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GEOMORPHOLOGICAL RISKS ASSESSMENT BASED ON SYSTEM-MORPHOLOGICAL APPROACH

Abstract. *Studies of risks remain among the most claimed issues of geology and geomorphology. The system-morphological approach developed by A.N. Lastochkin provides a new promising basis for this. We studied slopes of the ridge Aibga, Western Caucasus, to assess geomorphlogical risks in the area of construction of the mounting ski facilities for Winter Olympics, 2014. The first step of study is a compilation of an analytical map, which covers all morphological elements of the area. Then we studied current geologic and geomorphological processes and estimated risks associated with them. The last step is the assessment of risks related to certain characteristics of exposed rocks and to possible tectonic movements. These morphological, geological and engineering parameters are combined within an integrated score of geomorphological risks, which is presented on the appropriate map.*

Key words: *System-morphological approach, geomorphic risks, geohazards, assessment, mapping, Aibga Ridge.*

Introduction. It is well known that the assessment of geomorphic risks is an important part of various engineering and environmental studies. Many Russian geomorphologists contributed a lot to the development of geomorphic risks' theory and practice: Yu.P. Seliverstov ([Seliverstov, 1993]; [Likhachyova and Timofeev, 2004]) et al. Geomorphologists from St. Petersburg State University have developed a new system-morphological approach that substantially helps in resolving many engineering-geomorphic issues.

Methods. The system-morphological approach is developing by Alexander Lastochkin [Lastochkin, 1991]. The paradigm is as follows: from the morphological studies to the dynamics of relief. According to this concept, the geomorphic risk is the probability of activation of an adverse geomorphic event, which can harm the economy and population. The geomorphic risks emerge from both geomorphic conditions and morphological parameters. The geomorphic conditions can be divided into: 1) existing topography, 2) climatic and other geographic conditions, 3) endogenous (tectonic and lithological) conditions that determine the probability and intensity of hazardous geomorphic processes. Morphological parameters are responsible for the probability of activation of an adverse geomorphic event. This approach can bring perfect results even in hard-to-reach and geomorphologically complicated areas.

In order to evaluate the geomorphic risks, first you need to compile an analytical map, which comprises all the relief elements: linear (structural lines), point (characteristic points), and areal (elementary

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surfaces). This map allows choosing representative elementary surfaces for the further field engineering-geomorphic investigations. The latter give us the necessary data about key geomorphic processes and their peculiarities within the territory of interest. Next, you do the final operation: interpolation and extrapolation of the data, taking into account the morphological parameters of all the elementary surfaces identified.

Assessment and mapping. Mapping of geomorphic risks and geohazards. As an example of the implementation of this technology, we will consider the case of the geomorphic risks assessment in the area of Krasnaja Polyana (Western Caucasus) – slope of the ridge Aibga where the mountain ski ways for the Sochi Olympic Games have been constructed later. This giant slope has a height of approximately 1,800 meters. It is very uneven, i.e. geomorphologically complicated, with utterly varying steepness and exposure of individual parts.

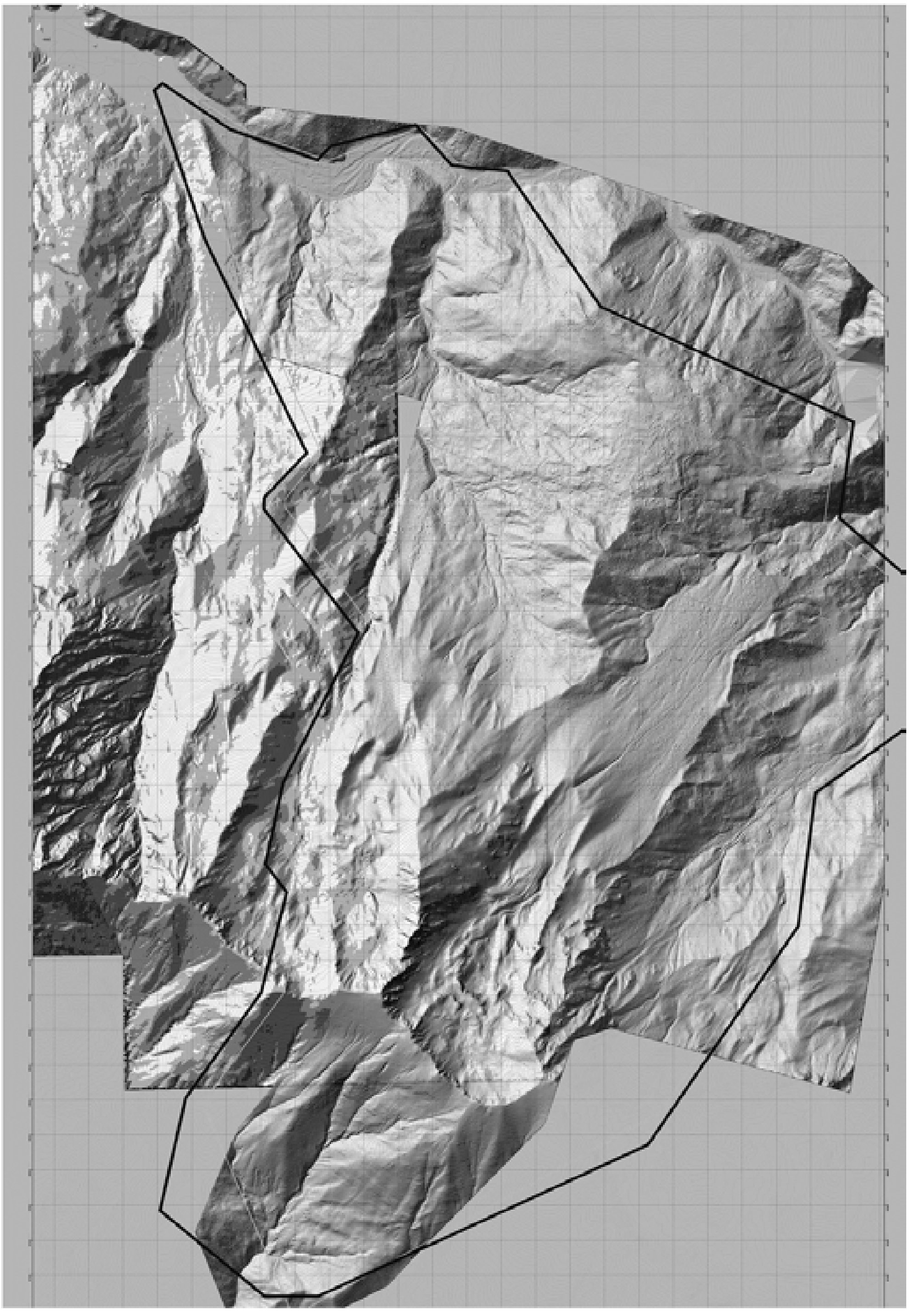

Fig. 1. 3D model of topography with the border of examined area

That territory has a humid climate of the temperate zone. The leading relief-forming processes are gravitational and fluvial ones. The detailed data on the structure of loose cover on the slopes were absent – that is why we had to rely only on morphological studies and field investigations.

We carried out the following operations to assess and to map geomorphic risks and geohazards of the territory:

Compilation of the Map of structural lines based on the topographic map and remote shooting data.

Morphological analysis of the area: altitudes and gradients, vertical and horizontal curvature, different exposures (Fig. 2).

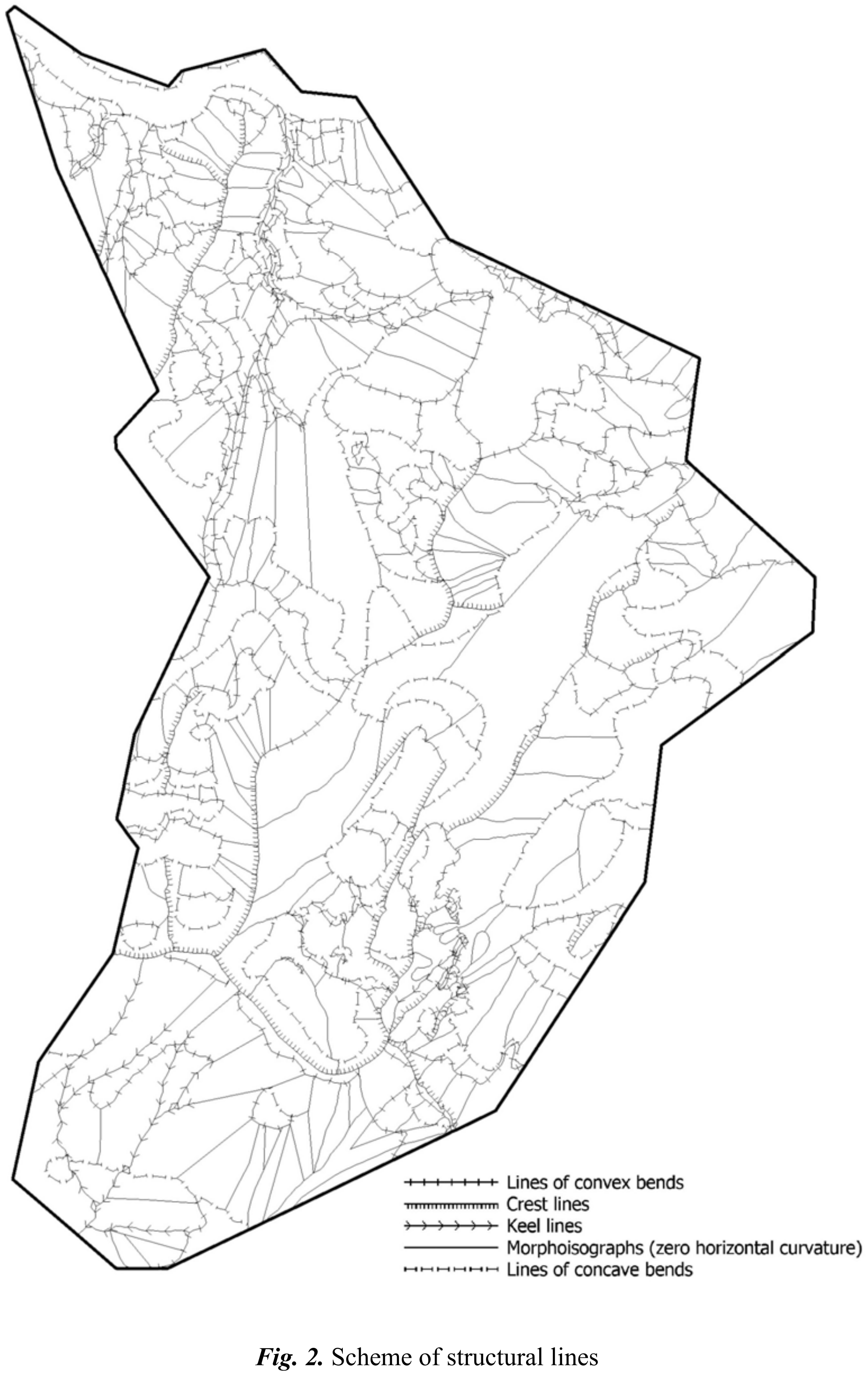

Fig. 2. Scheme of structural lines

Classification of the elementary surfaces identified and, as a result, compilation of the Analytical geomorphic map.

Field engineering investigation to study hazardous geologic and geomorphic processes of the area.

Compilation of the Map of geologic and geomorphic zoning: we outlined five zones with their specific sets of climatic conditions, geological processes and morphological parameters.

Six-point hazard assessment of geologic and geomorphic processes (see below).

Assessment of geohazards that are related to characteristics of exposed rocks (five categories: from rocky to loose) and to possible tectonic activization (estimated by the density of faults) of the area studied. Loose rocks that are situated within zones of faults are more likely to be hazardous.

Compilation of the Map of geomorphic risks and geohazards calculated for every elementary surface – based on their morphological parameters and defined geologic and geomorphic risks.

Assessment of geologic and geomorphic risks. Six-point hazard assessment for the Aibga area included geomorphic processes as follows:

Relatively safe – nival-denudation, structural-denudation, eluvial, and alluvial accumulative processes.

Low hazard – accumulation-colluvial, eluvial-landslide, and proluvial-accumulative processes.

Moderate (low-to-medium) hazard – nival-solifluction, solifluction, talus, avalanche-gravity, and alluvial-proluvial accumulative processes.

Medium hazard – nival-talus, erosion solifluction, collapse-talus, landslide, and alluvial-proluvial accumulation-erosion processes.

High hazard – nival-collapse, solifluction erosion, solifluction landslide, collapse, transit-landslide, accumulative landslide, and alluvial-proluvial erosion processes.

Extreme hazard (catastrophic) – alluvial-proluvial erosion and landslides processes.

The geomorphic risks were additionally specified within every elementary surface according to its location and morphology. The negative factors, which increased the degree of hazard, related to the definite vertical and horizontal curvature of the elementary surface, its steepness and position with respect to both superposed and subjacent surfaces. This additional sum could be up to 1.75 points of hazard more. Finally, the matrix of the basic and additional points was done and, on its basis, the Map of geomorphic risks and geohazards (Fig. 3) was compiled.

Conclusions:

We believe that the main advantages of this technique are as follows:

Clear and single division of the territory into the areal elements; risks' assessment tied to these elements.

Taking into account of the strong correlation between morphological parameters of relief elements and hazardous geologic and geomorphic processes.

Exogenous conditions, which are hydraulically and climatically determined, are included in the consideration by means of geomorphic zoning (altitudinal belts).

Endogenous conditions are included in the consideration by means of taking into account of risks related to characteristics of exposed rocks and to possible tectonic activization.

All abovementioned points let us tell about a new multipurpose technique, based on the system-morphological approach, of the assessment of georisks and geohazards.

Results obtained during this project were successfully utilized while designing of the mountain skiing center Roza-Khutor where many important events of Winter Olympics, 2014 took their place.

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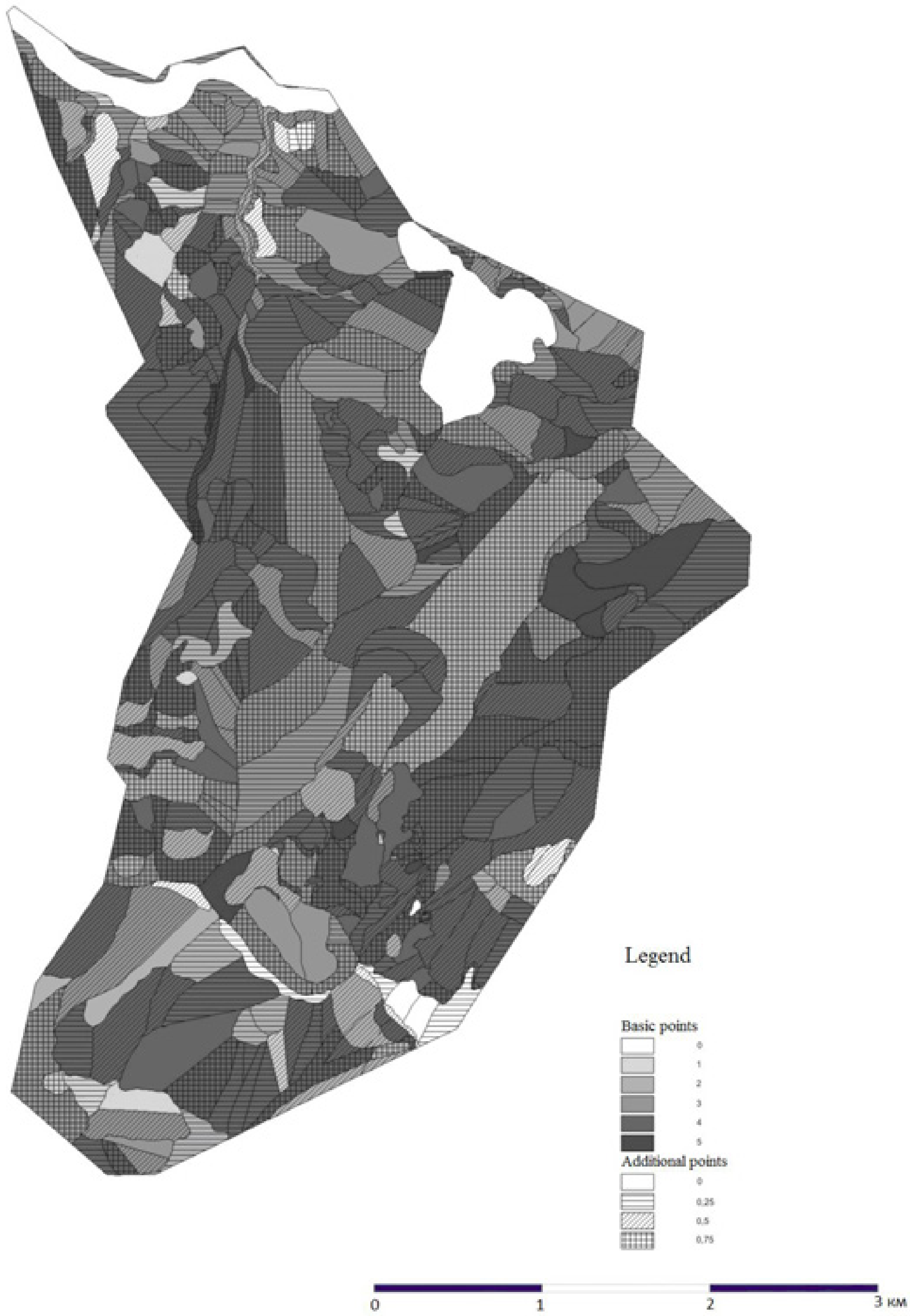

Fig. 3. Map of geomorphic risks and geohazards (Aibga area)

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