till now. The loess form complex is most widely distributed. It builds the loess accumulative surface. It is strongly dismembered by gullies, dry valleys and ravines (Fig. 5).

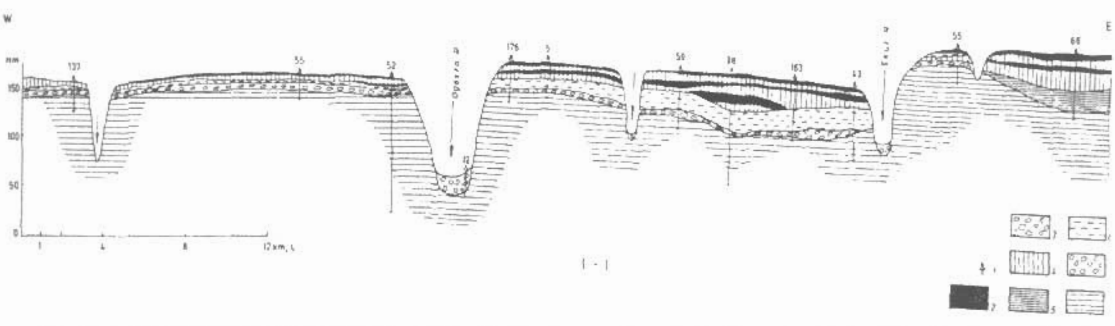

Fig. 5. A generalised geological section of the Quaternary sediments in the watershed of the Ogosta and Skut Rivers in the Danubian Plain along the profile I-I (Fig. 2): 1 - borehole; 2 - soil horizons; 3 - contemporary alluvium; 4 - loess horizons; 5 - clayey loess; 6 - red clays; 7 - gravel cover; 8 - pre-Quaternary rock complexes.

The surface relief in the investigated region is strongly anthropogenic as a result of the economic activity - riverbed corrections, microdams, terraced slopes, quarries, dikes, etc.

3. QUATERNARY TECTONICS

The investigated territory comprises parts of the Moezian Microplate (Lom structure) and the Deformed Continental Edge (Angelova et al., 2000). Steps of the block type formed as a result of the listric extensional tectonics are included in the deformed continental edge. The Quaternary tectonic units did not inherit the depression Neogene units. They were controlled by the specific geodynamic processes in the investigated region. The differences between the local tectonic units were realised during the Late Pliocene - Early Quaternary stage, mainly during the Middle Pleistocene and at the Pleistocene-Holocene boundary. The Quaternary vertical tectonic deformations have a total value between 80-100 m and 120-180 m. The vertical tectonic deformations were reflected in the vertical deformations and outlevellings of the terrace levels. For example, the fifth overflood Ogosta River terrace in the various sections is observed at levels 75-85 m, 60-70 m and 50-60 m. The vertical tectonic movements between it and the fourth overflood terrace are between 10 and 45 m for the various local morphostructural units. The fourth overflood terrace is on the average at a level of 40-45 m, but in the section near the Hairedin village is at a height of 30-35 m and reflects the local tectonic subsidence. The tectonic movements realised at the boundary between the fourth and third overflood terraces is of the order of 10-15 m, between the third and second, and the second and first overflood terraces - about 10-12 m. The tectonic movements realised at the Pleistocene-Holocene boundary were very differentiated - between +7 m and -30 m. Tectonic anomalies are observed in some sections too - for example, between the villages of Lehchevo and Kriva Bara, where the alluvial deposits of the second overflood terrace are in tectonic contact with the alluvial deposits of the flood terrace. The horizontal tectonic deformations have a strike-slip fault character. Generally, these are small-amplitude movements along fault structures. They played the control role in the change of the direction of river water movement to the NE towards the erosion basis. For example, the Ogosta River flows along a fault directed to the WE between the Vladimirovo and Gromshin villages, while it abruptly changes its flow direction to the NE to the north of the Gromshin village. The morpho-delineating fault structures are seismo-generating. Earthquakes with M=2-4 took place along them in the period 1980-1987. The contemporary vertical movements for the period from 1930 till 1985 are 1.2-2.0 mm/a (Karagjuleva, Shanov, 1990, Vaptsarov et al., 1993, Spiridonov, 1994, Angelova et al., 2000). The tectonic movements at the Holocene-Pleistocene boundary were characterised by great deformations and as a result the Kozloduy local block structure was formed. The total value of the Holocene tectonic movements within its range were from -20 to -30 m. The contemporary vertical movements here were from -1.2 to -2.5 mm/a, calculated for the period from 1930 till 1985 (Spiridonov, 1994, Angelova et al., 2000).

4. CONCLUSIONS

The investigated terrain is representative for the geodynamic development of the Moezian Platform (the Lom depression) during the Quaternary and the contemporary stage. Moreover, similar investigations are very necessary especially in connection with the monitoring carried out for the "Kozloduy" Nuclear Power Plant, situated in this area, as well as for other strategic economic enterprises in Bulgaria.

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