Geomorphological Researches in the Northeastern Part of Sofia Kettle, Bulgaria

Sonya S. Stoyanova
Department of “Climatology, Hydrology and Geomorphology”, Sofia University “St. KlimentOhridski”, Bulgaria

Abstract: During the construction of the North Tangent in Sofia, Southwestern Bulgaria, there were found archaeological structures in the fluvial deposits of Perlovska River (a left tributary of Iskar River). Therefore, it was necessary to perform complex descriptions, field sampling and sedimentological analysis.

Key words: Sofia kettle, archaeological structures, sedimentological analysis

1. Introduction
The studied area is located in the northeastern part of Sofia kettle, Southwestern Bulgaria. There were found two archaeological structures during the construction of site No. 3 along the North Tangent (Fig. 1). The cultural layer is in 120-150 cm depth of the present topographic surface, near the Perlovska River bed. The archaeological excavations are made in area of 160 m length and a width of 22 m. In the mentioned area, the geomorphological researches are marked in several key points. Samples were processed in a sedimentological laboratory and put through morphoscopic and grain-size analysis.

2. Geological and Morphohydrographic Characteristics
The study area is located in the northeastern part of Sofia kettle. This morphological and tectonic structure (graben) is filled with Neogene and Quaternary sediments. The sinking part, represented by the kettle level, has contributed the lacustrine and fluvial sedimentation. On the other hand, the rising part between hillsides of Stara Mountain and Srednagora Mountain has stimulated the active denudation and bedrock weathering [5].

Neogene deposits in the kettle has 200-700 m thickness and in some places it is more than 750 m (gravel, sand, clay, lignite). These sediments are overlapped by the quaternary alluvial deposits of Iskar River and its left tributary Perlovska. The thickness of the alluvium increases towards Iskar River and in the researched area it varies between 70-85 m [5].

Perlovska river flows round 200 m western and to the east the study area is bordered by ploughland (Fig. 2). The altitude is between 460 m in the midstream of Perlovska and to the east it reaches 535 m. It decreases from east to west — to the mainstream, and from south to north — along the river. The topographic surface is relatively flat. The average slopes are hesitant in narrow range — between 0 and 12°. Horizontal surfaces with 0° are registered along Perlovska valley. Relatively equal parts of the floodplain terraces have slopes between 0 and 2°. The values of this index are increased to the east (to the mound) — between 5 and 12° slope.

As a result of the flat nature of the terrain, it became clear that the predominating slopes are...
between 0 and 2°. These surface indicators contribute to the accumulative processes and soil formation.

**Fig. 1** Location of the study area.
(Sources: topographic map, downloaded from www.cadastre.bg; geodetic map TEMPI 2015)

**Fig. 2** Hypsometric map of the studied area.
(DEM source: www.earthexplorer.usgs.gov)
In regard to hydrographic feature Perlovskara River basin is a part of Iskar catchment as its left tributary. The river begins from the southern slopes of Vitosha Mountain (from 820 m a.s.l.). It flows to north-northeast and empty into the left of the Iskar river (at 513 m a.s.l.). From the springs to the mouth Perlovskara has length of 31 km. In its accumulative zone Perlovskara valley is extensive. The processes of accumulation are performed by the constantly flowing water and also swamping.

Therefore, the morphohydrographic characterization shows that this is an area with very low slopes, where the accumulative processes and soil formation are dominated. These slopes are a precondition for meandering and furcation of the mainstream and formation of swamping.

3. Archaeological Data

The studied area is a part of the larger site No. 3 in the route between 8+400 km to 9+030 km (Fig. 1, geodetic map), which is conditionally numbered with the letter “A”. In the section between 8+ km 400 to km 8+ 560 boreholes were made with a width of 1 m, total length of 430 m and a depth from 0.90 m to 1.20 m. By means of the boreholes there are registered two archaeological structures. One of them is a platform with 5 clay pots, which are made of rough clay with impurities. Three of them are cups with two handles (Fig. 3a). The morphology of the pottery, the texture and the clay color, the impurities, the method of firing, they clearly prove that the pottery belong to the cultural layer of the final phase of the Early Bronze Age.

The second structure is a crowding of pottery fragments and refer to the same chronological period (Fig. 3b).

![Ceramics from the first (a) and the second (b) archaeological structures; a sand horizon with rusty brown color (c) and single fragments with highly polished edges (d).](image)
On hand it was studied the area between 8+ 460 km and 8 + 480 km (Fig. 1, geodetic map). Here is described a horizon from sand with rusty brown color (Fig. 3c). It contrasts sharply with the surrounding horizons. In the sand were found single fragments of various pottery with highly polished edges from the Roman era and Late Antiquity (Fig. 3d). Such smoothing is only possible at relatively long (over 5 km) transporting in fluvial environment.

After researching and documenting the structures, it was reached sterile soil, gravel and sand everywhere in the 3A site.

4. Geomorphological and Sedimentological Results

Geomorphological (sedimentological) researches are marked in five key points. A cross section with four horizons are characterized, which is conditionally called “Profile 3A”. It is composed of sediments that form horizons without cultural layers. There are made morphoscopic (Table 1) and grain-size (Fig. 4) analyses of the deposits.

| Table 1  Morphoscopical analysis of the course material in profile. |
|-------------------|-------------------|-------------------|-------------------|-------------------|
| Horizon       | 0-40 cm | 40-110 cm | 110-170 cm | 170-200 cm |
| Count         | 10      | 9        | 5         | 30        |
| Min (mm)      | a-15; b-12; c-6 | a-14; b-10; c-4 | a-15; b-13; c-9 | a-11; b-6; c-3 |
| Max (mm)      | a-46; b-40; c-23 | a-43; b-24; c-21 | a-29; b-22; c-14 | a-86; b-54; c-34 |
| Average (mm)  | a-28; b-19; c-13 | a-26; b-17; c-12 | a-20; b-16; c-12 | a-46; b-31; c-21 |
| Petrography sort | gneiss | gneiss | gneiss | gneiss |
|Mean roundness | 3,8 | 2,9 | 3 | 3,4 |
| Broken pebbles % | 40 | 0 | 0 | 27 |
| Saltation %   | 50 | 56 | 60 | 53 |
| Dragging %    | 50 | 44 | 40 | 47 |

![Fig. 4  Grain-size analysis of the deposits in Profile “3A”](image-url)
The morphoscopy analysis (Table 1) shows similar composition of the course material in horizons with the petrographic province of Perlovsk river that springs from Vitosha — gneiss, quartz, andesite, granitoids. High roundness of gravel and pebbles associated with traveled distance along the river. The found ceramic fragments have the same roundness. Axis “a” of the course material (in horizon 170-200 cm) shows the movement of the mainstream to the north. This was also observed in the contemporary mainstream of Perlovka.

Grain-size data (Fig. 4) shows that the first two horizons (0-40 cm, 40-110 cm) are formed by sand and clay. The difference between them is about the size and roundness of the course material. The sediments are bigger and well rounded in the first horizon (0-40 cm) then the lower. Over 70% of the sample from 110-170 cm is clay. The lower horizon (170-200 cm) is composed of sand, with inclusions of coarse gravel and small boulders.

Therefore, the results indicate the transfer of two facial environments in depth (Fig. 4). Horizon 170-200 cm characterize a river bed facies. It has been a relatively calm situation during the formation of the upper horizon 110-170 cm.

It is possible this horizon to mark a riverside swamping and subsequently forming of floodplain terrace.

From the presented data, we concluded that Perlovka permanently shifted its river bed to the west, where is its present mainstream (Fig. 5).

![Fig. 5 Reconstruction of the terrain by the results of sedimentological analysis and cartographic materials.](image)

The investigation of alluvial deposits in points 3A-1, 2, 3, 4 (Fig. 6) show that river beds have been several or branches of the same river. To the west, from Profile 3A to a distance of 13.3 m we observed the same deposits, which are described in the horizon 170-200 cm. From 13.3 m to 15.4 m there is a transitional strip with another river bed. Point 3A-1 indicates deposits from the second presumptive river bed. The grain-size analysis of 3A-1 sample showed a predominance of sand fraction (70%), which is well washed and sorted. The transience in this strip is expressed mostly in the deposits color — alternating dark orange and black stripes.
To the west again, it is observed a sand area with alternating and interweaving of orange, reddish, whitish and black stripes. Three samples were taken from 3A-2, 3, 4 which show almost identical grain-size of the deposits, with predominating sand fraction (2-0.063 mm, Wentworth grain-size chart). Again, difference is in the deposits color. We assume that the area between 15.4 m and 21.3 m is a sand island in the middle of mainstream or between two branches of the same river. This area is relatively higher than the river bed and there are found the best-preserved ceramic pottery (Fig. 3a). Probably, this island has been periodically flooded and dried. The sediments have been under conditions of oxygen regime (orange sand) during freshet and at the low water level the river has been meandering and formed swamping (black sand and organic material). Then, the regime has dramatically changed, because of some places there is a geochemical barrier (red sand) with the upper horizon. Therefore, the river facial environment has become a floodplain and dark clay horizons have overlapped. As a result, we observe another river shift to the west. Subsequently, it has formed a floodplain terrace onto the island from the temporary flooding. These facial conditions on the terrace have caused accumulation of organic material and humus.

5. Conclusion

The data obtained from sedimentological analysis confirmed that alluvial sediments are characterized by two facies: river and floodplain. Distribution of sand and clay, as well as the characterization of course material attest to that. The present location of Perlovska river bed shows migration from east to west. This was confirmed in a report with available cartographic materials, as well as the analysis of the deposits, which allowed us to recreate the paleoenvironments. The results of geomorphological studies give us reason to assume that the site № 3 along the North Tangentin Sofia is located on the old Perlovska river bed, which actually is transported the ceramic fragments from other place.

In a conclusion, the dynamics of fluvial processes and their replacement with floodplain environment are clearly reflected into the alluvial deposits, as a result of the hydroclimatic conditions in the watershed of Perlovskariver.

References

[9] www.cadastre.bg (Topographic map 1: 5 000)