Landform Analysis, Vol. 11: 60–70

Natural environment predispositions of north-western Pamirs towards development of contemporary morphogenetic processes

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Abstract: Natural environment of high mountains is undergoing rapid changes. One of its elements is the relief. What needs to be particularly emphasized here is its contemporary morphogenesis.
The aim of the study is an attempt to define the predisposition of natural environment of the chosen region (NW) of the Pamirs towards the development of contemporary morphogenetic processes. In order to carry it out, quality classes method was implemented. Quality classes method was carried out on two kinds of basic fields of assessment: geometric and natural (geomorphologic). It was preceded by a selection of 14 characteristics of the study area, elements or components of the natural environment, which were analysed from the perspective of their influence on initiating, change of intensity or vanishing of the contemporary land formation processes. Maps of predisposition of natural environment of north-western part of the Pamirs towards the development of modern morphogenetic processes for the two kinds of fields constitute the final result of the study.
Gained results enable to state that the significant part of the study area is characterized by big predispositions towards the development of contemporary morphogenetic processes. However, on the basis of research on location it was find out that in a few places there is a more intensive forming of the surface than it results from the gained results. Areas of average and small predispositions almost precisely coincide with the range of big Pamirs glaciers. Moreover, it can be said that an extremely important issue for the high mountain region characterized by a big spatial changeability of all analyzed elements of natural environment is the size of the basic field of assessment.

Key words: contemporary morphogenetic processes, natural environment, predispositions, quality classes method, north-western Pamirs

Introduction

Mountain regions are one of the last fragments of the so-called natural environment. Mountain ecosystems influence the lives of over half of the inhabitants of the Earth (Ives et al. 1997). That is why it is important to recognize the style of functioning of geographic environment in these parts of the world. Difficulties in examining mountain regions, especially high mountains, are most often caused by their limited accessibility which result from the stretch of the mountain ranges, absolute heights and extreme climatic conditions. Such features are also characteristic for the Pamirs where the scope of research is based. The major part of the mountain range is within the borders of Tajikistan. Over half of the area of the country is above 3,000 m a.s.l. (Wielka… 2005). Despite the fact that Pamir has been the subject of many expeditions, it has been the unexplored region of Central Asia for the longest period of time.

One of the elements of natural environment of high mountains which are subject to relatively fast changes is the relief of the land. Special attention needs to be put to the contemporary morphogenetic processes. The attempt to define predispositions of natural environment of the chosen region of Pamir for their development constitutes the aim of this study. In order to carry it out, quality class method was

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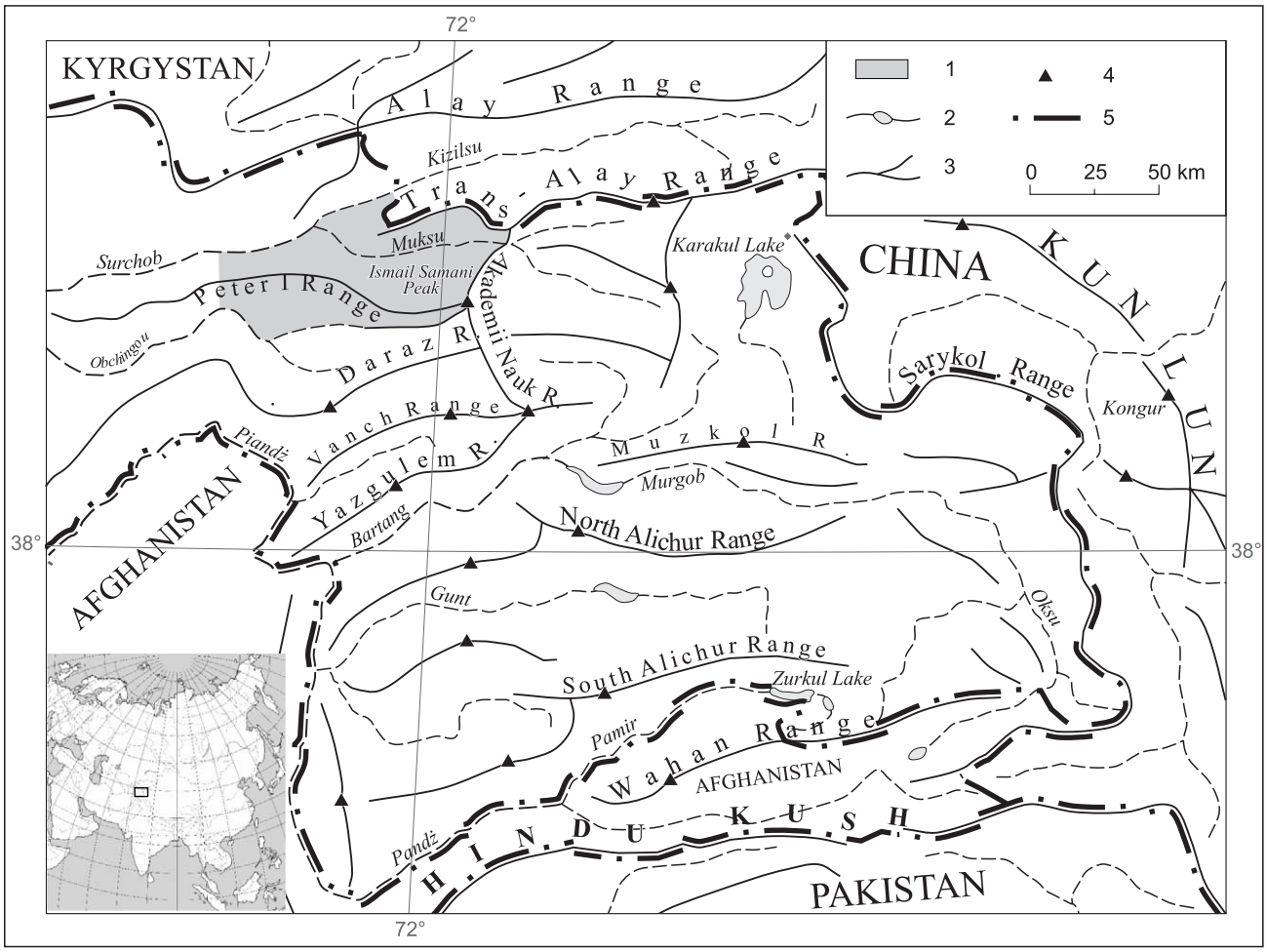


Fig. 1. Orography of the Pamirs
1 – study area, 2 – rivers and lakes, 3 – ranges, 4 – peaks, 5 – state borders

implemented. The additional aim was the assessment of its implementation in the high mountains region.

Area of study

The area of study is situated in the north-western part of the Pamirs, in Tajikistan. It covers the area of 2,757 km^2 (longitudinal extent – 81 km, latitudinal extent – 52 km). Within its borders we find fragments of Trans-Alay Range, Peter I Range and Akademii Nauk Range with seven-thousand-meter high mountains: Ismail Samani Peak (Ismoil Somoni Peak, former Communism Peak, 7,495 m a.s.l.) and Peak Korzhenevskaya (7,105 m a.s.l.) as well as parts of river valleys: Muksu, Kizilsu, Surkchob and Garmo (Fig. 1, 2). The study area is one of the highest and most glaciated in Pleistocene and presently part of the Pamirs (Rojan 2009).

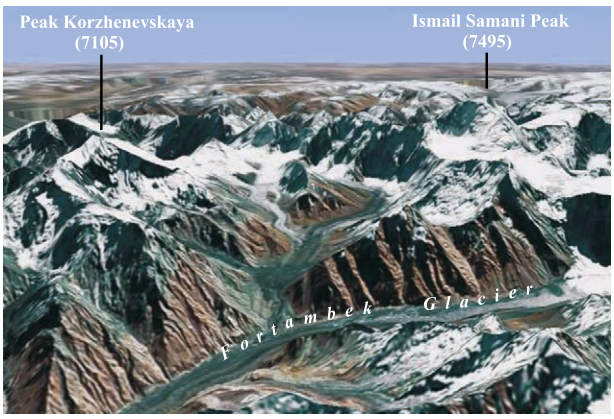
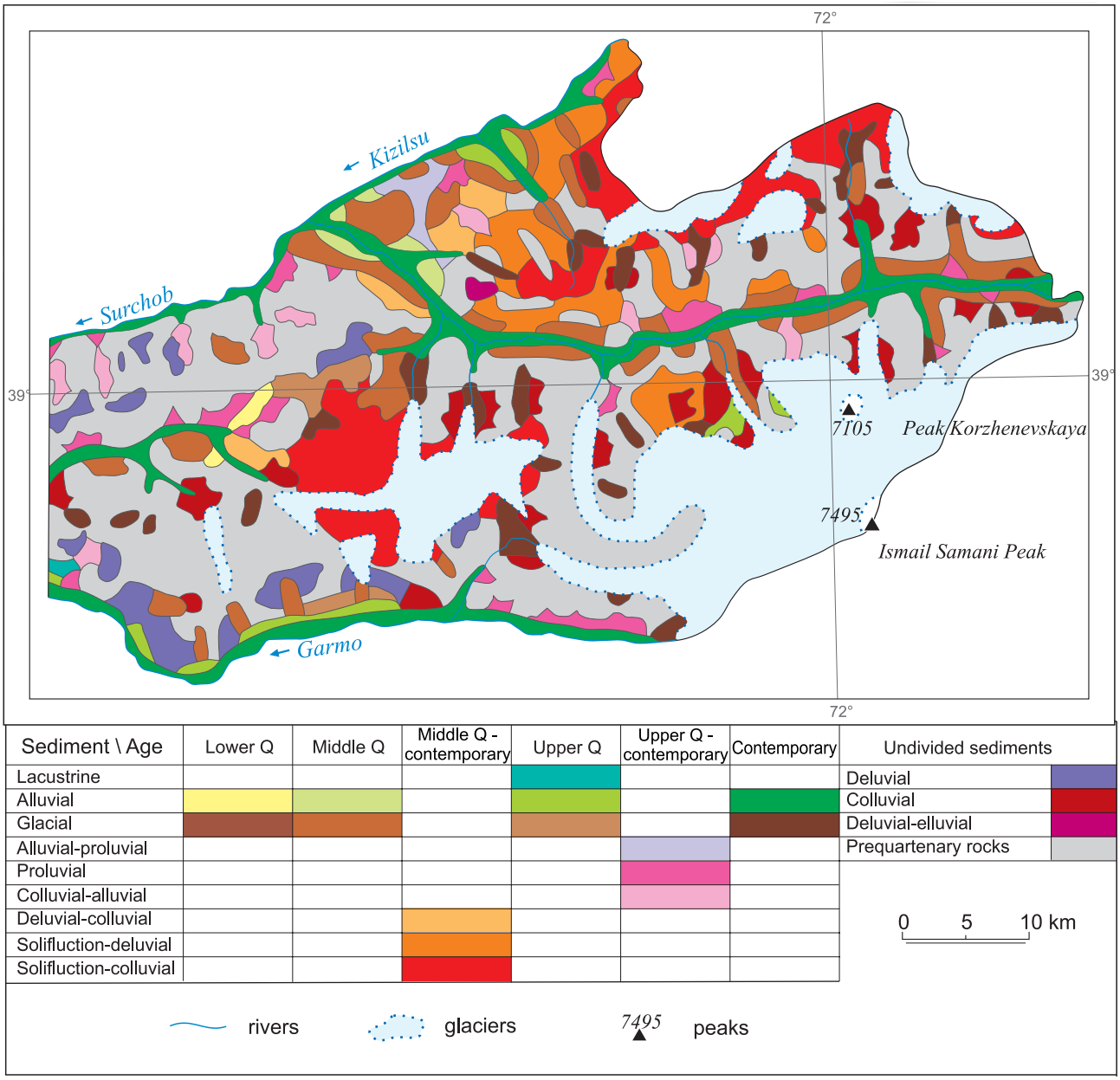


Fig. 2. SE part of study area with Fortambek glacier valley (Google Earth 2009)

Characteristics of chosen elements of natural environment of the study area in relation to the whole area of the Pamirs

Geological history of the whole mountains range is very complicated. It consists of rocks of various age, from Precambrian to the contemporary ones. The oldest ones are deeply metamorphosed Precambrian rocks represented by the surfacing gneisses and crystalline schists (Lozev 1968). The youngest, Quaternary ones, occur on the beds of river valleys



Sediment \ Age	Lower Q	Middle Q	Middle Q - contemporary	Upper Q	Upper Q - contemporary	Contemporary	Undivided sediments
Lacustrine							Deluvial
Alluvial							Colluvial
Glacial							Deluvial-elluvial
Alluvial-proluvial							Prequartenary rocks
Proluvial							
Colluvial-alluvial							
Deluvial-colluvial							
Solifluction-deluvial							
Solifluction-colluvial							

Fig. 3. Map of Quaternary sediments of the study area (after Reynam 1968)

(alluvia) and on the areas of presently glaciated as well as in their vicinity, where ice accumulation used to occur and still takes place (Fig. 3). Apart from many kinds of sediments constituting the plate structure of the Pamirs, magmatic intrusive rocks are widely spread.

The Pamirs was folded during the following orogeneses: Caledonian, Hercynian, Cimmerian, and Alpine. The last of them in a significantly bigger extent than the previous ones influenced the shaping of this massif (Meshcherakov 1981). It is characterized by, among others, increasing the speed of epeirogenic movements (Chediya 1968).

Contemporary lie of the land of the north-western part of the Pamirs is a result of transformations of the tertiary relief in Pleistocene and Holocene. Still, elements of older lie of the land have been preserved. Surface evolution in the above mentioned periods took and takes place as a result of activities on the study area of a number of morphogenetic processes causing creating of forms belonging to various types of the relief (Rojan 2008).

The Pamirs belongs to areas glaciated in the past (2–3 times: Tupchan and Lyahsh glacial ages) as well as presently glaciated mountain ranges of Central Asia. Late-Pleistocene glacial ages ended about 9500 years ago (Bondarev et al. 1997). The area covered by glaciers of the time was only 5–20% bigger than the presently glaciated area. The area of present glaciers of the Pamirs is about 8000 km^2 (Dolgushin & Osipova 1989). The area of glaciations constitutes about 10–13% of the total area of the mountain range and in the last century underwent slight decreasing (Fig. 4).

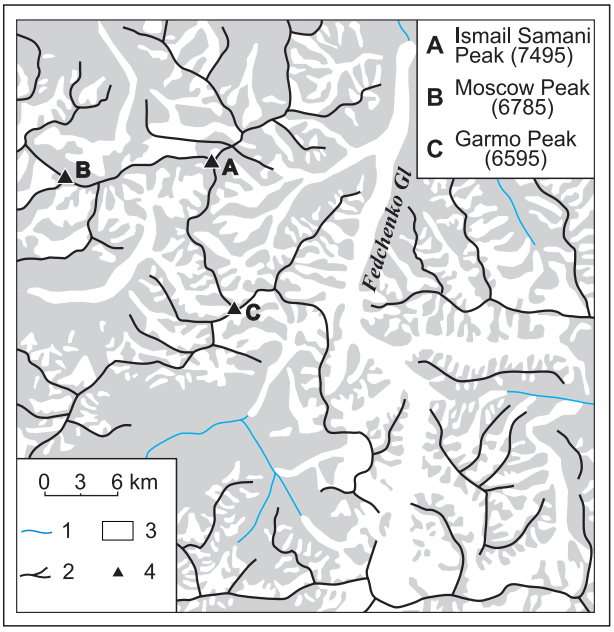


Fig. 4. One of the most glaciated fragments of the Western Pamirs (with Fedchenko Glacier) (after Dolgushin & Osipova 1989)
1 – rivers, 2 – ranges, 3 – glaciers, 4 – peaks

Climate conditions of the mountain range are formed most of all under the influence of higher masses of troposphere which have a significant meaning for mountain ridges and slopes. To a small extent they shape the conditions in the floors of deep valleys, where there is local climate. Then, this local climate in cold periods of the winter is conditioned most of all by the differences in the relief (concave and convex forms), and in the summer the character of the surface (glacier and non-glacier surfaces). Climate of the Pamirs is characterized most of all by: significant daily and seasonal fluctuations in temperature, small cloudiness, high concentration and sums of solar radiation and low air humidity. On the study

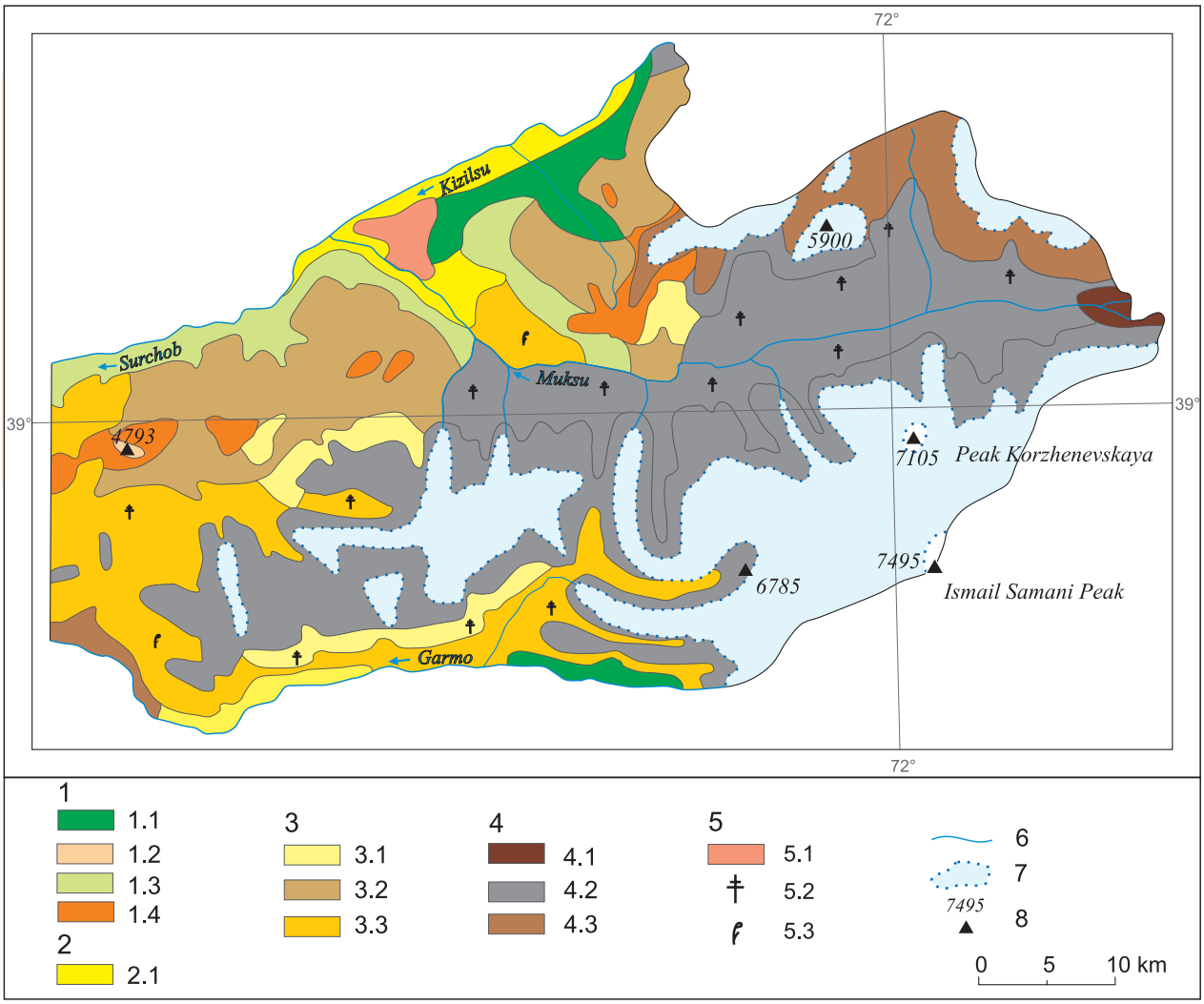


Fig. 5. Vegetation map of the study area (after Ovchinnikov 1968)
1 – Tree-bushy vegetation: 1.1 – juniper with associating graminaceous vegetation, 1.2 – forest steppe – almond and pistachio trees thickets, 1.3 – rose thickets with rich vegetation, 1.4 – shrubs thickets, 2– Deserts: 2.1 – sagebrush deserts, 3 – Graminaceous vegetation: 3.1 – meadow steppes with thorny species, 3.2 – typical steppes, 3.3 – semisavannah, 4 – rare vegetation: 4.1 – stones and sands, with isolated vegetation, 4.2 – rare vegetation of screes as well as rocks of mid- and high mountains zone, 4.3 – rocks of nival zone, without vegetation, 5 – Arable lands: 5.1 – lands irrigated with the remains of desert and semidesert vegetation, 5.2 – juniper thickets, 5.3 – rose thickets

area, mainly due to latitudinal, open towards the west, arrangement of the mountain ridges, air masses from the west and north-western are predominant.

Vegetation of the Pamirs is not much developed. On most of its area there is no vegetation. Majority of plants, which can survive in difficult conditions are xerophytes and resistant to low temperatures. In the Western Pamirs, vegetation is mainly represented by Artemisia-brine plant communities. On the floor there are forests and thickets consisting mainly of local species of birches, poplars and willows. Higher, to the level of 3,000–3,200 m a.s.l., there are mountain steps including: Astragalus, Stipa, Festuca Rupicola, various species of Poa, Prickly thrifts (Ovchinnikov 1968). Above them, sometimes even as high as 4,500 m a.s.l., there are high mountain pastures with Umbelliferae (Fig. 5).

Methods and results

Due to the size of the study area as well as test examination of the chosen elements of natural environment in a detailed scale in order to carry out the established purpose available thematic maps were used at a scale of 1:500,000, topographical maps at the scale of 1:200,000, aerial and satellite photographs. Additionally, results of observations and research on location carried out on the contemporary

Fig. 6. Connected glaciers: the Walter Glacier (left) and the Traube Glacier (right) (4,300 m a.s.l.). In the background: visible ridge of the Pamir Firn Plateau and Ismail Samani Peak (7,495 m a.s.l.).
Photo by J.Osińska

Fig. 7. Study area with geometric basic fields of assessment
1 – rivers, 2 – glaciers

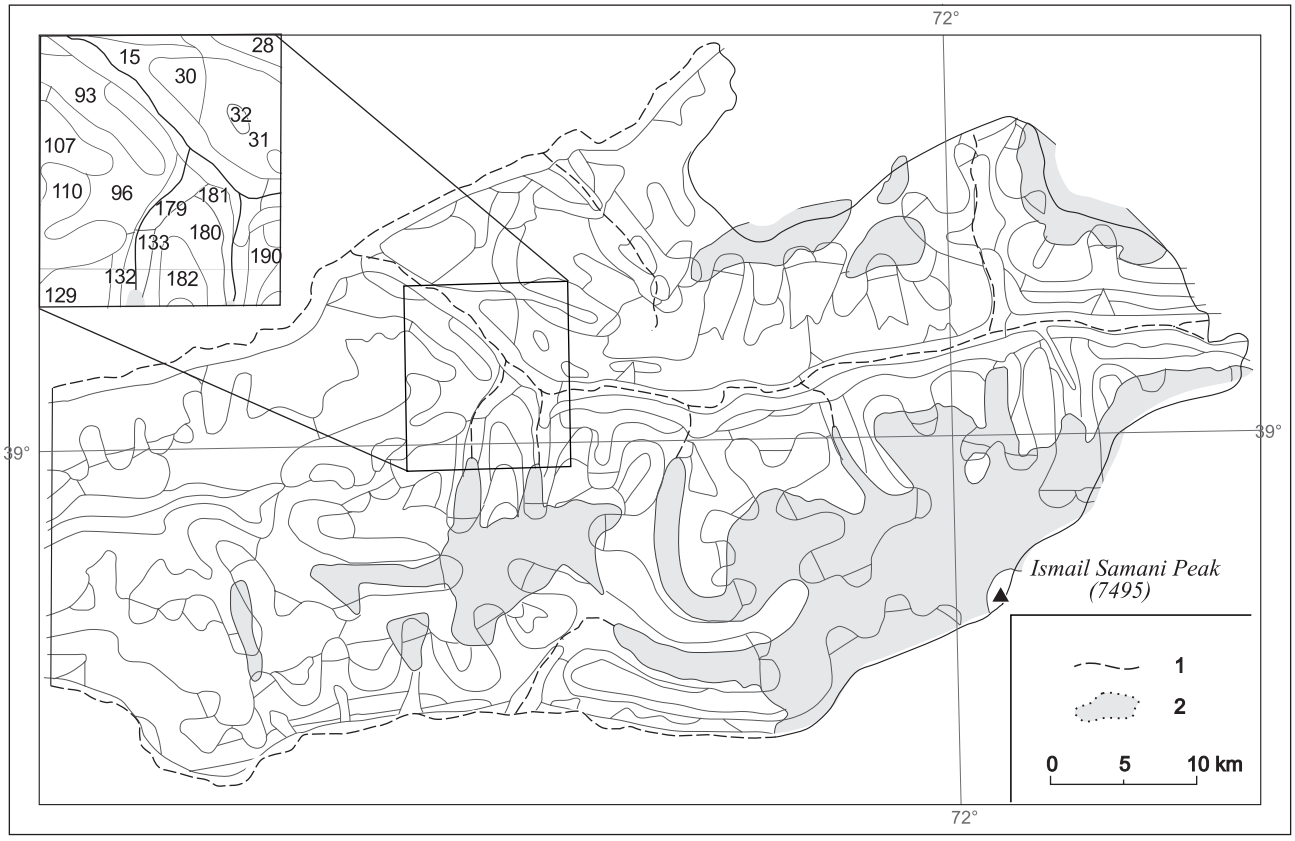


Fig. 8. Study area with geomorphologic basic fields of assessment
1 – rivers; 2 – glaciers

morphogenetic processes in the zone of 1,500 m to 6,100 m a.s.l. were added. Research was most of all focused on the area of the Ismail Samani Peak (Fig. 6) and Korzhenevskaya Peak as well as in the valley of the Muksu River.

The achieve the purpose of the study presented at the beginning, a quality classes method was implemented. In the process of quality classes (assessment of value, evaluating of ingredients and characteristics of environment structure) usually two stages are distinguished:

– quality class classification, that is creating a so-called sequence with relative values
– point class classification – changing the quality values to point values.

Class classification is performed on the area of basic fields of assessment. Their selection is one of the main problems of all evaluations of procedures of spatial character. While assessing the landscape potential, the most often suggested basic fields are natural, administrative or geometric units (Kistowski 1997).

In the study quality classes were introduced for comparative purposes, on two kinds of basic fields of assessment: geometric and natural. In the first case, the study area was divided into squares with a side of 2.4 km (area of 5.76 km^2). As a result of such a division 1033 fields were created. However, in the "borderlands" these were not total km^2 squares (Fig. 7). In the latter one, on the basis of geomorphologic map, 283 basic geomorphologic units of assessment. were sectioned off. Their area is very much varied: from 0.52 do 87.5 km^2 (Fig. 8).

The next stage of works proceeding the very quality classes was based on the choice of characteristics of the area of study, elements of the natural environment or only their components, henceforth called categories which were then examined from the point of view of their initiating, change of intensity or vanishing the contemporary landform creation pro-

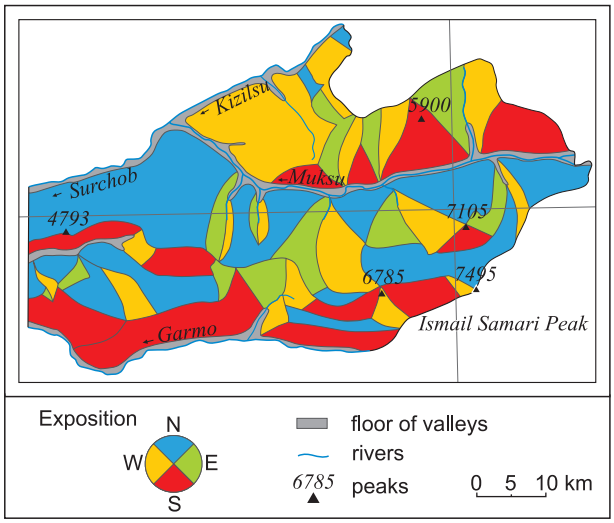


Fig. 9. Slopes exposure map of the study area

Table 1. Assessment of selected categories for first ten geometric basic fields of assessment

No. of the field	Categories														Total points	Class
	A	B	C	D	E	F	G	H	I	J	K	L	M	N		
1	4	1	3	3	0	3	4	1	3	4	1	2	1	2	32	IV
2	3	1	3	3	0	3	4	1	3	4	1	1	1	2	32	IV
3	4	2	3	3	0	3	4	1	2	3	2	2	2	3	38	IV
4	3	1	3	3	0	2	4	1	3	3	1	1	1	2	30	IV
5	4	2	3	3	0	3	4	1	3	3	2	1	1	2	34	IV
6	4	2	3	3	0	3	4	1	2	2	2	4	2	3	39	V
7	2	1	0	3	0	2	4	0	4	4	1	2	1	2	27	IV
8	3	2	1	3	0	3	4	1	3	3	1	1	1	2	30	IV
9	4	2	3	3	0	2	4	1	3	3	2	1	1	2	33	IV
10	4	2	3	3	0	3	4	1	2	2	2	4	2	3	39	V

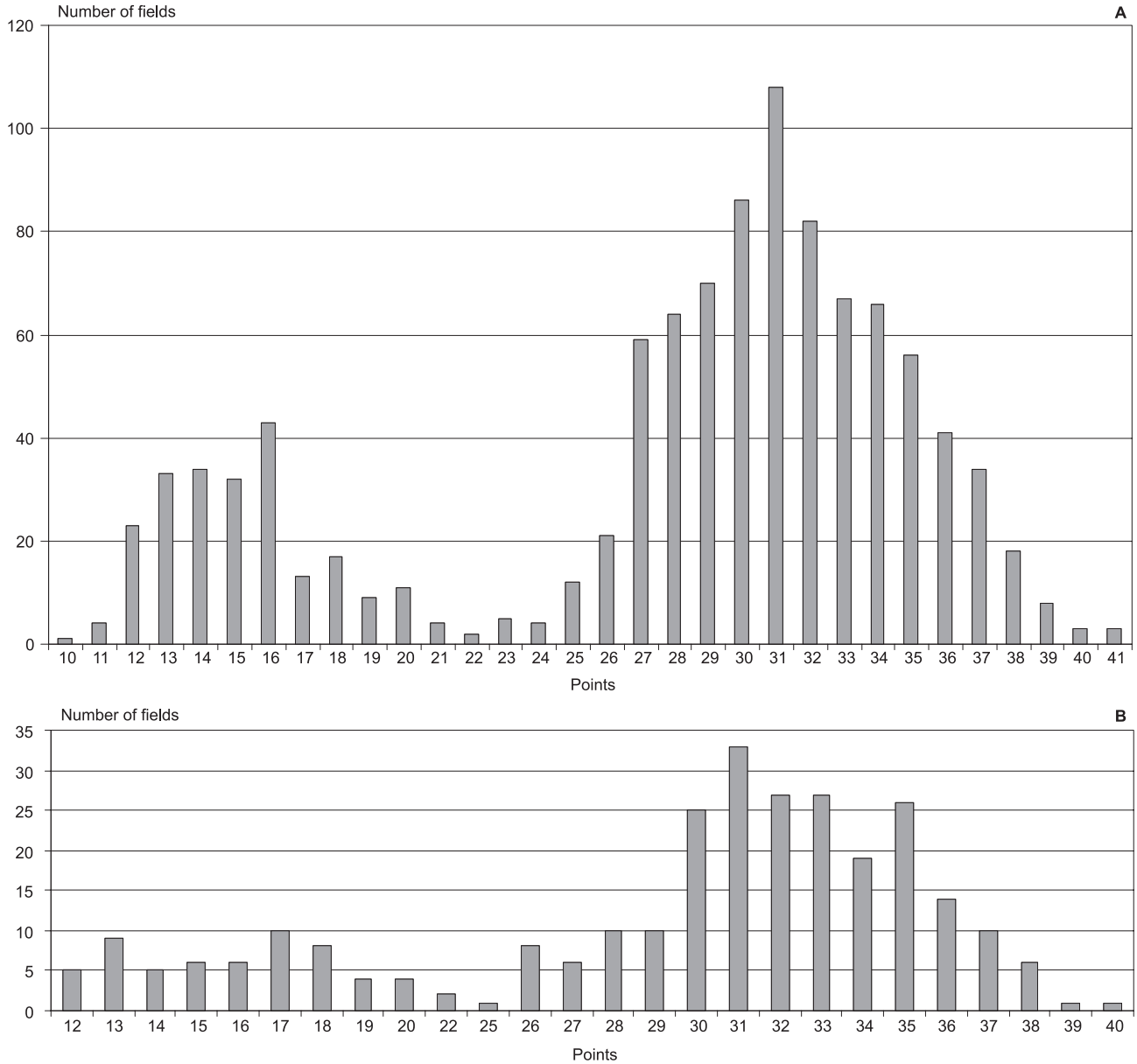


Fig. 10. Histograms: A – geometric basic field of assessment, B – geomorphologic basic fields of assessment

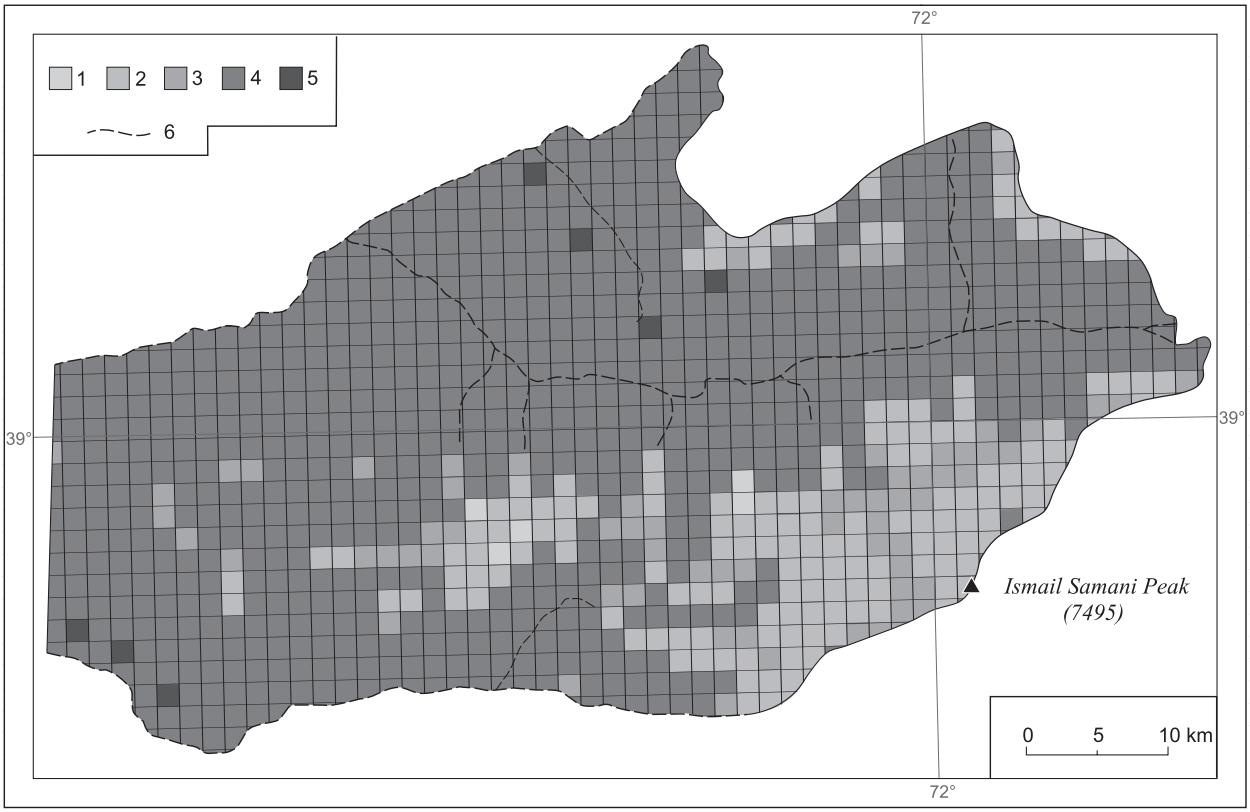


Fig. 11. Map of predisposition of natural environment of north-western part of the Pamirs towards the development of contemporary morphogenetic processes – geometric basic fields of assessment
Predispositions: 1 – very small, 2 – small, 3 – average, 4 – big, 5 – very big. 6 – rivers

cesses. As a result of selection, 14 categories were chosen: absolute height (A), relative height (with local denudation bases) (B), slope exposition (C) (Fig. 9), glaciers expansion (D), geology (without Quaternary sediments) (E), Quaternary deposits (F) (Fig. 3), tectonic lines (G), neotectonics (H), average monthly air temperature in January (I), average monthly air temperature in July (J), precipitation (K), number of days with a snow cover (L), soil (M) and vegetation (N) (Fig. 5).

For the above mentioned categories the following assessment criteria were applied:
0 – no influence on the contemporary shaping of the relief constituting the scope of research
1 – small influence,
2 – medium influence,
3 – big influence,
4 – very big influence.

The area of each allocated basic field was subject to assessment in all chosen categories. Gained results are included in the table whose demonstration part is represented by table 1.

Each of the previously sectioned off fields, as a result of summing up the assessments of particular categories, received the following number of points (Table 1). For geometric fields the lowest sum is 10, and the highest 41. In case of natural units, the range of the sums is 12–40.

The next stage of works was based on determining class ranges. In order to determine them properly, natural histograms were used, a different one for each of the 2 kinds of fields (Fig. 10).

On the basis of their analysis 5 classes were created, from I to V. Each of the classes was assigned fields with a particular number of points. As a result, for the study area divided into squares, the classes are as following:
I: < 11
II: 12–16
III: 17–26
IV: 27–37
V: 38–41

For the area divided into natural units to the particular classes belong fields with the following sums:
I: < 18
II: 19–25
III: 26–29
IV: 30–38
V: 39–40

Moreover, each class number corresponds to the descriptive assessment presented below which provides information on predispositions of the area inside the limits of a given class to the development of contemporary morphogenetic processes:
I – very small predispositions
II – small predispositions

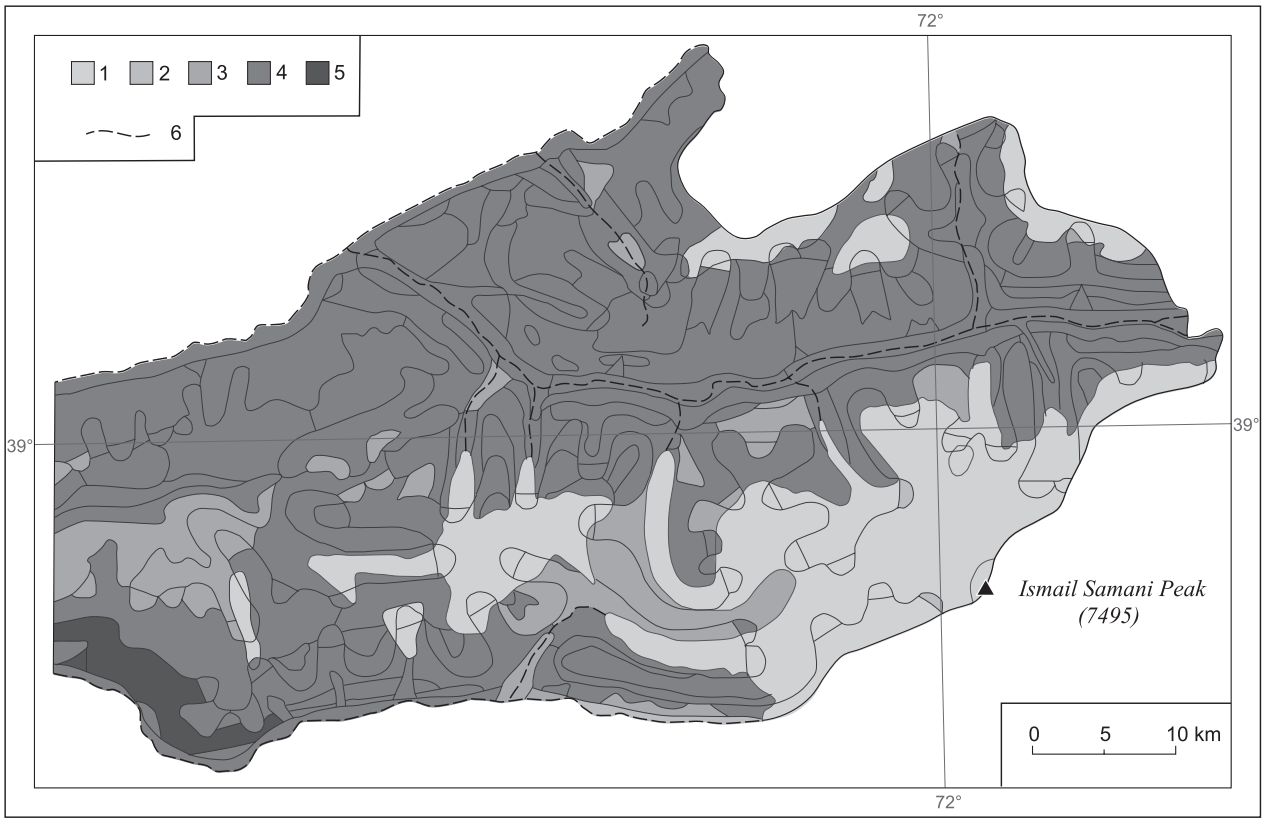


Fig. 12. Map of predisposition of natural environment of north-western part of the Pamirs towards the development of contemporary morphogenetic processes – geomorphologic basic fields of assessment
Predispositions: 1 – very small, 2 – small, 3 – average, 4 – big, 5 – very big. 6 – rivers

III – average predispositions
IV – big predispositions
V – very big predispositions.

As a result of conducted calculations and analyses, 2 maps for two kinds of fields were created which are the final result of having implemented the quality classes method (Fig. 11 and 12).

Conclusions

On the basis of analysis of the gained results (predisposition maps) it can be said that about ¾ of the area of the scope of research is characterized by big predispositions to develop contemporary morphogenetic processes (Fig. 13). However, there is a very small amount of fields belonging to extreme allocations. What is especially interesting is their small number belonging to class V, namely with very big predispositions. Total area of average predisposition towards the development of contemporary processes is bigger on the map with natural units. The difference between the two maps concerns areas covered with glaciers: on the map with geometric units their significant part has small predisposition, and on the map with geomorphologic units it is average. Most probably such a difference results from the division into classes different for each of the 2 kinds of basic fields of assessment resulting from the implementation of natural histograms.

Areas of big and very big predispositions towards the development of contemporary morphogenetic processes are modelled by diversified (horizontally and vertically) processes. Here, gravitational mass movements with an extremely high intensity play the

Fig. 13. Area with big predispositions towards the development of contemporary morphogenetic processes (gravitational mass movements and glacial processes). The Walter Glacier, Moskvin Glade (4,200 m a.s.l.) with a small lake.
Photo by J. Osińska

Fig. 14. The Moskvin Glacier with 5- and 6-thousand-high mountains in SE part of the study area. Area with predispositions towards the development of contemporary morphogenetic processes: from average to very big ones. *Photo by J. Osińska*

Fig.15. Hanging glaciers stuck to steep slopes of the Pamir Firn Plateau.
Photo by J. Osińska

most significant role. An important role to prepare rock material to their operation is played by physical weathering. Areas of average and small predispositions are most often transformed by glacial processes (Rojan 2005, 2009) (Fig. 13, 14). What needs to be emphasized here is the protective role of compact covers of big Pamir glaciers on these areas (Fig. 15). On areas small in relation to the study area (SE part) a more intensive contemporary shaping of the area takes place than it results from the data obtained from implementing the quality classes results method (natural environment predispositions towards the development of contemporary morphogenetic processes – big, real transformation – very big).

An extremely disputable issue is the size of basic fields of assessment (Bartkowski 1977, Richling 1997), especially for the area of high mountains characterized by a significant spatial changeability of all analyzed elements of natural environment.

This changeability was fund on the study area during works on location. That is why the marked off areas of the both kinds of basic fields of assessment, even the smallest ones, still appear to be too big. However, the choice of the size of the fields was dictated by the scale and quality of the available cartographic materials.

Summary

Mountain ecosystems are treated as one of the least changed areas on Earth as a result of human activity. It results most of all from characteristic features which do not favour or enable their development. They include, among others, significant absolute height, big dismembering of the area and inclination of slopes, extreme climate conditions, poorly-developed soils, poor vegetation. The above mentioned features of natural environment of mountain areas, especially of high mountains as well as lack of adaptation of human organism to functioning in such conditions make conducting research and scientific observations difficult. As a result, there is a relatively poor or fragmentary knowledge of elements of natural environment, including the relief, of some mountain ranges. Pamir is one of them, within whose borders the study area is situated – its north-western part. It is characterized by natural environment predispositions to the development of contemporary morphogenetic processes which are quite characteristic of high mountains. Results were obtained by implementing a quality classes method. What still remains disputable is the size of basic fields of assessment, most of all due to significant spatial changeability of all analyzed elements of natural environment.

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