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Determining of the Morpholithology Types in the Kamchia River Basin (Eastern Bulgaria) by means of Geographic Information System (GIS)

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Abstract

The article presents the morpholithology types in the Kamchia River basin (Eastern Bulgaria) – the catchment area of the largest Bulgarian river which flows into the Black Sea. These types are determined on the base of information about the relief and lithological substrate. The rocks in the investigated area are divided into groups according to their physical-mechanical and chemical composition, and the relief types are determined in regards to the morphographic features of the catchment area. The research is done on the base of geological and topographic maps in scale 1:200 000 and also terrain observations are taken into account. As a result of the research a map of morpholithological types (1:200 000) is made. The map shows a considerable variety of the morpholithological types in the Kamchia River basin. This variety determines the appearance of the territory and also influences on the landscape differentiation. The analyses and composition of the morpholithology map are done in GIS environment. For that purpose a GIS database of lithology and relief (topography) of the Kamchia River basin is built as spatial "overlay" analysis is done.

Key words: morpholithology, rocks, relief, GIS, Kamchia River basin

Introduction

The morpholithology types are determined by the composition of relief types and types of rock composition. Every morpholithology type includes territories covered by one relief type and one lithological ground. The variety of the morpholithology types determines the variety of the forms of territory and influences on the landscape differentiation (we accept the landscapes as a territorial complexes consisted of homogeneous rocks, relief, climate, water condition, soils, flora and fauna). Chemical -physical composition of the rocks influence on the erosion processes, denudation, weathering, underground water level. In this regards the morpholithology types are used as a diagnostic criterion in landscape classification (Popov, 1987). The aim of the research is the morpholithology types in the Kamchia River basin to be determined and to show the possibilities of GIS technology for visualization and analysis of geological and relief data. The results of the research could be used for further landscape investigation of the territory and as a basis for a middle scale landscape mapping

An object of the current research is the Kamchia River basin – the largest Bulgarian river which flows into the Black Sea (Fig. 1). Kamchia River is formed by confluence of the two main rivers: Luda Kamchia and Gloyama Kamchia. The Kamchia River basin includes the southern and the highest parts of the Eastern Danube plain, almost the whole Eastern Fore-Balkan and the most part of the Eastern Balkan. The investigated area in these boundaries is 5390 km^2. Hilly relief is predominating. The highest point is peak Bulgarka (1181 m) in Slivenska mountain and the lowest – Kamchia River mouth. In regards to the geotectonics the Kamchia River basin includes Moesian plate, Fore-Balkan tectonic zone and East Balkan tectonic zone.

The rock composition and geotectonic features of the Kamchia river basin are detailed investigated by Botev (1953), Ganev (1961), Atanasov,

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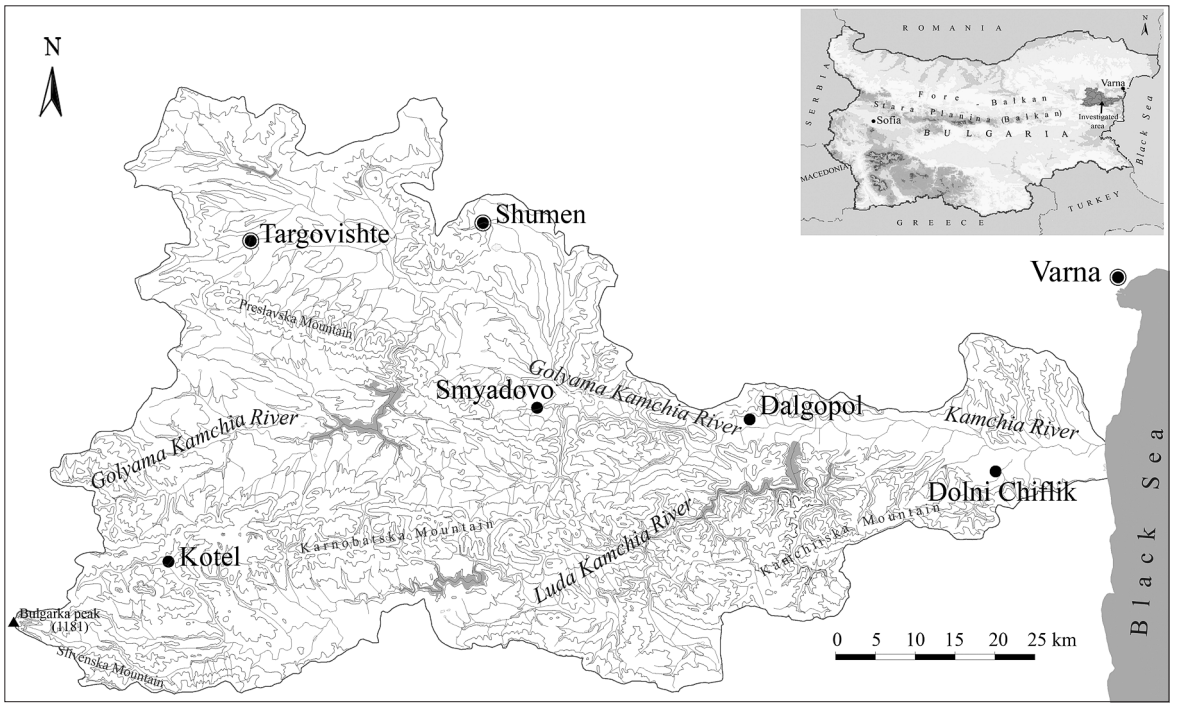

Figure 1. Outline of the investigated area

1961, Kanchev (1971). The investigations of the relief are given in the publications of Radev (1927), Koen (1953), Mishev and Daneva (1972), Glovnya and Velchev (1972), Marinov (1991), Konstantinov (1992), Vladev and Aleksiev (1998), Vladev, (2001, 2003).

Method for determining the morpholithology types and composing of a morpholithological map

Determination of the morpholithology types in the Kamchia River basin is done in GIS environment (ESRI ArcInfo) by spatial analysis "overlay" of relief and lithology data. Application of GIS technology in environmental studies and particularly in geomorphology shows a large development in the last years (Butle D.R et al., 1998; Stephen J. Walsh et al., 1998; Bocco et al., 2001; Oguchi, 2001; Murayama, 2001; Marianne Font et al., 2010). For the propose of the current study area objects are entered in digital format and are visualized as a combination of points and lines, determined by their spatial coordinates. The graphic data is taken by the geological and topographical maps of Bulgaria in scale 1:200 000. The data about relief types and lithology composition is built in two different layers (files) and polygon topology is generated. This allows making up a morpholithology map and carrying out the spatial analyses. The morpholithology map is made by overlay of polygons of the both layers (relief and rocks). The intersection of the contours of polygons generates new polygons – morpholithology types which have characteristics of the relief type and lithology ground of the relevant territory. Besides the real areas, many sliver polygons are generated on the map created in this way. These polygons are not considered to be substantial ones. Taking into account the map scale (1:200 000) we determine which polygons are unsubstantial by filtering those with area of less then 1 km² and those which have long and narrow shape (Fig. 2).

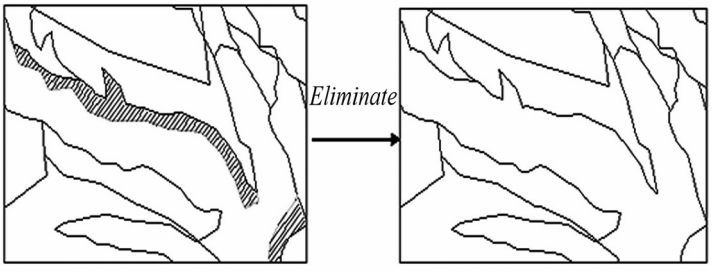

Figure 2. Generalization of polygon coverage

In regards to the requirement of compliance, the scale of the visualized objects with the map scale, the polygons less then 1 km² and those ones for which the formula *"Area * 5 < Perimeter"* is valid are removed during the map generalization (Nikolova, Vasilev, 1998). The attributive characteristics of the polygons are also taken into account in the process of generalization. In this case the possibility to eliminate some small polygons which are typical of the territory is minimal. Relief types, which cover more compact and large areas in comparison with the lithological groups, are presented on the morpholithology map by sol-

id background and rock composition - by different patterns.

GIS database allows easily calculation of the area of different lithology and relief types, and making up analyses of the variety of the investigating area, as well as could be useful in territorial planning.

Rocks composition

The rocks in the Kamchia River basin are divided into six groups according to their physical-mechanical properties and chemical composition (Fig. 3):

- consolidated non-carbonate rocks;
- consolidated carbonate rocks;
- alternation of carbonate and non-carbonate rocks;
- loess and loess-like clays;
- unconsolidated non-carbonate rocks;
- volcanic rocks.

Consolidated non-carbonate rocks are presented by clay-sandy slates, sandstones, conglomerates and clays. They were formed mainly during Cretaceous and Paleogene. These rocks build Gerlovo hollow, the northern low slopes of Preslavska and Dragoevska mountains, valley slopes of Vrana, Golyama Kamchia and Kamchia rivers. They are slightly spread in the Luda Kamchia River catchment (Fig. 2). The total area of these rocks group covers 44.4% of the whole Kamchia River basin.

Consolidated carbonate rocks (limestones, dolomites, sandy and marlly limestones) are of Triassic, Cretaceous, Paleogene and Neogene ages. They are located in Shumen plateau, Pakusha River basin, and east of Tsonevo dam, in Kotlenska Mountain, at the northern slopes of Varbishka and Malka Karnobatska Mountains (Fig. 2). Consolidated carbonate rocks cover about 4% of the investigated area and occupy comparatively small areas. Appearance of the carbonate rocks on the surface and rain activity determines the development of the karst processes. These processes influence on the mineral substances migrations, geochemical background of the territory and also on the river water quality. Karst relief in the Kamchia River basin is presented by karren, sinkholes (whirlpools) and caves.

A considerable part of the Kamchia River catchment (about 40%) is built by *alternations of carbonate and non-carbonate rocks* (slates and sandy limestones, clayey marls and limestones, clayey-sandy slates). Such alternation is observed in Preslavska Mountain, Luda Kamchia basin, Eminska and Kamchiiska Mountains (Fig. 3). Paleogene flisch takes essential place in this rock complex. It is located in the Luda Kamchia River. The flisch is easily accessible to weathering and denudation. This

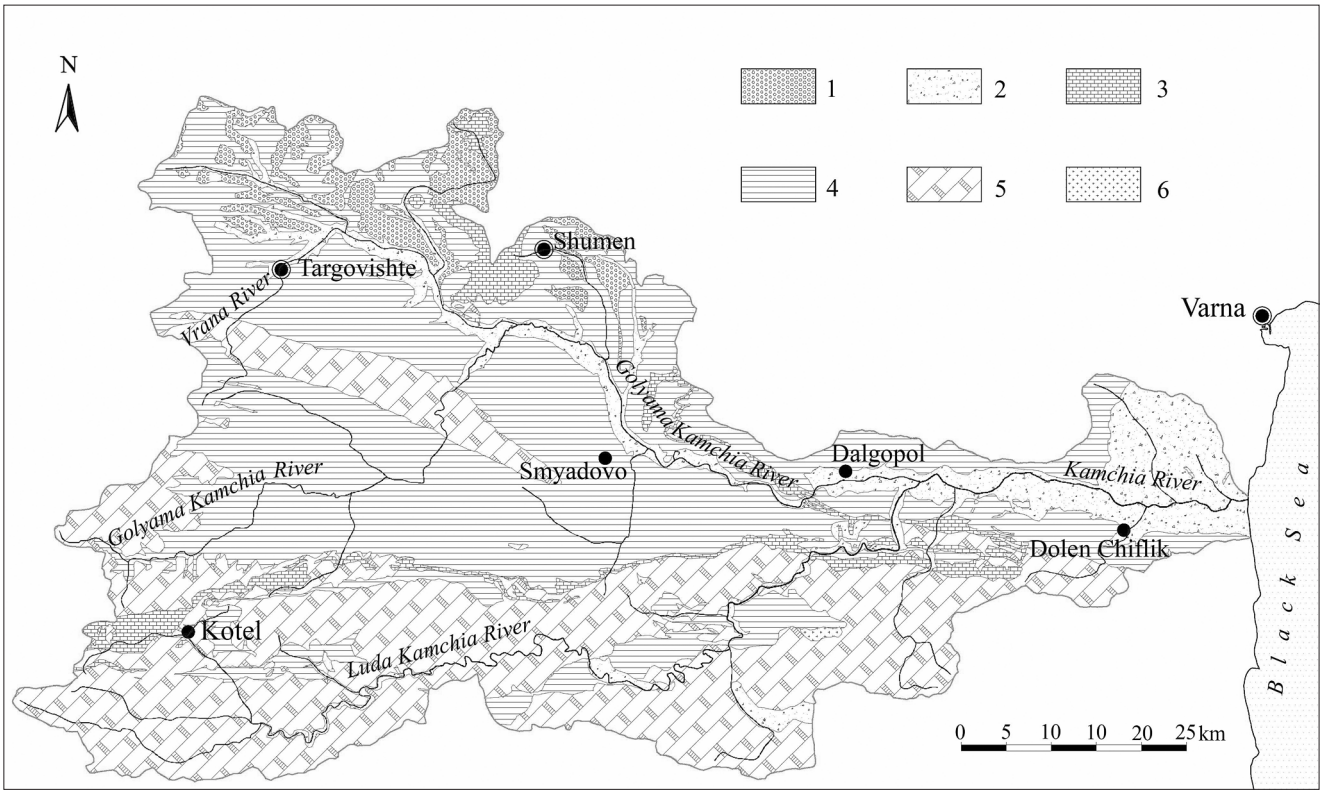

Figure 3. Rock composition in the Kamchia River basin (according to the Geological map of Bulgaria, scale 1:200 000, 1962)
1 – loess and loess-like clays; 2 – unconsolidated non-carbonate rocks; 3 – consolidated carbonate rocks;
4 – consolidated non-carbonate rocks; 5 – alternation of carbonate and non-carbonate rocks; 6 – volcanic rocks

is the reason for developing of rounded relief and intensive activity of the contemporary morphogenetic processes. The weakly steady flisch sediments ground the well formed denudation surfaces.

Loess and loess-like clays are formed in Quaternary; they cover the northern part of the investigated area, and the left valley slopes of the Vrana River. This sedimentary complex builds about 4% of Kamchia River basin (Fig. 3).

Unconsolidated non-carbonate rocks (gravel and sand) are the youngest rocks in the researched area. They are accumulated in the lower part of the river valleys and take about 10% of the whole catchment area of the Kamchia River. These rock materials are mainly located in the dense forest valley of the Kamchia River (near to the river mouth) and also in the Golyama Kamchia and Vrana rivers valleys (Fig. 3). Diluvial materials are accumulated on the left valley slopes of Kamchia and Golyama Kamchia rivers and ground smooth transition between slopes and low flood terraces. The gorge nature of Luda Kamchia River is a reason for weak accumulation and limited distribution of the alluvial deposits in this part of the catchment area.

Volcanic rocks are presented by tuffs and andesites with Upper Cretaceous age. They have limited distribution at southern slopes of Kamchiiska Mountain, south of Zaimchevo village (Fig. 3). Because of their limited area these rocks do not have a substantial role in the landscape differentiation in the Kamchia River basin.

Relief

The following relief types are determined in the Kamchia River basin according to the morphographic features of the territory: lowland, hilly, low-mountain, plateaus and hollows. The altitude (above sea level) is also taken into account as follow: from 0 to 200 m – lowland; 200 to 600 m – hilly; 600 – 1181 m (the highest point in the Kamchia River catchment) – low mountain. Vertical and horizontal segmentation of the territory also impact on the morpholithology differentiation as well as slope and exposition of the territory but in regards to the scale of the investigation (1:200 000) they were not used as diagnostic criteria in this case. The largest area is covered by hilly relief and the smallest one – by plateau (Fig. 4). The main exogenetic processes which form the relief in the researched area are: *erosion-accumulation, weathering-denudation and karst processes*. Modeling of the earth forms, in the eastern part of the Kamchia River catchment area, is also done under the influence of *sea water activity* (abrasion and accumulation). The sea water activity, low coast line, eollian activity and accumulation of sands are the reasons for the formation of the

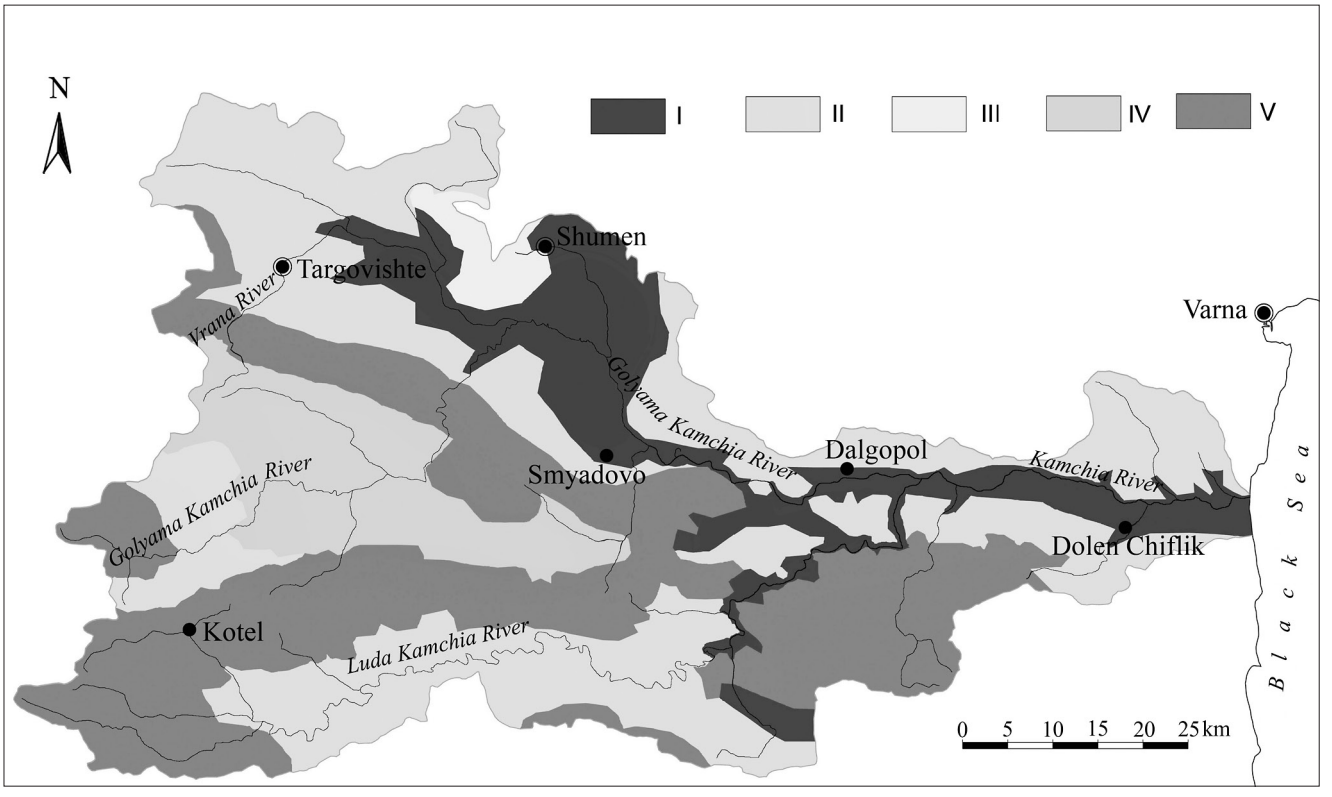

Figure 4. Relief types in the Kamchia River basin (according to the topographical map of Bulgaria, scale 1:200 000, 1994)
I – low land; II – hilly; III – plateaus; IV – hollows; V – low mountain

wide beaches. There is also a well expressed correlation between planation processes and lithologycal composition. The planation processes are facilitated by non consolidated flycsh sediments.

Description of the morpholithology types

Combinations of the relief types and lithology background determine different morpholithology types (Fig. 5, Fig. 6). The morpholithology types with mainly hilly relief are predominant in the investigated area. Five morpholithology types are formed here. The largest area is covered by the complexes of hilly relief and consolidated non-carbonate rocks (18.8% of the investigated area). These complexes are located mainly in the northern part of the Kamchia River basin. The second are the complexes on alternation of carbonate and non-carbonate rocks (12.4%) and they take central and southern part of the catchment area. The horizontal segmentation of the relief here is from 1 to 2.5 km/km^2. In the northern part of the investigated basin the morpholithology types formed on loess and loess clays are spread. They take a limited area – about 3% of the Kamchia River basin.

The low-mountain complexes are formed mainly on consolidated carbonate and flisch materials. The morpholithology types of alternated carbonate and non-carbonate rocks have an average area of 155 km^2 and take about 23% of the investigated catchment area. One morpholithyology type of low-mountain relief and volcanic rocks is also determined. Its small area (about 0.5 km^2) shows that this complex is not typical of the Kamchia River basin.

Rocks that are relatively equal in lithological composition are observed at hollow and at plateaus relief, and this determines a few numbers of the morpholothological complexes (2 at hollow and 3 at plateaus relief). Almost the whole area of hollow relief is built by one lithological substrate – consolidated carbonate rocks.

Areas with plateaus relief are formed mainly on the consolidated carbonate rocks, followed by consolidated non-carbonate rocks. The smallest area is taken by loess and loess-like clays.

The relation rock base – type relief is clearly expressed at lowland morpholithological types. The complexes built on consolidated non-carbonate rocks, unconsolidated non-carbonate rocks, loess and loess-like clays are predominant here. The large spreading of the non-carbonate rocks and clayey materials is a reason for higher level of the underground water and influence on the soil features and vegetation in these areas.

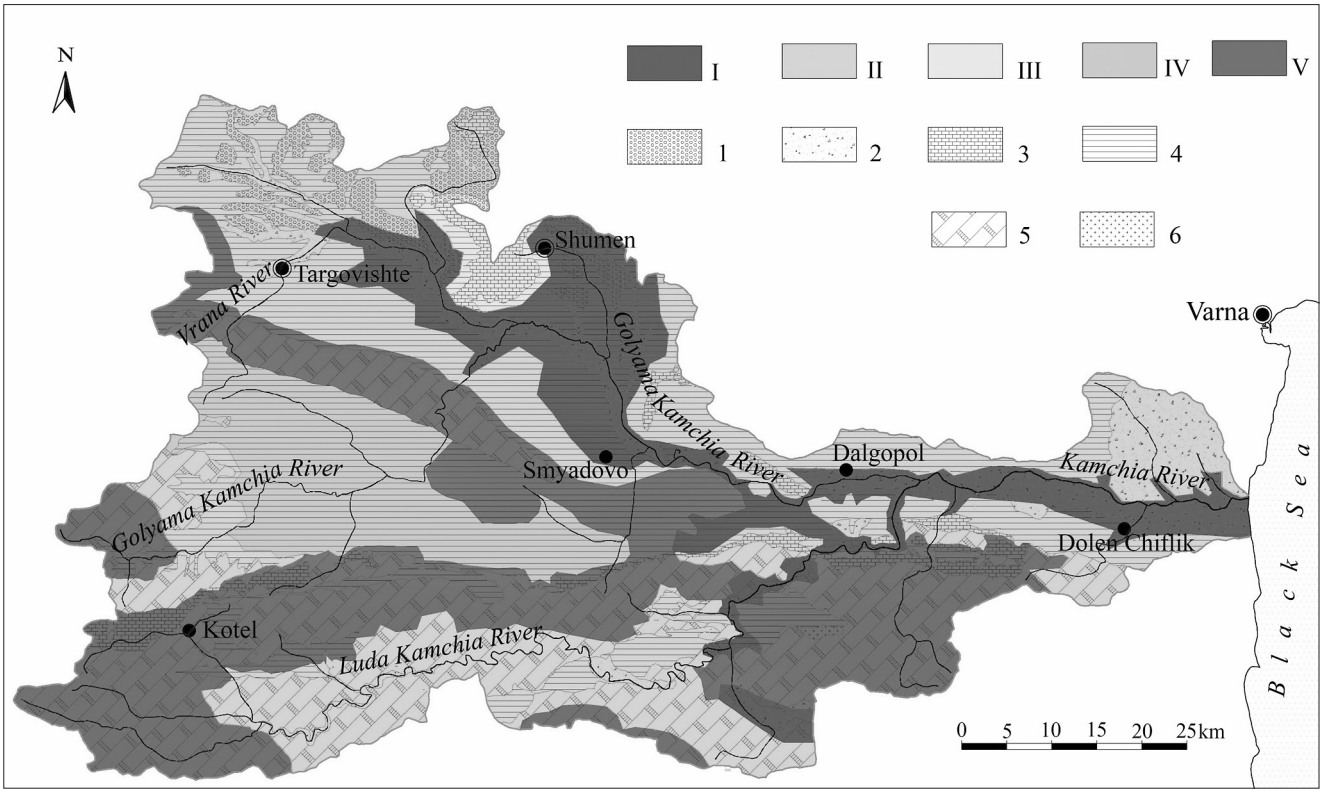

Figure 5. Morpholithology types in the Kamchia River basin
RELIEF: I – low land; II – hilly; III – plateaus; IV – hollows; V – low mountain
ROCKS: 1 – loess and loess-like clays; 2 – unconsolidated non-carbonate rocks; 3 – consolidated carbonate rocks; 4 – consolidated non-carbonate rocks; 5 – alternation of carbonate and non-carbonate rocks; 6 – volcanic rocks

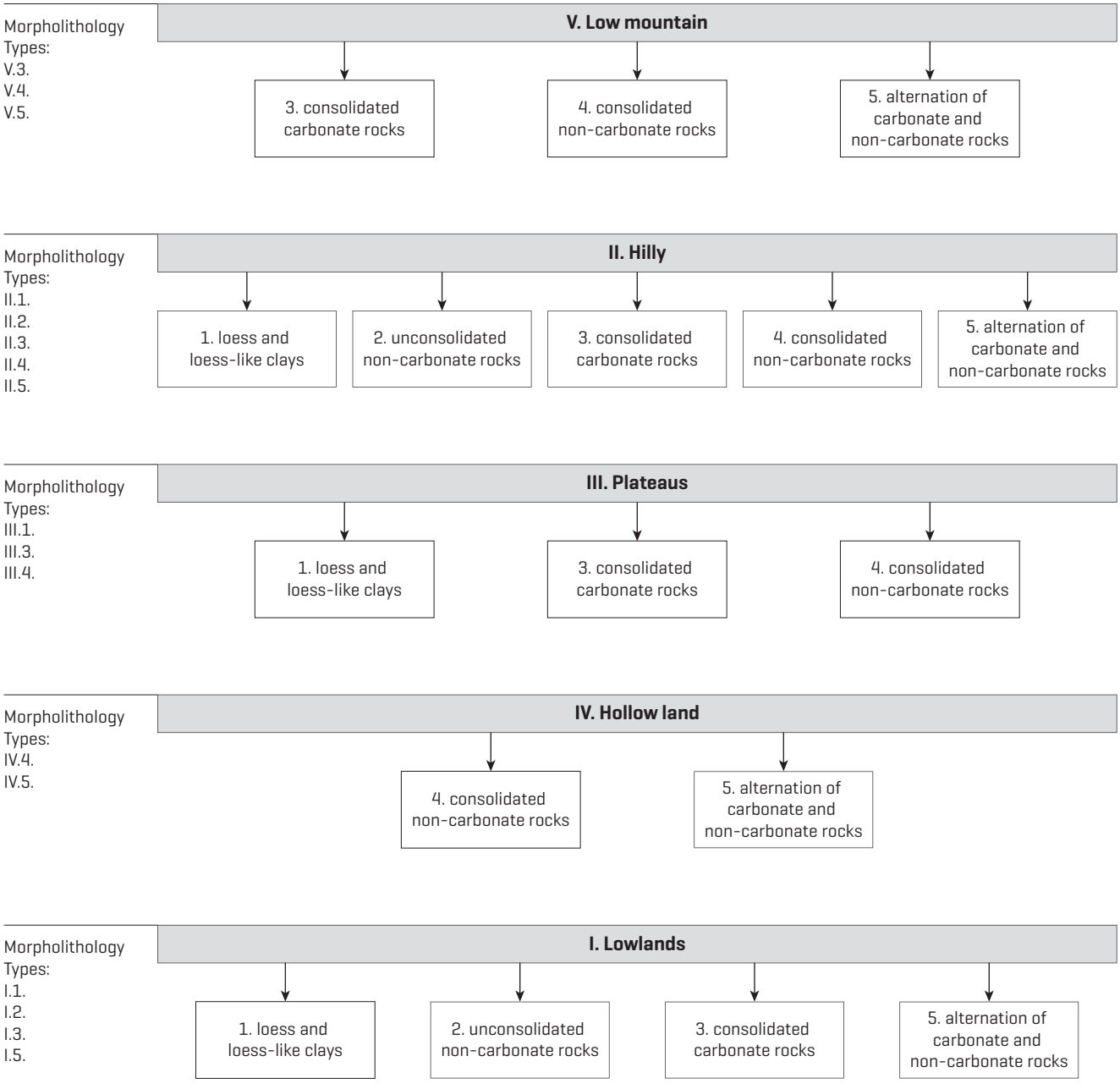

Figure 6. Chart of the morpholithology types in the Kamchia River basin
(numbers correspond to the numbers given to the legend of Fig. 5.)

Conclusions

On the basis of the above research the following can be concluded:

- The complexes with hilly relief cover the largest area of the Kamchia River basin and the smallest are the complexes with plateaus relief. The variety of the morpholithology types depends on geological development on the territory as well as on the contemporary morphogenetic processes. The large area of the hilly territories and their complicated geological development cause a large variety of the morpholithology types at hilly relief while the calm geological conditions at hollow and plateaus relief determine relatively equal in lithological substrate rocks and a few number of morpholithology types. Physical-mechanical and chemical characteristics of the rocks influence on the development of the contemporary morphogenetical processes and on the variety of the relief, and also on the landscapes as a whole in the Kamchia River basin.
- GIS technology allows quick determination of the morpholithology types as well as the analyses of their spatial structure, visualized on the map. Using a GIS gives possibilities for easy processing and visualization of large data massifs. Collection and preservation of the graphic information in digital format allows map gener-

alization to be done easily on the base of the objects area and in regards to the map scale, but in this case there is a risk of the removal of typical territory objects with small areas. In this relation not only geometric generalization are required to be done but also the attributive characteristics of the polygons have to be considered.
- The results from current research could be used as a basis in landscape classification and making landscape map.

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